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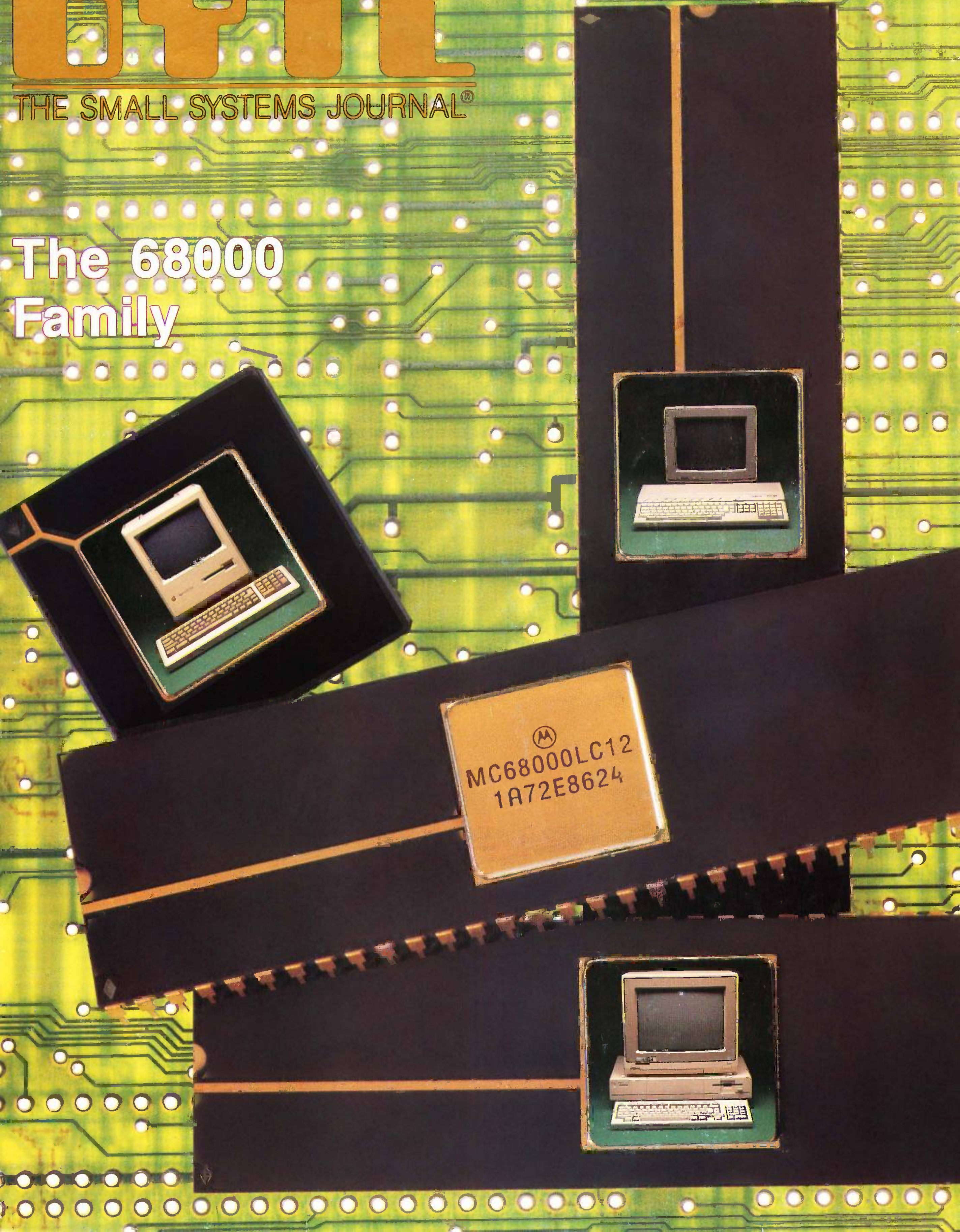
The 68000 Family



Turbo GameWorks™

Also recently released, Turbo GameWorks is what you think it is: "Games" and "Works." Games you can play right away (like Chess, Bridge and Go-Moku), plus the Works—which is how computer games work. All the secrets and strategies of game theory are there for you to learn. You can play the games "as is" or modify them any which way you want. Source code is included to let you do that, and whether you want to write your own games or simply play the off-the-shelf games, Turbo GameWorks will give hours of diversion, education, and intrigue. George Koltanowski, Dean of American Chess, and former President, United States Chess Federation, reacted to Turbo GameWorks like this, "*With Turbo GameWorks, you're on your way to becoming a master chess player,*" and Kit Woolsey, writer, author, and twice Champion of the Blue Ribbon Pairs, wrote, "*Now play the world's most popular card game—Bridge . . . even program your own bidding or scoring conventions.*" Suggested retail: $69.95.

Turbo Graphix Toolbox™

It includes a library of graphics routines for Turbo Pascal programs. Lets even beginning programmers create high-resolution graphics with an IBM, Hercules,™ or compatible graphics adapter. Our Turbo Graphix Toolbox includes all the tools you'll ever need for complex business graphics, easy windowing, and storing screen images to memory. It comes complete with source code, ready to compile. Suggested retail: $69.95.

Recognition for Borland International has come from business, trade, and media, and includes both product awards and awards for technical excellence and marketing. Borland was named "Company of the Year" by PC Magazine; Sidekick, the #1 best seller for the IBM PC, was named "Product of the Year" by InfoWorld; Turbo Pascal was selected one of PC Week's Top 10 Products for 1984; SuperKey won one of PC Magazine's "Best of 1985" awards; Reflex, The Analyst was recognized in the "Software Products of the Year" awards by InfoWorld; and Reflex and SideKick were both nominated for British Micro Awards in 1986.

Turbo Database Toolbox™

A perfect complement to Turbo Pascal, because it contains a complete library of Pascal procedures that allows you to search and sort data and build powerful database applications. Having Turbo Database Toolbox means you don't have to reinvent the wheel each time you write a Turbo Pascal program. It comes with source code for a free sample database—right on disk. The database can be searched by keywords or numbers. Update, add, or delete records as needed. Just compile it and it's ready to go to work for you. Suggested retail: $69.95.

Technical Specifications:

TURBO PASCAL 3.0 Minimum memory:128K; includes 8087 and BCD features for 16-bit MS-DOS and CP/M-86 systems. CP/M-80 version minimum memory: 48K; 8087 and BCD features not available

TURBO DATABASE TOOLBOX Minimum memory: 128K. CP/M-80 minimum memory: 48K. Requires Turbo Pascal 2.0 or later.

TURBO GRAPHIX TOOLBOX* Minimum memory: 192K. Requires PC/MS-DOS 2.0 or later, Turbo Pascal 3.0, and IBM CGA, Hercules Monochrome Card or equivalent.

TURBO TUTOR 2.0 Minimum memory: 192K. CP/M-80 version minimum memory 48K. Requires PC/MS-DOS 2.0 or later and Turbo Pascal 3.0.

TURBO EDITOR TOOLBOX* Minimum memory: 192K. Requires PC/MS-DOS 2.0 or later and Turbo Pascal 3.0.

TURBO GAMEWORKS* Minimum memory: 192K. Requires PC/MS-DOS 2.0 or later and Turbo Pascal 3.0

TURBO PROLOG* Minimum memory: 384K.

REFLEX: THE ANALYST* Minimum memory: 384K. Requires IBM CGA, Hercules Monochrome Card or equivalent. Works with Intel's AboveBoard-PC and -AT; AST's RAMpage! and RAMpage! AT; Quadram's Liberty-PC and -AT; Tecmar's 640 Plus; IBM's EGA and 3270/PC; AT&T's 6300 and many others.

REFLEX WORKSHOP* Minimum memory: 384K. Requires Reflex: The Analyst. Two disk drives or hard disk recommended.

TURBO LIGHTNING* Minimum memory: 256K. Two disk drives required. Hard disk recommended.

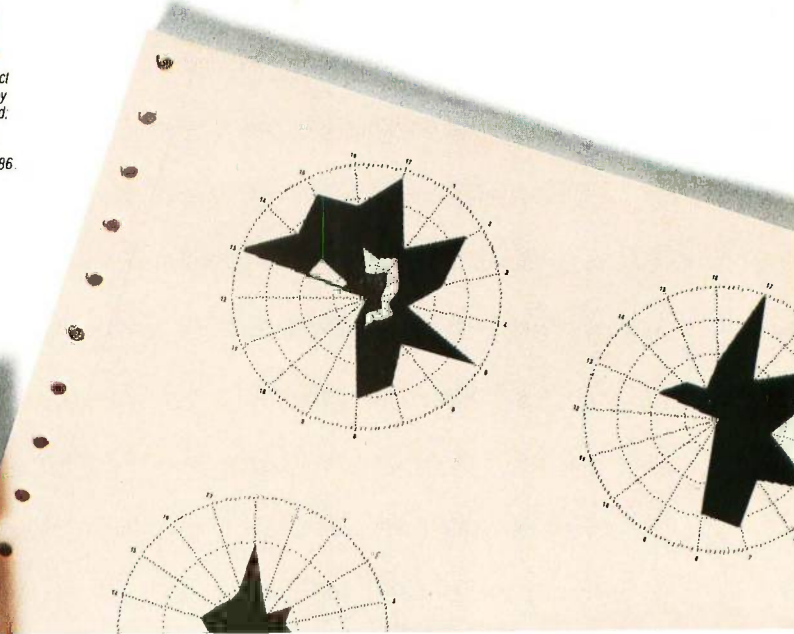
LIGHTNING WORD WIZARD* Minimum memory: 256K. Requires Turbo Lightning. Turbo Pascal 3.0 required to edit source code.

SIDEKICK* Minimum memory: 128K.

TRAVELING SIDEKICK* Minimum memory: 256K.

SUPERKEY* Minimum memory: 128K.

*For IBM PC, AT, XT, PCjr and true compatibles only, running PC/MS-DOS 2.0 or later.



COMPLETELY NEW VERSION!

Turbo Tutor® 2.0

Just released (July '86), the new Turbo Tutor can take you from "What's a computer?" on through to complex data structures, assembly languages, trees, tips on writing long programs in Turbo Pascal, and a high level of expertise. Source code for everything is included. New split screens allow you to put source text in the bottom half of the screen and run the examples in the top half. There are quizzes that ask you, show you, tell you, teach you. You get a 450-page manual—which is not as daunting as it sounds, because unlike many software manuals, it was not written by orangutans. (With our all "almost-free" upgrade, you can upgrade to Turbo Tutor 2.0 by sending us your master diskettes, proof of purchase, and $10.00, which covers shipping and handling.) Suggested retail: $39.95.

NEW SPECIAL!

Turbo Pascal® 3.0

"*For the IBM PC, the benchmark Pascal compiler is undoubtedly Borland International's Turbo Pascal,*" says Gary Ray of *PC Week*. We and more than 500,000 other people around the world think Mr. Ray got that right. Since launch, Turbo Pascal has become the *de facto* worldwide standard in high-speed Pascal compilers. Described by Jeff Duntemann of *PC Magazine* as the "*Language deal of the century,*" Turbo Pascal is now an even better deal than that—because we've *included* the most popular options (BCD reals and 8087 support). What used to cost $124.95 is now only $99.95! You now get a lot more for a lot less: the compiler, a completely integrated programming environment, and BCD reals and 8087 support—all for a suggested retail of only $99.95.

Turbo Editor Toolbox™

Recently released, we called our new Turbo Editor Toolbox a "construction set to write your own word processor." Peter Feldmann of *PC Magazine* covered it pretty well with, "*A 'write your own word processor' program for intermediate level programmers, with lots of help in the form of prewritten procedures covering everything from word wrap to pull-down windows.*" Source code is included, and we also include MicroStar, a full-blown text editor with pull-down menus and windowing. It interfaces directly with Turbo Lightning to let you spell-check your MicroStar files. Jerry Pournelle of *BYTE* magazine said, "*The new Turbo Editor Toolbox is the Turbo Pascal source code to just about anything you ever wanted a PC-compatible text editor to do.*" Suggested retail: $69.95.

Borland's Business Productivity Programs:

Reflex: The Analyst™ Analytical database manager. Provides complete new look at data normally hidden by programs like 1-2-3® and dBASE.® Best report generator for 1-2-3.

NEW! **Reflex Workshop™** Important new addition to Reflex: The Analyst. Gives you 22 different templates to run your business right.

SideKick® Complete RAM-resident desktop management includes notepad, dialer, calculator and more.

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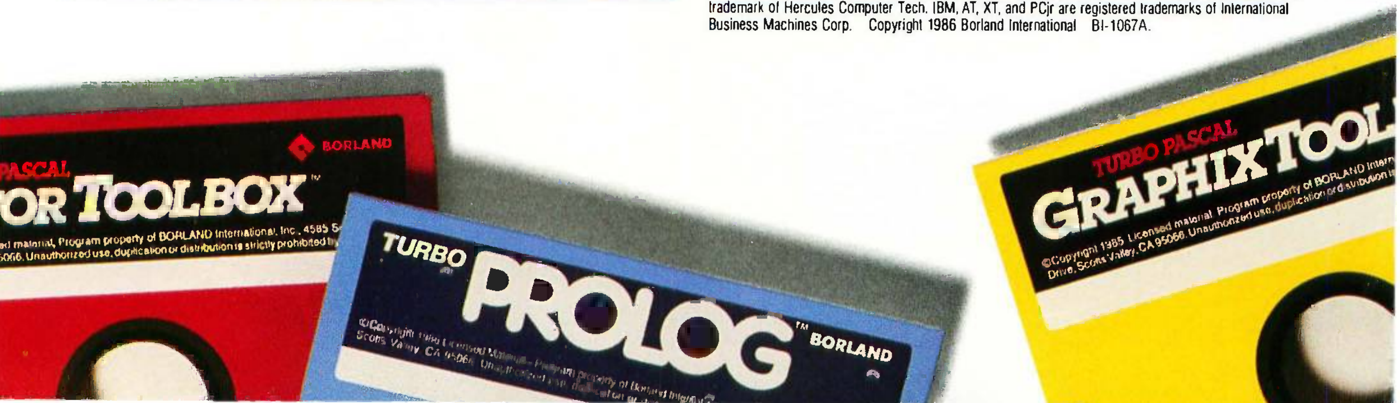
Borland's Electronic Reference Programs:

Turbo Lightning™ Works with all your programs and checks your spelling *while you type*! Includes 80,000-word Random House® Concise Dictionary and 50,000-word Random House Thesaurus. Forerunner of Turbo Lightning Library.

Lightning Word Wizard™ Includes ingenious crossword solver and six other word challenges. If you're into programming, Lightning Word Wizard is also a development toolbox and the technical reference manual for Turbo Lightning.



News from Borland International! Vol. 1 No. 1

We frequently surprise people with inventive, imaginative software, and people frequently surprise us with the way *they* use it.

For example, you'll read on this page how Michael J. Watkins of the Petroleum Technology Center in Houston, Texas, used Turbo Pascal® (and Turbo Graphix Toolbox™ and Turbo Tutor®) to cut down the tedium and time in creating Circular Performance Profile Charts (CPPCs).

We didn't know they existed, but you learn something new every day!

Applications like CPPCs might not fit your exact needs, but at the same time they might stimulate fresh ideas in your mind about how you can put Turbo Pascal and the Turbo Pascal family to work for you.

And thank you for your interest in and support for Borland International.

Philippe Kahn,
President, Borland International

INSIDE STORIES!

- ■ Turbo Pascal 3.0, already described by *PC Magazine* as *"Language deal of the century,"* is now an even better deal than that, because we've included the most popular options (BCD reals and 8087 support). What used to cost $124.95 is now only $99.95!
- ■ Completely new Turbo Tutor 2.0 now available. New software. New manual. New split screens. New quizzes. Only $39.95. Upgrades available under Borland's "Almost-Free" upgrade plan. Details inside.

LATE NEWS!

- ■ June/July Special Artificial Intelligence Issue of The *Micro Technical Journal* says, *"Turbo Prolog looks like it's going to be a winner, for both the beginner and professional programmer."*

Turbo Pascal deliberately programmed to go around in circles

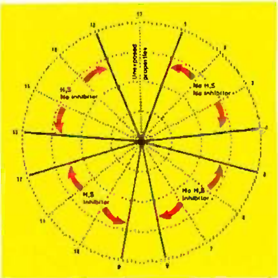
Circular charts (or CPPCs) are used by Michael J. Watkins of the Petroleum Technology Center in Houston, Texas, to plot a single performance property for a large number of elastomers, which have elastic, rubber-like properties.

Mr. Watkins wrote us saying, "*Because CPPCs condense a lot of data in one graphic, they can be very tedious and time-consuming to draw.*"

What he did to solve those problems was to write a Turbo Pascal program for IBM® personal computers to "*generate these charts quickly and easily.*"

He used Turbo Pascal "*because it has a companion set of very powerful graphics programs (Turbo Graphix Toolbox) which greatly simplifies the required programming.*

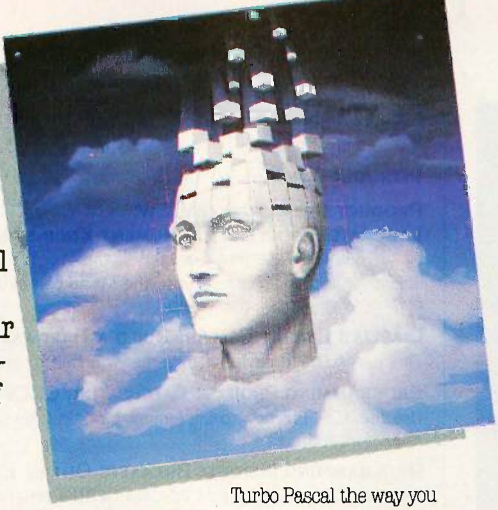
Turbo Pascal is not a difficult language to use and can be easily learned by persons who can program in FORTRAN or BASIC. An excellent tutorial (Turbo Tutor) is available for the novice or experienced programmer. The Turbo Pascal products are also very moderately priced."



"The computer is no better than its program."
Elting Morison, author of "Men, Machines and Modern Times"

Step-by-step tutorial, demo programs with source code included!

Borland's new Turbo Prolog is the powerful, completely natural introduction to Artificial Intelligence



Prolog is probably one of the most powerful computer programming languages ever conceived, which is why we've made it our *second* language—and "turbo-charged" it to create Turbo Prolog.™

Our new Turbo Prolog, the natural language of **A**rtificial **I**ntelligence, brings supercomputer power to your IBM® PC and introduces you step-by-step to the fascinating new world of **A**rtificial **I**ntelligence. And does all this for an astounding $99.95.

Turbo Prolog is to Prolog what Turbo Pascal® is to Pascal!

Our Turbo Pascal astonished everyone who thought of Pascal as "just another language." We changed all that—and now Turbo Pascal is the de facto worldwide standard, with hundreds of thousands of enthusiasts and users in universities, research centers, schools, and with professional programmers, students, and hobbyists.

You can expect at least the same impact from Turbo Prolog, because while Turbo Prolog is the most revolutionary and natural programming language, it is also a complete development environment—just like Turbo Pascal.

Minimum memory: 384K

> "Turbo Prolog offers generally the fastest and most approachable implementation of Prolog."
>
> Darryl Rubin, *AI Expert*

Even if you've never programmed before, our free tutorial will get you started right away

You'll get started right away because we have included a complete step-by-step tutorial as part of the 200-page Turbo Prolog Reference Manual. Our tutorial will take you by the hand and teach you everything you're likely to need to know about Turbo Prolog and artificial intelligence.

For example: once you've completed the tutorial, you'll be able to design your own expert systems utilizing Turbo Prolog's powerful problem-solving capabilities.

Think of Turbo Prolog as a high-speed electronic detective. First you feed it information and teach it rules. Then Turbo Prolog "thinks" the problem through and comes up with all the reasonable answers—almost instantly.

If you think that this is amazing, you just need to remember that Turbo Prolog is a 5th-generation language—and the kind of language that 21st century computers will use routinely. In fact, you can compare Turbo Prolog to Turbo Pascal the way you could compare Turbo Pascal to machine language.

You get the complete Turbo Prolog programming system for only $99.95

You get a complete Turbo Prolog development system including:

- The lightning-fast Turbo Prolog incremental compiler and the interactive Turbo Prolog editor.
- The 200-page reference manual which includes the step-by-step Turbo Prolog tutorial.
- The *free* GeoBase™ natural query language database including commented source code on disk—ready to compile. GeoBase is a complete database designed and developed around U.S. geography. It includes cities, mountains, rivers, and highways, and comes complete with natural query language. Use GeoBase immediately "as is," or modify it to fit your own interests.

So don't delay—don't waste a second—get Turbo Prolog now. $99.95 is an amazingly small price to pay to become an immediate authority—an instant expert on artificial intelligence! The 21st century is only one phone call away.

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Prices include shipping to all US cities.

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*Limited Time Offer until September 1, 1986.

**YES, if within 60 days of purchase you find that this product does not perform in accordance with our claims, call our customer service department and we will gladly arrange a refund.

Prices subject to change without notice.

Turbo Prolog 1.0 Technical Specifications

Compiler: Incremental compiler generating native in-line code and linkable object modules. The linking format includes a linker and is compatible with the PC-DOS linker. Large memory model support. Compiles over 2500 lines per minute on a standard IBM PC.

Interactive Editor: The system includes a powerful interactive text editor. If the compiler detects an error, the editor automatically positions the cursor appropriately in the source code. At run-time, Turbo Prolog programs can call the editor, and view the running program's source code.

Type System: A flexible object-oriented type system is supported.

Windowing Support: The system supports both graphic and text windows.

Input/Output: Full I/O facilities, including formatted I/O, streams, and random access files.

Numeric Ranges: Integers: −32767 to 32767; Reals: 1E−307 to 1E+308.

Debugging: Complete built-in trace debugging capabilities allowing single stepping of programs.

Inquiry 49 for End-Users. Inquiry 50 for DEALERS ONLY.

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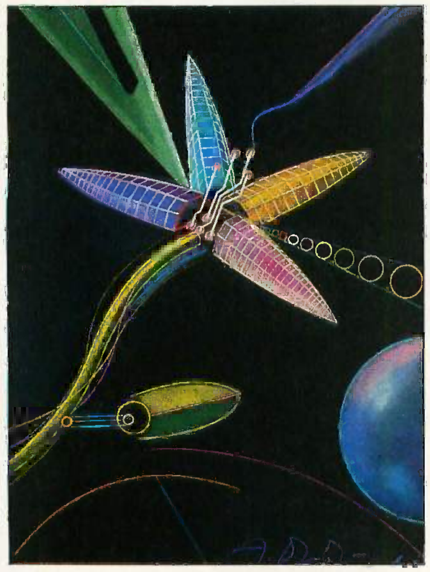

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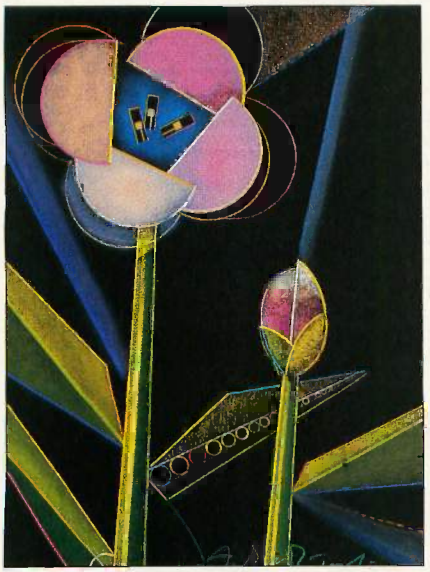

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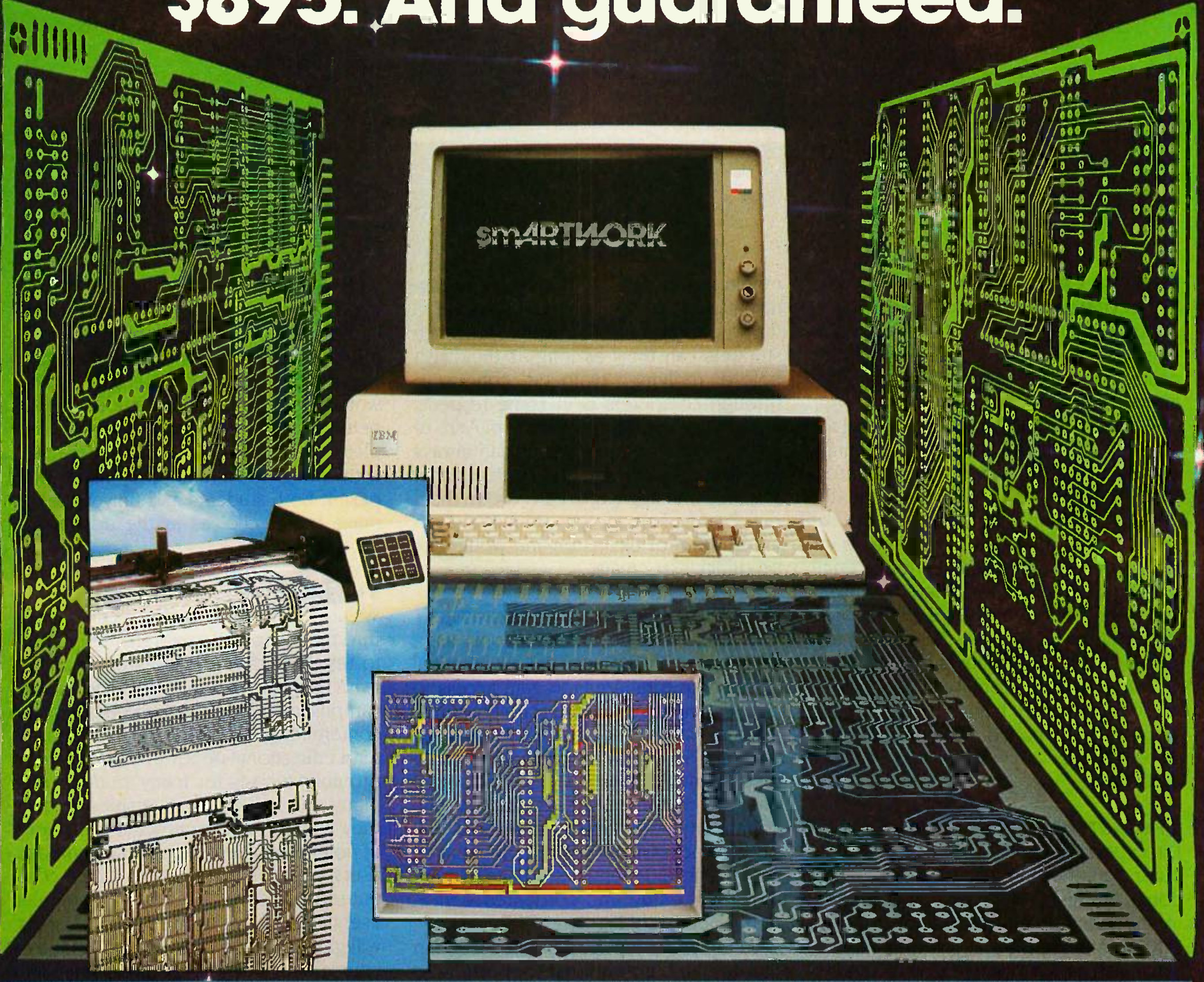

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EDITORIAL

COLLEGE CREDITS THROUGH TELECOMMUNICATIONS

We urge colleges and universities to expand the practice of granting credits for courses taught through computer conferencing.

We have become aware of the need for computer-mediated instruction because BYTE's offices are located in a rural area. In order to advance professionally, members of our staff often need to take university courses to increase their knowledge of computer science or engineering. Unfortunately, we have no universities in easy commuting range that offer broad curricula in these fields of study. Some of our staff members have endured long commutes to continue their studies, but work loads are high at BYTE, and few employees can both do their jobs well and undertake regular university studies at distant sites.

THE INSTRUCTIONAL MEDIUM

Direct observation has shown us that computer conferencing works as an instructional medium. We have seen tutorial topics spring up in many conferences on BIX. People learn about programming a new machine, for example, from volunteer teachers in distant areas. Sessions have the quality of free and open classroom discussions. The lack of face-to-face contact has not proved to be a hindrance.

We also know that instruction by computer conferencing has already worked in a university. The New School for Social Research, through an association with Connect Ed, has already taught graduate courses in media studies. Connect Ed uses the EIES conferencing software developed at the New York Institute of Technology by Murray Turoff. Some members of the BYTE staff visited the New School last year and spoke with students and teachers in the New School/Connect Ed program. All agreed that the system works. In their program, computer conferencing is supplemented by some actual classes. The requirement of occasional classes on campus is much less daunting than a long commute several times each week.

From the teacher's perspective, computer conferencing has some advantages as an instructional medium. It is easy to monitor attendance and to measure participation. Questions can be addressed to the whole class or to an individual. Since students can think as long as they wish before replying, dialogue conducted through computers is in some respects easier than spoken conversation. And, of course, shy and quiet people can always have their say in computer conferencing. The loud and aggressive can't drown them out. Examination tools to simplify the administration of exams on-line would not be difficult to create.

NEW EDUCATIONAL OPPORTUNITIES

The use of telecommunications as a means of instruction can enable potential students in rural areas to gain access to outstanding teachers and scholars at major universities. If computer conferencing software is used, students can enjoy discussion and debate with students from different regions and backgrounds. The community of higher education will become accessible from remote areas as never before. Potential students in rural areas will enjoy unprecedented educational opportunities.

Moreover, computer conferencing can make many educational opportunities now beyond commuting range available to everyone. Even the opportunities available to those in urban areas will increase.

COST ADVANTAGES

Sadly, the cost of higher education has now become prohibitive for many people. Instruction through computer conferencing can alleviate this situation by reducing expenses for both the university and the student. Universities will be able to add more students without building more dormitories and classrooms. The student can continue to live at home, incurring no new room and board expenses. This will effectively reduce the student's expenses to the amount of tuition, which can be exactly the same for on-line students as for on-campus ones. With tuition remaining the same, the university will experience no loss of revenue.

COMBINED STUDY

It seems likely that universities will be able to combine on-line instruction with on-campus instruction to provide improved courses. Daily on-line instruction could be supplemented by on-campus instruction—perhaps one or two Saturdays per month. Another intriguing possibility would be letting on-line students compete for on-campus scholarships to complete their studies. On-line interaction with prospective students might also permit both students and universities to make better choices in the admissions process.

THE BIG STEP

We urge universities to offer credit courses through computer conferencing in order to test the limits of the medium and to learn how best to combine on-line and on-campus instruction. We believe computer conferencing can help preserve and extend educational opportunity in a time of prohibitive costs for many students and many universities. If universities do this, they will open their curricula to millions of potential students—personal computer users everywhere. Through their computers and modems, personal computer users, even those located in rural areas, will gain access to an enormous range of courses. Let's hope that universities and accrediting associations will seize this opportunity to extend educational programs.

—*Phil Lemmons*
Editor in Chief

Update on Availability of Listings

This issue contains postage-paid cards for ordering source code listings on disk or in print. You can order individual disks or take out an annual subscription. While the postage-paid cards and our agreement with a disk fulfillment service will make ordering more convenient, they will also add to our costs. As a result, we have had to raise prices. Previously, IBM and other available 5¼-inch disks were priced at $5 each, or $60 for the year. The IBM disks will now cost $8.95 each, or $69.95 for the year. Pricing for other available disks is stated on the order cards.

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MICROBYTES

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

Philips Working on WORMs Compatible with CD-ROMs

Philips Subsystems and Peripherals (New York City) is working on a new type of write-once read-many (WORM) optical disk drive that will be compatible with CD-ROM optical disks. Philips calls the new disks CD-PROMs and says that the disks will store the same amount of data (540 megabytes), formatted in the same way, as CD-ROM disks. CD-PROMs are more than a year away from commercial availability.

Currently, most small write-once optical disks are 5.5 inches in diameter (compared to the 4.7 inches of the CD-ROM disk) and can store only 100 to 200 megabytes per side. What will differentiate CD-PROM disks from standard CD-ROM disks is the manner in which the bits of information are stored. On a normal CD-ROM disk, the bits are stored as pits in the medium. On the CD-PROM disk, the bits are stored as phase changes in the medium.

Philips is working on a drive that not only reads and writes the new CD-PROM disks but can also read regular CD-ROM disks. One problem is the sizable amount of processing required for the error-correction techniques CD-ROM disks need (see May BYTE, page 164).

Another problem is that CD-PROM disks are more delicate than CD-ROM disks, which are relatively impervious to normal wear and tear. Philips is proposing to other manufacturers a disk cartridge designed to protect CD-ROM and CD-PROM disks.

The CD-PROM drives may be useful for archival purposes or for publishing large amounts of information in small quantities—that is, quantities not cost-effective for regular CD-ROM publishing. Another possible application will be for companies that want to test prototype CD-ROM disks before mass-producing them.

The cartridge for the CD-ROM disks will probably be introduced at the Fall COMDEX show. Samples of the CD-PROM drives will probably not be ready until the second half of next year. Production units will most likely not be available until 1988. Philips expects the drives to cost less than $1000, and the disks somewhere under $100.

The Terabytes Are Coming, the Terabytes Are Coming

Remember when a gigabyte was an unbelievably large quantity of data? Well, now a Dutch company named DOCdata is planning an optical tape drive that can store 1 terabyte—that's 1000 gigabytes—of data. The device, called the DOCwheel, uses 128 optical data cassettes arranged in a wheel; it has a footprint of approximately 3 square feet. The DOCwheel will supposedly be able to access any file on any cassette in an average time of 10 seconds.

Each cassette is approximately the same size as a standard audio cassette, measuring 4.4 by 2.2 by 0.6 inches. With a data capacity of up to 8 gigabytes, the cassette's ratio of data capacity to volume is said to be 30 times that of an optical disk. For durability, the cassette has a steel casing and is hermetically sealed to keep out dust.

The DOCwheel and the smaller DOCreader, which can read only one cassette, are designed to be used with large systems and will be plug-compatible with existing magnetic tape drives, DOCdata said. Although the system uses write-once optical tape, DOCdata does not think this will be an impediment, since most magnetic tape is used in a similar way (that is, magnetic tape is written on once and might later be recycled, but it is rarely updated).

Both devices are scheduled to be available commercially in 1987. DOCdata N.V. can be reached at P.O. Box 1021, Maaskade 11, 5900 BA Venlo, The Netherlands, (0) 77-544100.

Colorado Crystals Changing Face of Display Technology

A new type of liquid-crystal device has been designed by a physics professor at the University of Colorado in Boulder and a colleague from Sweden's Chalmers Technical University. The device, called an electro-optic light valve, uses a ferroelectric liquid crystal between closely spaced glass plates. It's described as being much faster than liquid-crystal light valves currently in use. In large arrays, the ferroelectric crystals can provide display screens that have inherent memories.

(continued)

The Colorado professor, Noel Clark, says that when voltage is applied, the valves change color in less than a microsecond. According to Clark, who with Sven T. Lagerwall has patented the technology, the crystals provide a high-speed electrically operated light valve with built-in memory.

Clark said that because the technology offers very fast switching times, it could be used in shutters that respond in less than a microsecond, in high-speed switches for fiber optics, and in optical modulators. Another possibility Clark cited is optical printers, which he called "fast and inexpensive enough to make laser printers obsolete."

Along with David Walba, a chemistry professor who helped synthesize the new crystals, Clark set up a Boulder-based firm that's selling the ferroelectric crystal materials.

GaAs Chip Passes Test As Microprocessor

McDonnell Douglas (Huntington Beach, CA) has built a gallium arsenide chip for use as a microprocessor and claims it's the first such chip to be tested successfully. The MD2901 "contains the logic elements to process information, not just to store it," said Bill Geideman, microprocessor program manager at McDonnell Douglas. "It would form the brains of a gallium arsenide computer." Gallium arsenide as an IC material is noted for its speed, resistance to natural radiation, and use of less power than silicon chips.

Geideman said the new chip, a bit-slice processor, is "tested and fully functional." It emulates the AMD2901 and could run the same software. The 4-bit chip measures one-eighth inch square, contains 1860 transistors, and uses 135 milliwatts of power.

Geideman said he hopes to assemble a 16-bit computer using the new architecture and several other chips. The company said it is developing a 32-bit GaAs microprocessor.

And Jessica Had Amnesia, and Dorian Really Wasn't Dead, and...

A computer science professor at Columbia University (New York City) is working on a program designed to generate plot outlines for soap operas. The program, called Universe, can currently generate only a few outlines. But professor Michael Lebowitz thinks he can get the program to generate a significant variety of plots by expanding its knowledge base to a size approximately two orders of magnitude larger than its present dimension.

To design the program, Lebowitz monitored one soap opera, "Days of Our Lives," and noticed some patterns. For example, there is usually some force keeping lovers apart. In a two-year period, Lebowitz counted three dead spouses who turned out to be alive, four lovers who died (at least temporarily), and three lovers who contracted some type of disease (one of which, of course, was amnesia).

Universe is being written in LISP and is now running on a DEC 20 mainframe, although Lebowitz says it could easily run on an IBM PC AT. Lebowitz predicts that the program will probably not replace scriptwriters but says it may be useful as a scriptwriter's assistant.

Nanobytes

An industry source who recently dissected IBM's 3½-inch external disk drive (introduced in April and available for the PC, PC XT, and PC AT) says the drive itself is a 2-megabyte drive, from **Alps Electric USA**, that could be formatted for as much as 1.4 megabytes of data, instead of its current capacity of 720K bytes. This leads to speculation that a new version of PC-DOS will enable users to exploit the full 1.4 megabytes, which would provide incentive to switch from 360K 5¼-inch drives to the new microfloppies. . . . **Phoenix Technologies Ltd**. (Norwood, MA) and **Interactive Systems Corp**. (Santa Monica, CA) have agreed to jointly develop software designed to provide a "virtual" PC environment under UNIX System V version 3.0 for computers based on the Intel 80386 microprocessor. The V86/ix (an internal name) software would allow PC-compatible DOS applications to run as a task under UNIX without modification. . . . **The Association of Independent Microdealers** (Peoria, IL) has formed a special interest group called the Computer Musicians Cooperative, aimed at bringing together computer dealers, music dealers, manufacturers, and people who are interested in computer music. . . . **The U.S. Naval Observatory** (Washington, DC) is planning to put out a disk of astronomical information for professional and amateur star-watchers, navigators, meteorologists, engineers, and other people who want to know what's happening in the heavens. The Floppy Almanac will run on MS-DOS machines. . . . **NSI Logic Inc**. (Marlboro, MA) has integrated five graphics standards on one chip. The user-programmable EVC (Enhanced Video Controller) -315 can emulate the Color Graphics Adapter, the Monochrome Display Adapter, the Enhanced Graphics Adapter, the Hercules Graphics Controller, and the Professional Graphics Adapter.

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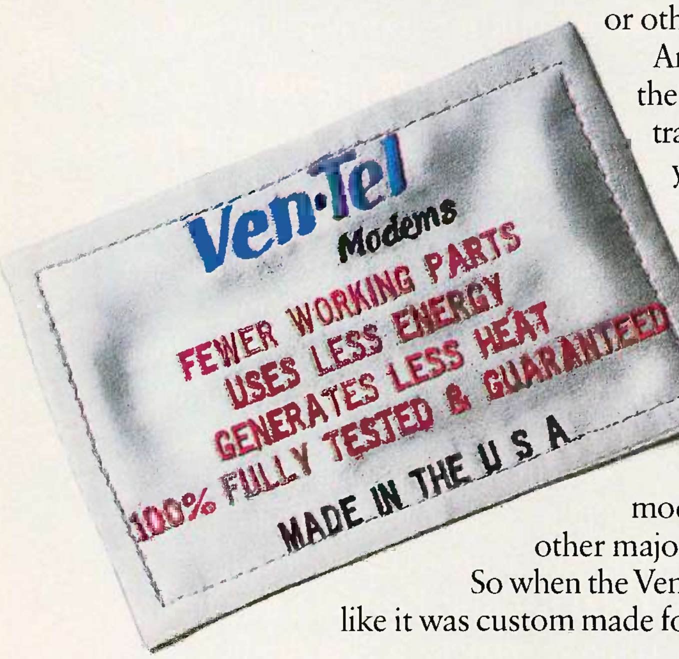

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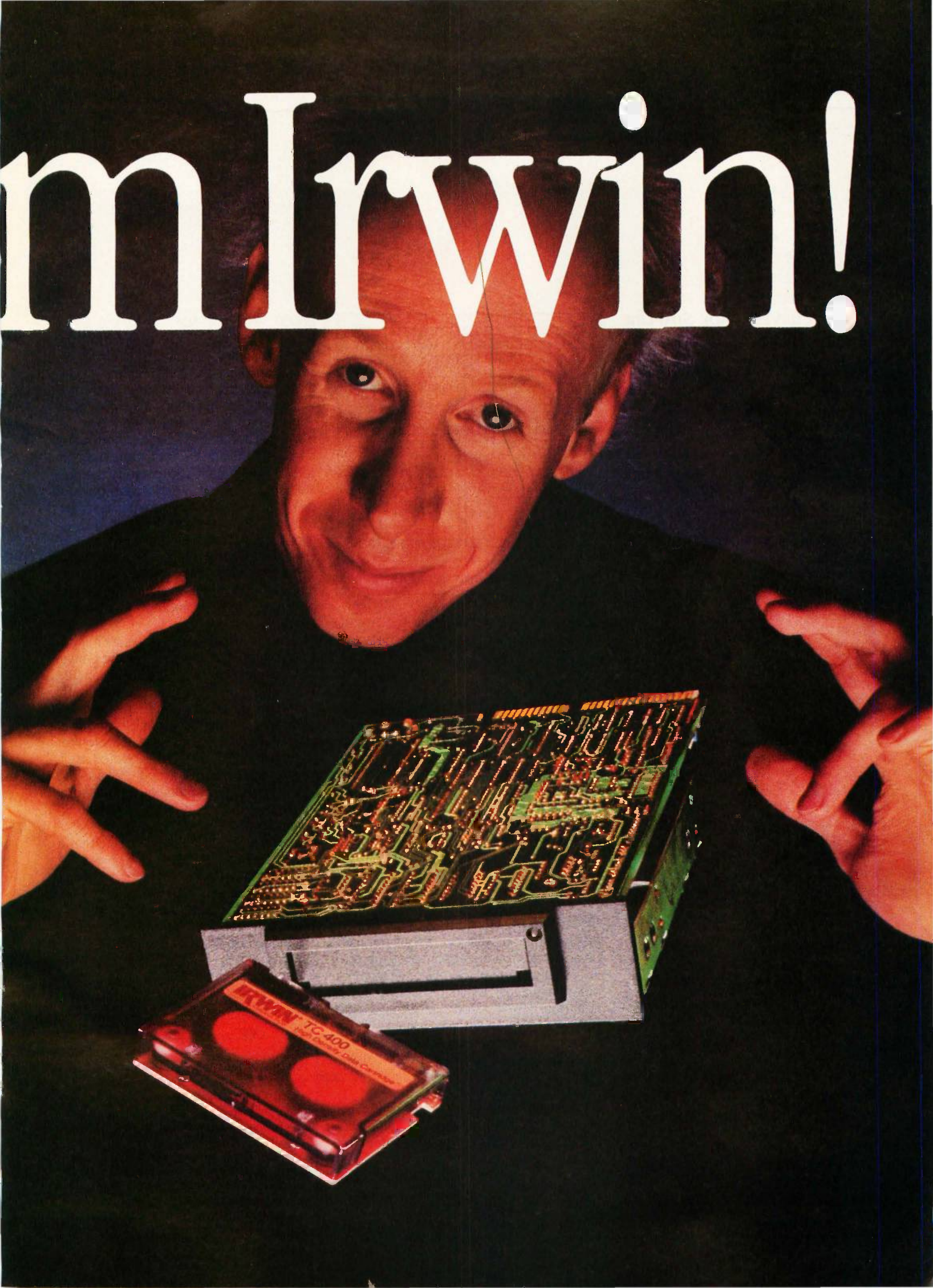
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HILBERT CURVES MADE SIMPLER

Thank you for June's Programming Insight, "Hilbert Curves Made Simple." I was not familiar with these elegant designs. It seemed to me, however, that the Hilbert curve would lend itself to simpler, more self-evident instructions in the Logo language rather than in BASIC.

After reviewing Michael Ackerman's article, I sat down with Apple Logo II and taught the turtle that Hilbert curves, regardless of complexity, were simply right-hand curves and left-hand curves that alternate in a constant, recursive pattern. I carefully explained to the turtle that these curves could be generated with only three procedures and two variables:

```
TO HILBERT :ORDER :SIZE
PENUP
SETPOS [-125 115]
SETHEADING 180
PENDOWN
CURVRIGHT :ORDER
END

TO CURVRIGHT :ORDER
IF :ORDER = 0 [STOP]
LEFT 90
CURVLEFT :ORDER - 1
FORWARD :SIZE
RIGHT 90
CURVRIGHT :ORDER - 1
FORWARD :SIZE
CURVRIGHT :ORDER - 1
RIGHT 90
FORWARD :SIZE
CURVLEFT :ORDER - 1
LEFT 90
END

TO CURVLEFT :ORDER
IF :ORDER = 0 [STOP]
RIGHT 90
CURVRIGHT :ORDER - 1
FORWARD :SIZE
LEFT 90
CURVLEFT :ORDER - 1
FORWARD :SIZE
CURVLEFT :ORDER - 1
LEFT 90
FORWARD :SIZE
CURVRIGHT :ORDER - 1
RIGHT 90
END
```

The first procedure, HILBERT, tells the turtle where to start and that the largest pattern will be that of a right-hand curve. The other two procedures (CURVRIGHT and CURVLEFT) show the turtle how to make right- and left-hand curves and where to make the little side trips.

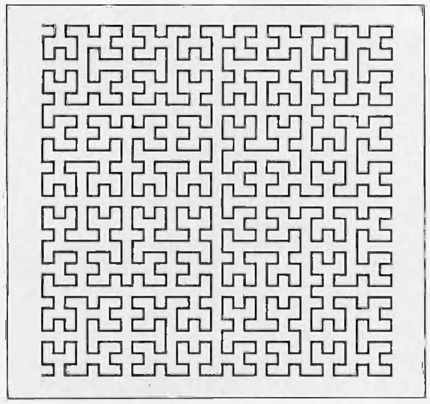

Figure 1: *Hilbert curve with Logo.*

The symmetry of the curve is suggested in the palindromic nature of the two mirror-image procedures. The swapping of right and left turns is built in. Even to those unfamiliar with programming, this Logo program conveys how complex designs (like figure 1 above) can be generated by a few simple, understandable instructions.

MARK D. WIDOME
Hershey, PA

IN DEFENSE OF AMIGA

Much of the "discussion" about popular personal computers approaches the fervor usually reserved for religion (and computer languages). While it is not my intention to turn BYTE readers into Amiga converts, the misinformation in Ronald Miller's comments in the June Letters column ("Putting the Amiga to Good Use," page 14) cries out for clarification.

Specifically, Mr. Miller:

- Based his opinions on a conversation he had with one dealer. I know a dealer who worships the Osborne 1 and has little use for anything else.
- Concludes that the IBM PC's 8087 chip is faster and more precise for numerical work than the 68881. BYTE readers should keep in mind that the 68881 is to the 68000 what the 8087 is to the 8088. Would it be fair of me to say that the 68881 runs rings around the 8087 for accuracy and speed? Astute readers will also notice that the IBM PC does not come with the 8087. In both machines the math coprocessor is an add-on.
- Worries about RAM glitches corrupting his data. While this is not a meritless concern, it is minuscule compared to the possibility of a "bad bit" (or worse) on your disk, where far more information is stored. Memory errors seldom happen; disk errors happen too often. It is much more critical to have a file system that helps you recover from disk errors. AmigaDOS may well be the most secure file system on any personal computer, just for this reason.

A recent experience comes to mind: I was compiling a program on the Amiga while a friend sat next to me using an IBM XT. As I got up to stretch, I inadvertently kicked the power strip where the two computers were plugged in, flickering power off for a split second. The XT monitor flashed, then the machine rebooted itself. The Amiga monitor flashed. Period. The disk drive kept on spinning, and the compile finished normally. Which machine do I want to keep my database on?

- Is amazed at how bad the 80-column text is and suspects that a font change would fix that. Correct. In fact, the Amiga fonts are not generated by a character generator chip; all fonts are changeable. The Sidecar (Amiga PC-compatible add-on) font looks just like the IBM PC font, for example.
- Rules out the machine as a word processor because it does not have monochrome video output. I don't now how this

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could help. I am typing this letter on the Amiga, which (at the moment) has a black screen with amber letters (and a white cursor so I can always find it quickly, and blue depth-arranger icons, too, but that's beside the point) and a custom font. I have often sat here for hours and have never developed a headache from the display. A nice long-persistence monitor and my 50-line word processor work very well together, thank you.

- Dismisses the Amiga from being a "real graphics" machine without explanation. If he means it's not a $30,000 dedicated graphics processor, I see his point. Similarly, Mr. Miller asserts that it cannot be used for image processing work because it does not have 1K by 1K by 256 capability.

First, no personal computer fits these descriptions, save those that have been enhanced with third-party add-on boards. Second, for those who can't afford to do "real graphics" on a $30,000 system, a quarter of the functionality can be had for 5 percent of the price. Third, the *hardware* in the Amiga 1000 doesn't have 1K by 1K by 256 capability (yet), but the *software* has always had the capability.

- Asks the question, "What is an Amiga good for?" My mother asks that about all personal computers. For the amount of time and money we shovel into these glorified hobbies of ours, could we really justify them? Ten years from now we might come across an old issue of BYTE and remember what religions (machines, languages, text editors) were then. And laugh.

Bob Page
Andover, MA

SMALLTALK AND SPACE BLANKETS

As a developer of object-oriented languages and a Smalltalk fan, I read with great interest I. Ganapathy's letter in the June issue ("Problems with Smalltalk," page 24). I have to agree that Smalltalk-80's windowing problems are significant and a real drawback to anyone hoping to write an application and release it to inexperienced users.

Part of the problem is that getting Smalltalk's windows to work well on smaller machines would have required a great deal of optimization and recoding in machine language. This obviously makes the language far less portable and gives pause to any potential implementor.

Another part of the problem is the nature of Smalltalk's genesis. Smalltalk was developed in a research branch of Xerox and will never be a significant profit center. Since Smalltalk is hardly relevant to Xerox's corporate survival, there isn't the

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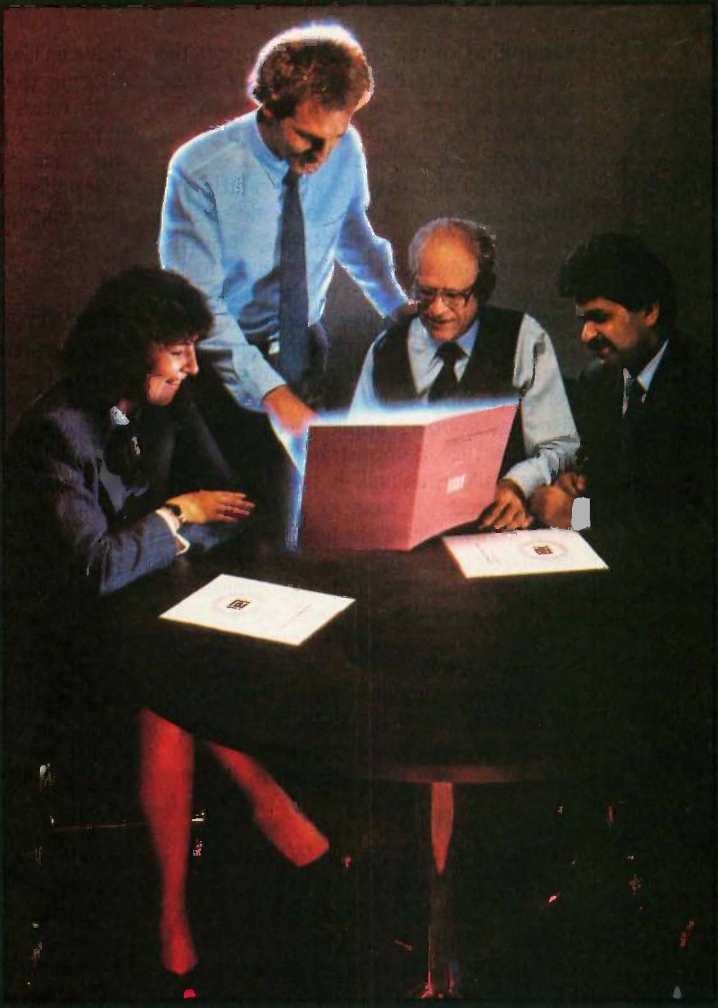
Inquiry 269

The source of Wizardry. . .



Throughout history people have sought the aid of wizards to advise and direct them through the mysteries of the age. These powerful beings were believed to be the purveyors of supernatural substances, the weavers of secret spells, and keepers of a magic lore. Today we know what was once magic is simply a combination of knowledge and ability–the ability to manipulate an environment and solve its most difficult problems.

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same kind of motivation to support the language with new releases. I'm sure Smalltalk is extremely important to the group at PARC, but their raison d'être is research, not technical support.

This may also explain why so little emphasis was placed on "cosmetic" issues such as clean, fast windowing. It seems that more attention has been given to the underlying elegance of the language than to the external features. Many of the windowing problems have been addressed in Smalltalk systems used internally at Xerox. As of a couple years ago, however, these fixes had not been applied even to the system used for demonstrations.

Ironically, Smalltalk is the system that popularized windows in the first place. Now that windows are hot, Smalltalk has been outclassed by hungrier, more profit-minded competitors in the commercial marketplace. Nevertheless, we all owe Smalltalk and Xerox PARC a tip of the hat for many innovations that are just now finding their way into the mainstream of personal computing. I suppose it's kind of like NASA and space blankets.

Charles B. Duff
Evanston, IL

LINKING DATA FLOW WITH DEVILED HANDS

I found "Linking Data Flow and Functional Languages" (by Chris Hankin, David Till, and Hugh Glaser, May) enlightening, but I had trouble getting used to the notation used in the data flow diagrams. To make reading data flow diagrams easier for novices like me, I would like to suggest replacing the symbols used in the article with more informative icons.

Figure 2 below shows the symbols for the basic operators and the apply node. I designed the icons to make the point that they can make learning easier.

Steve Metsker
Portland, ME

ITERATIVE VS. NONITERATIVE INVERSION

Several correspondents have pointed out something to me that should have been made clear in my article ("Inversion of Large Matrices," April) and was not; namely, for serial processing—meaning home computers—any iterative method of matrix inversion, such as Pan-Reif, is far inferior in speed and memory economy to established noniterative inversion-in-place methods such as Gauss-Jordan. Computations sent to me by Alfred Allen of Victoria College in Victoria, Texas, for example, show a speed advantage of the latter methods using compiled BASIC, over the program I gave using interpreted BASIC, by factors of 20 to 40 or even more.

To exploit the Pan-Reif "breakthrough," one has to be serious about needing speed in the inversion of very large matrices. This means investing sizable sums of money in parallel processing hardware.

On consulting the references I gave, one finds the following: Let $M(n)$ be the

(continued)

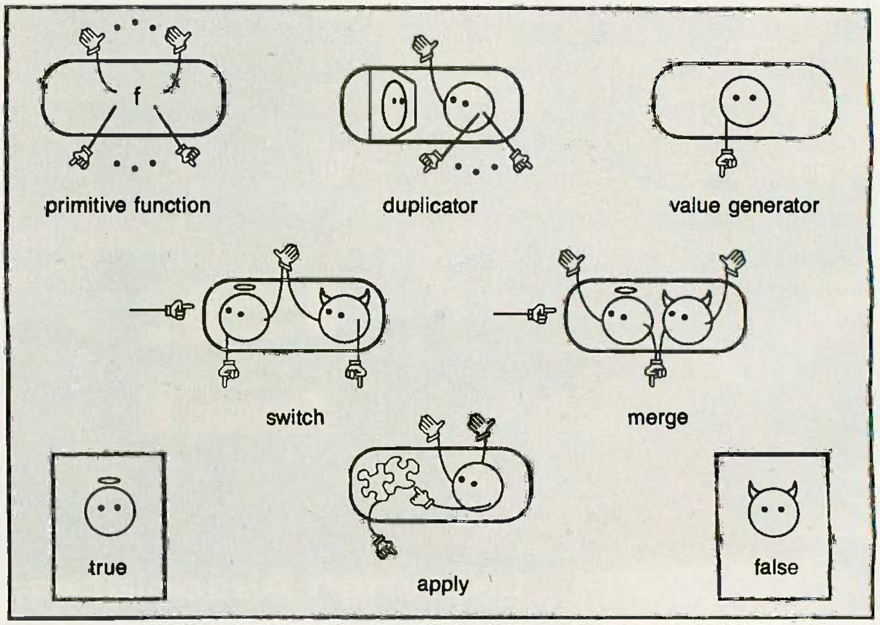

Figure 2: *Truth, Falsity, the basic operators, and the apply node.*

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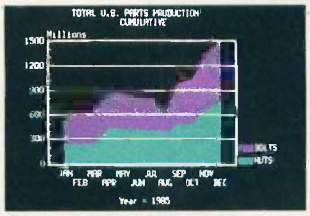

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number of parallel processors required to multiply two $n \times n$ rational-number matrices in total time of the order of the logarithm of n, written $O(\log n)$. Prior to Pan-Reif, the most efficient known algorithms for inverting a nonsingular $n \times n$ matrix required $O(\log^2 n)$ time and $M(n) \times n^{1/2}$ processors. Moreover, all known algorithms of this "polylog-time" type were unstable—that is, they required calculations of perfect precision to yield any results at all.

The Pan-Reif algorithms, of which I gave a sample, are stable and forgiving of low-precision arithmetic and run in $O(\log^2 n)$ time with $M(n)$ processors, provided the matrix is not too poorly conditioned. The requirement is that the number denoting the "condition" of the matrix be less than n^k for some constant k. The elements of the inverse matrix are obtained with relative precision 2^{-t}, where $t = n^k$ for some constant k. It should be added that fast multiplication methods are involved—I presume in hardware.

Needless to say, any polylog-time algorithm is much faster than any power-of-n-time algorithm for large enough n. So, we are speaking of exciting progress from the standpoint of, say, the Department of Defense, which may not care what it costs to invert large matrices of data on incoming enemy missiles. BYTE readers are not in this category. Still, for anyone interested in iterations, it is intriguing to watch the algorithm at work—struggling away, gradually overcoming its difficulties . . . so much like the human mind at work on a problem that one is tempted to view the "thinking" process as some sort of iterative algorithm.

My intent in assigning both plus and minus entries to the random-entry A-matrix to be inverted was to show that the Pan-Reif method works for any real-number entries and is not limited to those of one sign. Incidentally, the REM at line 130 of my listing 1 is misleading in its reference to an alleged need to "input normalized data" in case a user-supplied matrix is to be inverted. Any real numbers can be input—they need not be normalized. In reference to numerical checks on the inversion, line 250 of the listing assures that no entry of the difference between the identity matrix and the matrix product $B \times A$ for $B \approx A^{-1}$ exceeds in magnitude some chosen small number—be it called a criterion or a tolerance. The routine at lines 500 to 610 makes a similar check for the reversed-order product $A \times B$. I am indebted to a former BYTE technical editor, Tom Clune, for the latter refinement.

THOMAS E. PHIPPS JR.
Urbana, IL

CRT RADIATION

I am writing in response to the letter from William G. Nabor ("CRTs Are Safe," May, page 24). As Mr. Nabor correctly asserts, CRTs do not emit significant amounts of ionizing radiation. They do, however, affect the concentration and trajectory of ions (charged particles) in the vicinity of the screen. The relative concentration of positive and negative air ions is known to have physiological effects on humans and animals. High concentrations of positive ions can cause irritability, increased susceptibility to respiratory infections, and fatigue. These effects are seen on a large scale during certain weather phenomena that increase the concentration of positive ions in the air, such as the Santa Ana wind in California or the Witch Wind in Israel, for example.

The positively charged screen of the CRT creates a region of high positive ion

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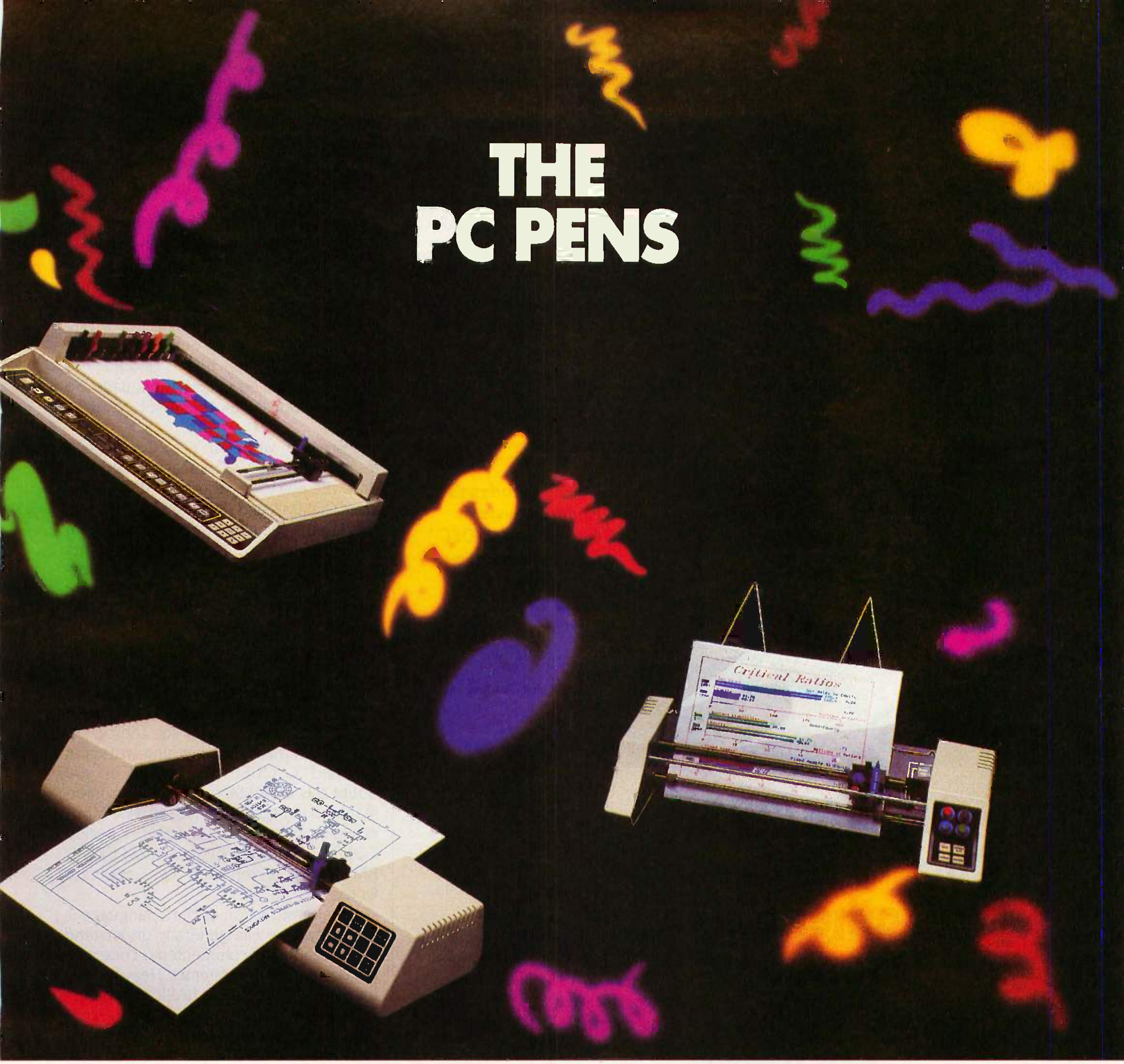

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Inquiry 164

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flux, in which the user's face is generally immersed. This could affect the health of users who are sensitive to ion concentrations. A grounded screen positioned in front of the surface of the CRT will reduce the flux of ions in the vicinity of the user. I have not seen the advertisement to which Mr. Nabor refers, but I suspect that the advertisers have confused the terms "ionizing radiation" and "ions."

WILLIAM L. COBB
Melrose, MA

EASY C: IS THE EASY WAY THE BEST WAY?

I much appreciate your continuing interest in the C language and the high caliber of BYTE's articles on C.

In "Easy C" (which appeared in the May BYTE), Pete Orlin and John Heath describe a set of mnemonic replacements for certain C operators, keywords, and syntactical elements. The intent was "to produce a version of C that is quicker to learn and apply."

This approach is undesirable for several reasons:

A programmer who learns Easy C will not be literate in standard C and will not be able to read fluently in the C literature. Does not communication require adherence to accepted rules of style (in this case the rules of standard C)? Is it not wrong to teach, "As with any question of style, subjectivity is the rule"? Should not changes in an established language be made cautiously, as the ANSI group is doing?

A program written in Easy C is difficult to read PERIOD Uppercase characters draw the eye to keywords COMMA operators COMMA and delimiters COMMA so moving the focus of attention away from the principal content of statements PARENTHESIS variables COMMA functions COMMA values COMMA etc PERIOD PARENTHESIS PERIOD In the examples given in figures 5 and 6 PARENTHESIS pages 146 and 148 PARENTHESIS COMMA it may be easier to follow the flow of the program in Easy C COLON but does not the eye of the reader more readily find the variables and see the operations upon them in something written in standard C QUESTION MARK If you doubt this COMMA try to scan for information a paragraph such as this COMMA in which punctuation EM DASH period COMMA comma COMMA etc PERIOD EM DASH is replaced by uppercase words.

A major attraction of the C language is its clarity. One can generally understand at first reading uncommented C code written by another programmer. Heavily commented FORTRAN and BASIC can be unreadable, even for the coder after a bit of time has gone by. As illustrated in the preceding paragraph, the introduction of uppercase mnemonics reduces the clarity of the C language. I am sensitive to this, perhaps because of having been compelled awhile ago to write a filter that helped maintain sanity by converting, back to standard C, code written in a version of C like Easy C.

An aesthetic point: I believe that much of the visual beauty of C code is lost when uppercase words replace sparse C tokens.

The use of #define statements to allow mnemonic replacements of standard C operators is found occasionally in the C literature, and the excellent Van Nuys Toolkit, placed in the public domain in 1983, was written in an Easy C–like dialect. Such attempts to change the form of C have not met with general acceptance.

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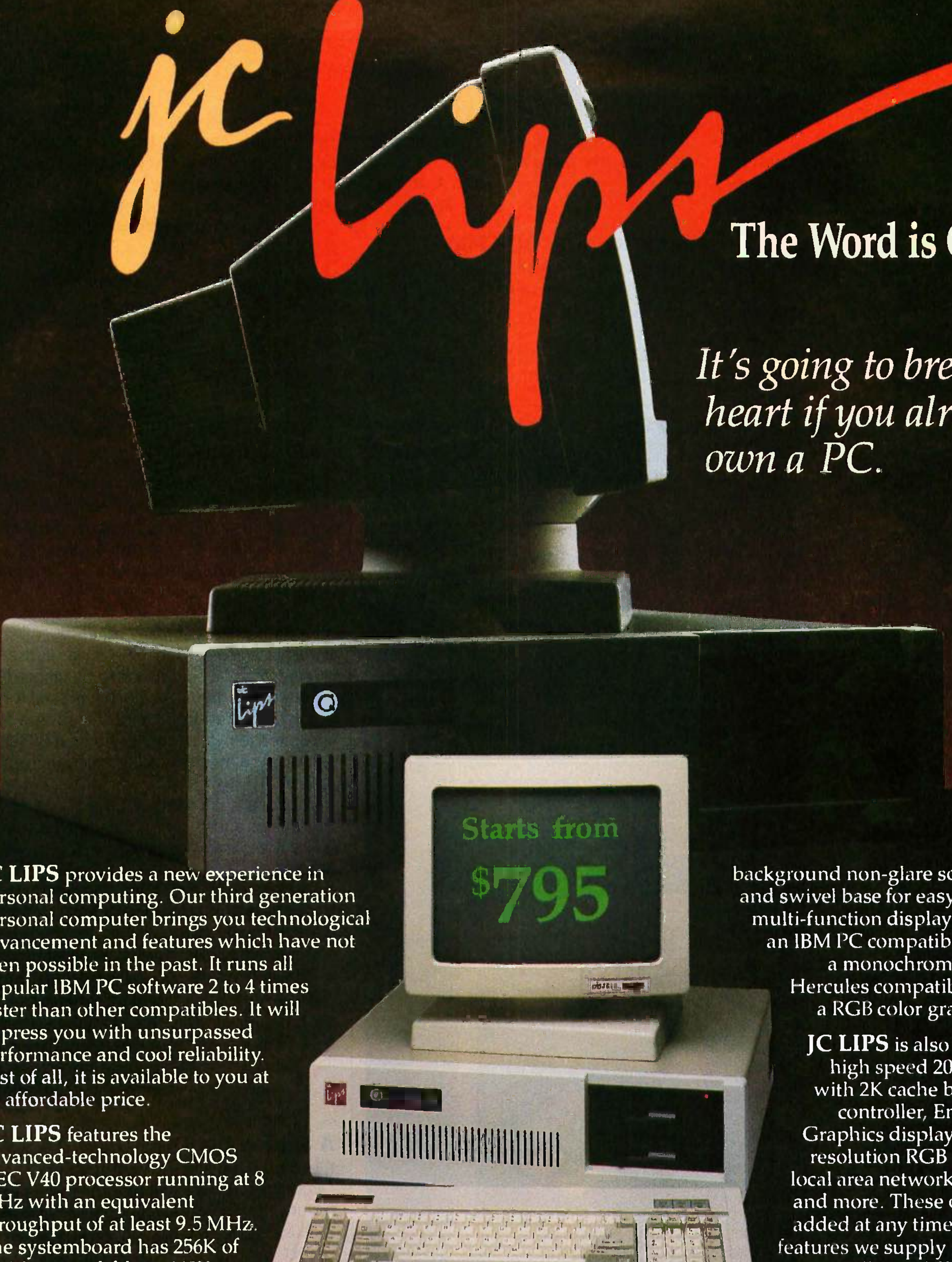

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perhaps because one has to pay too much in clarity to obtain a modest decrease in frequency of coding error. If one believes this judgment is wrong, then should not the ANSI Standardization Committee, rather than individual dissenters, be enjoined to wrestle with the problem?

The moral? If you generate a mutated C, keep the new species to yourself and please let no others learn of your forbidden engineering, unless you are sure the mutant is so well conceived that it will take over the world.

John A. Rupley
Tucson, AZ

MODIFICATIONS TO CP/M

I have some unofficial modifications to CP/M v. 2.2 that might benefit BYTE readers.

- The DDT D command displays nonprintable characters with a period. This arrangement causes some confusion, because a period is not an infrequently used character. A better choice, I believe, would be the ASCII tilde (~) character.

Method: Change memory address 0E41 from 2E to 7E.

```
A>DDT DDT.COM  press return
   -SE41       press return
    0E41 2E    enter 7E and press
               return
    0E42 C3    enter a period and
               press return
    -          press control key
               and C key
A>SAVE 19 DDT.COM
```

The following modifications assume the reader is proficient in the use of DDT.COM and can write assembly language utility routines to find the starting address of a byte sequence. A more intimate knowledge of CP/M is also necessary.

- When using Control-S to stop/start console output, pressing any other key, after initially issuing a Control-S, causes subsequent Control-S commands to be ignored.

Method: In the .COM file that is used for system generation, find the starting address of the byte sequence (in hex) B7 C2 G2. Change the next call instruction from call ??23H to call ??2AH; the ?? hex numbers are unchanged. Save the memory image and sysgen it. [*Editor's note: Be sure to keep a backup copy of your original system disk.*]

- Change the Control-S for stopping/starting console output to the space bar, which is more convenient.

Method: In a manner similar to that used in the second method above, find the starting address of the byte sequence (in hex) FE 13 C2 42. Change the 13H to 20H, save the memory image and sysgen it.

David A. Danello
Blacksburg, VA

A BUG IN PRODOS DIRECTORIES

I enjoyed the article "Sorting ProDOS Directories" (June) by Antonio Silvestri. Unfortunately, the sample program has a bug that Mr. Silvestri's test program will not detect.

The bug (pointed out by Glen Bredon, who noticed this same type of problem in early versions of several commercial ProDOS utilities) can be evidenced by expanding the size of a subdirectory file that has had its order in the parent directory altered by the sort. An easy way is to add more than 13 new files to the "relocated" subdirectory (which adds at least one block to the directory file's size); try the following steps:

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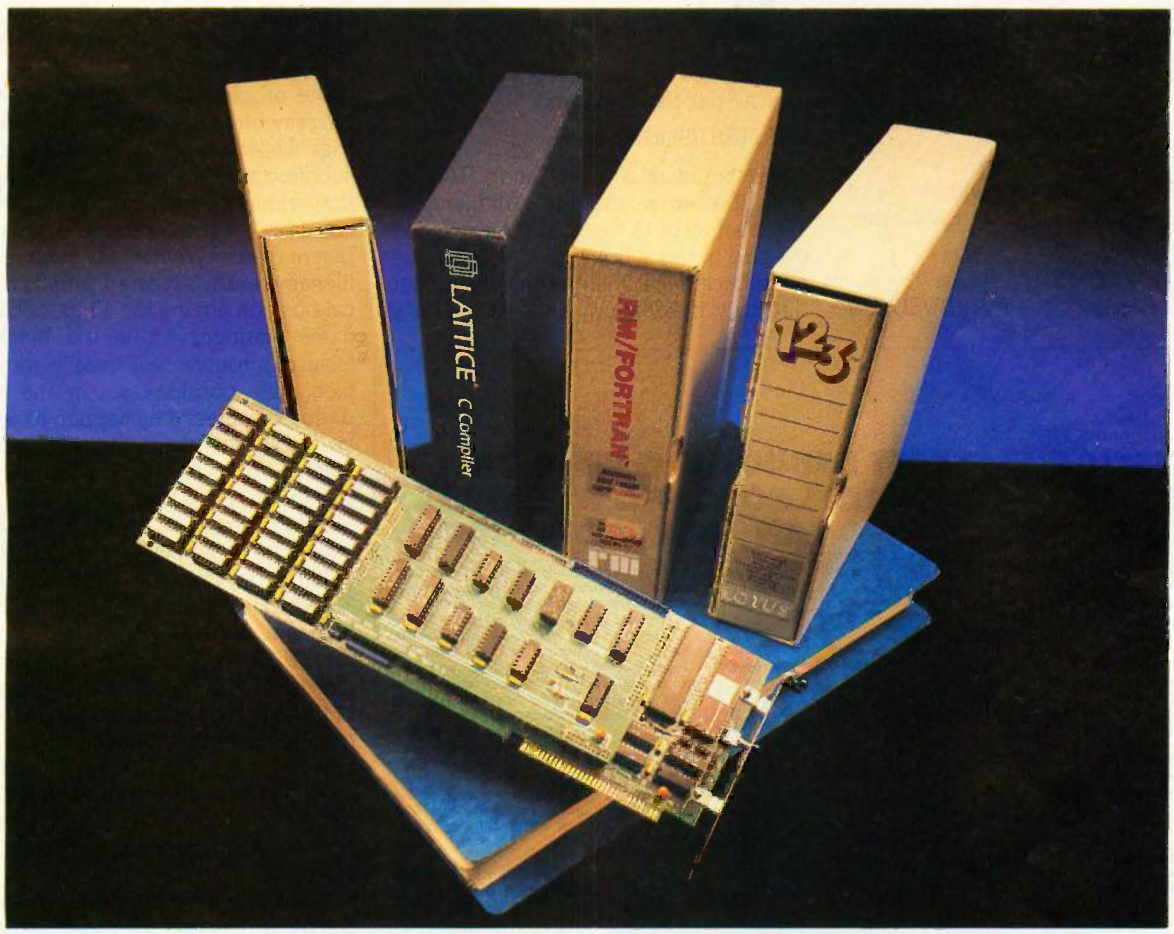

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1. Make (format) a ProDOS data disk (call it /TEST, for the sake of argument).
2. Create two files (in this order):

```
CREATE /TEST/SUB.B
CREATE /TEST/SUB.A
```

3. Alphabetize the test disk.
4. Create 13 or more files within one of the subdirectories. A simple BASIC program to do this is

```
10 FOR = 1 TO 15
20 PRINT CHR$(4);"SAVE /TEST/SUB.A/
   FILE.";I
30 NEXT I
```

5. Try to read the contents of the subdirectory, as per the command

```
CAT /TEST/SUB.A
```

You should get a "beep" and a RANGE ERROR message after the 13th filename. The creation of 15 files in SUB.A expanded the size of the subdirectory, but this was not reflected in its entry within the parent directory. Incidentally, you *can* LOAD any file within the subdirectory, even though you can't get CAT or CATALOG to display it.

The problem has to do with the rearrangement of subordinate directory entries while sorting a directory file. Each subdirectory file contains a link to its location within its parent directory. The link consists of a pointer to the block (of the parent directory) where the subdirectory's filename entry is located, and its numerical position among the 13 (possible) filename positions within the block. Mr. Silvestri's routine will usually move the filenames' positions within the parent directory (unless they happen to wind up in exactly the same positions after the sort) but does not correct the link in the subdirectory file itself.

In the example, we start with a newly formatted ProDOS volume named ?TEST (the volume directory will start block $2). ?TEST will occupy the position of the first filename. We then CREATE the directory file SUB.B as its second entry and the directory file SUB.A as its third entry. Each of these entries will point to the actual file assigned to each of these names. Information within the file SUB.B itself will point to its filename's location within /TEST's directory as the third file in block $2. SUB.A will similarly point to itself as being the second file.

Now we alphabetize the /TEST directory, SUB.A, SUB.B, and their associated data exchange places, so now SUB.A is the second entry and SUB.B is the third entry. But neither subdirectory file's links (pointing back to its original position in the parent directory) has been updated to reflect this! So now the link within the file SUB.A points to the entry (and data) associated with SUB.B.

The problem does not evidence itself immediately. What occurs is that any alteration in the status of one of the subdirectories that requires altering its entry within the volume directory will result in the improper entry being "updated." If SUB.A expands to eight blocks, the entry SUB.B will be assigned the new data instead, while the entry SUB.A is unchanged.

The way around this is to have the sort program correct the link to the parent within the subdirectory file. I don't have a quick and easy fix (I'm too lazy), but Glen Bredon has developed a set of ProDOS utilities that includes a program that may fix any directories after the fact. I hope Mr. Silvestri doesn't find this too discouraging, as a *lot* of programmers (and commercial programs) seemed to initially run into this bug. Volumes that do not use subdirectories (or in which the subdirec-

(continued on page 370)

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The first and most difficult plague was impossible to trap with software debuggers. These were carnivorous bugs which randomly overwrote programs, data, even the debugger. Nastiest were the ones that slipped in once every few hours, or changed their behavior after each new compile. Forty days and forty nights of recompiling, *trying something else*, caused many a would-be resident of the city to run screaming into the wilderness, never to be heard from again.

Second came the plague of not knowing where the program was, or where it had recently been. This compounded the first plague: How could anyone know *what* caused the random memory overwrites? Add to this random interrupts and timing dependencies, and you begin to understand *The Fear* that gripped the city.

Then came the last plague, which brought the wizards to their knees before they even started debugging. Their towering programs consumed so much memory, there wasn't enough room for their symbol table, let alone debugging software. Even if they could get past the first two plagues, this one killed their firstborn software.

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The Atron solution came as a revelation: Monitor every memory reference and every instruction executed, by adding a hardware board to the AT or PC with an umbilical probe to the processor.

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The second plague, not knowing from whence you came, was cured with PROBE'S real-time trace memory. The history of program execution is saved on-board, in real time. Once a hardware trap has occurred, PROBE displays the program execution in detail, including symbols and source code for C, Pascal, or assembly language programs. Which shows how out-of-range pointers got that way.

The third plague, not enough room for the debugging symbol table to be co-resident in memory with a large program, was cured with 1-megabyte of on-board, hidden, write-protected memory. System memory was then free for the program, keeping the symbol table and debugger safe from destruction.

When the job of bugbusting was done, the wizards used their PROBEs as performance analyzers. So they could have both reliability *and* performance. So they could send only the best software into the field.

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LANGUAGES THAT ARE CAUSING THE BIGGEST PROGRAMMING BACKLOG IN HISTORY ARE ALSO EATING NICE BIG HOLES IN OUR POCKETS.

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We've been given some incredibly powerful hardware in recent times, but the languages aren't a whole lot better than they were 20 years ago.

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With CLARION you simply design the screens using our SCREENER utility and then CLARION writes the source code AND compiles it for you in seconds.

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Programs that are easy to use.

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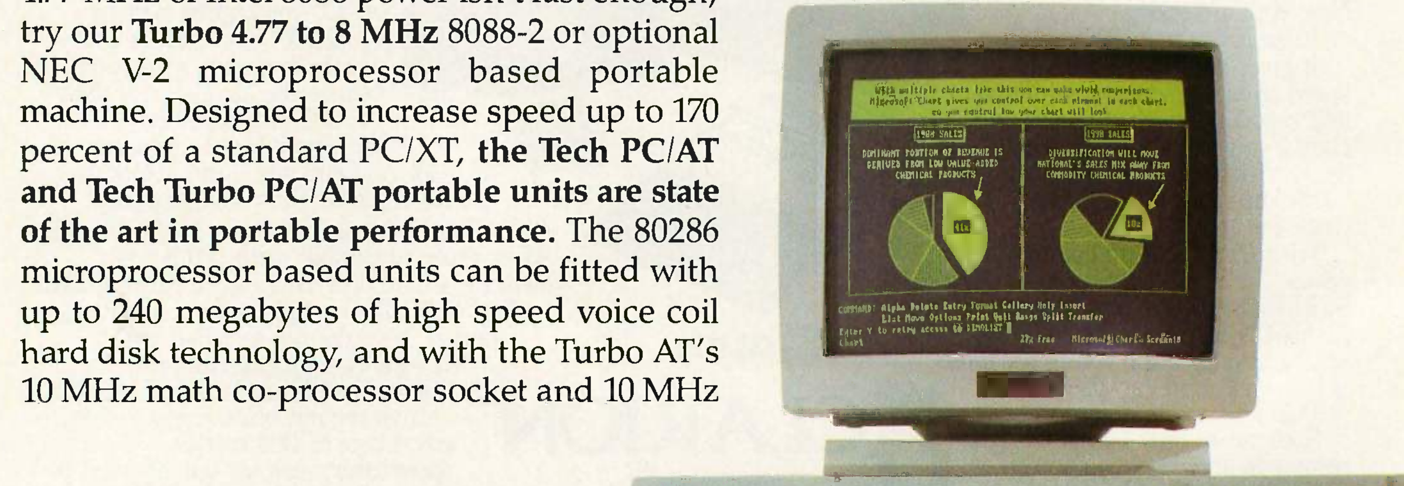

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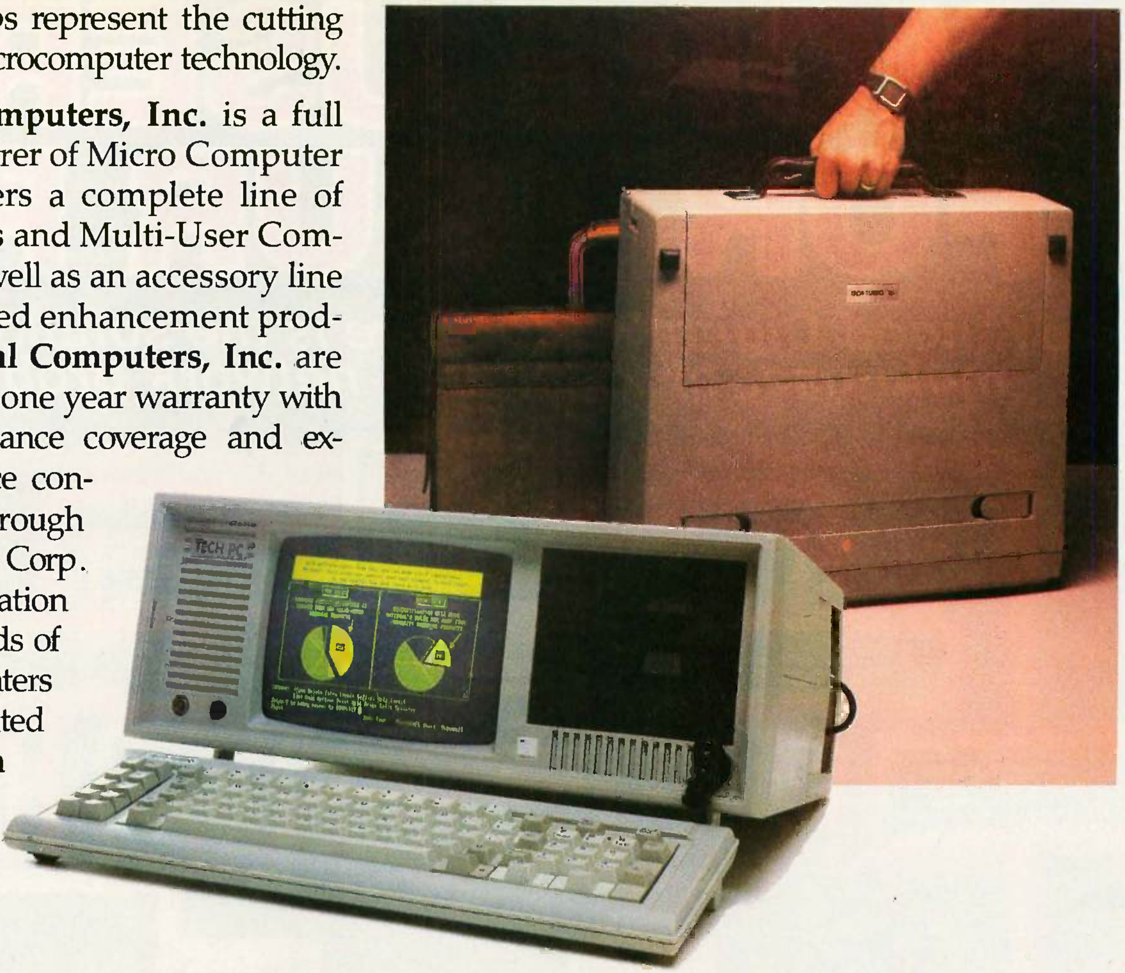

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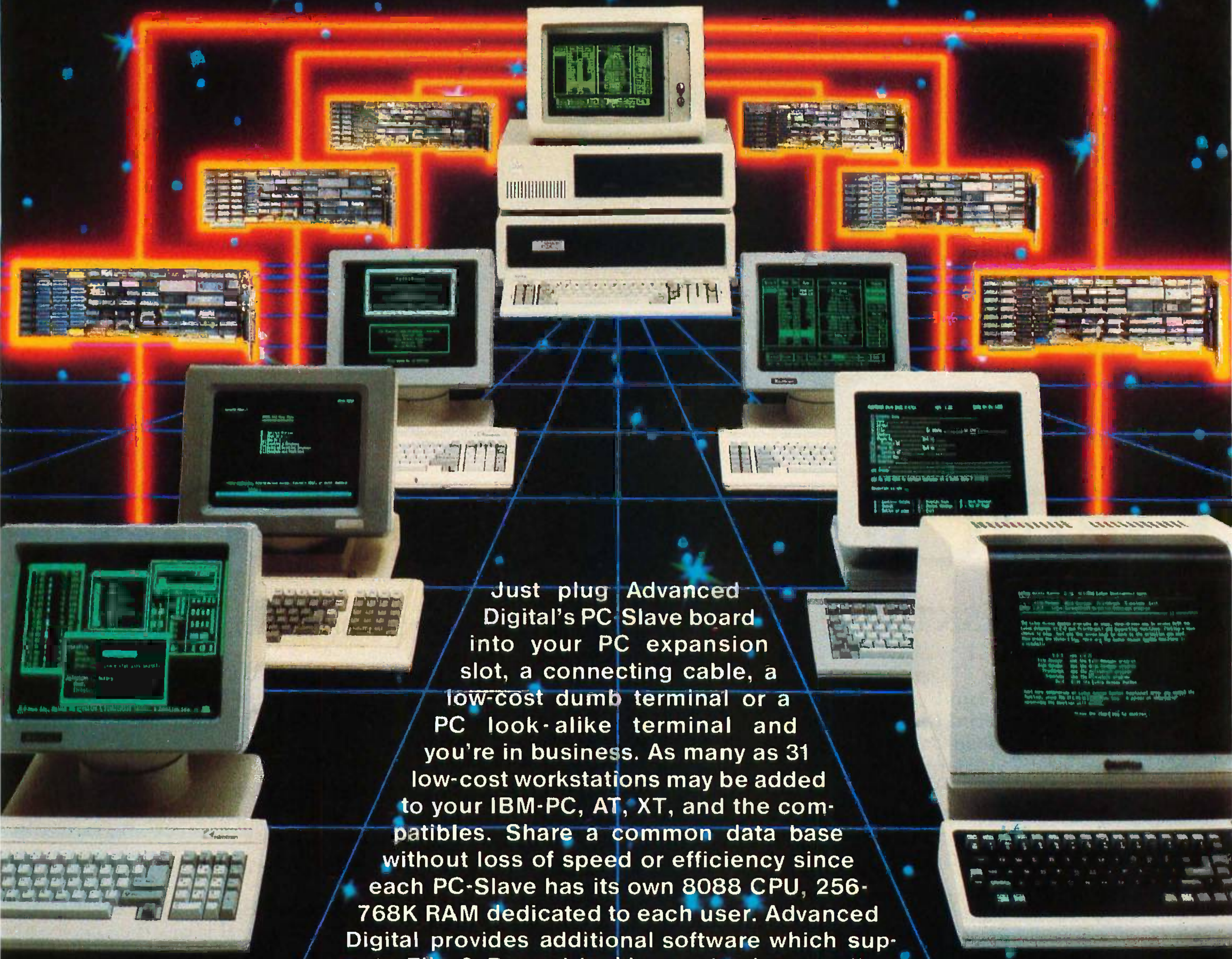

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Inquiry 5 for End-Users. Inquiry 6 for DEALERS ONLY.

Turbo Chassis for Amiga

Computer Systems Associates has released the Turbo Chassis, an expansion unit that adds a 32-bit 68020 microprocessor and 68881 floating-point coprocessor to the Commodore Amiga. Installed with the 68881 on a coprocessor board in the chassis, the 68020 runs at 14.28 MHz, twice the frequency of the Amiga's standard 68000 processor. The coprocessor board also provides 32-bit data and address buses, as well as 32-bit DMA operation. According to the company, the 68020 and 68881 are fully supported by AmigaDOS.

The Turbo Chassis attaches to the Amiga via a 100-pin expansion bus. In addition to the coprocessor board, the unit is equipped with a 512K-byte, 32-bit static RAM board, a 20-megabyte hard disk drive with an SCSI controller, and a power supply; a 40-megabyte hard disk is optional. The unit's two remaining expansion slots can accommodate additional boards from CSA or from other manufacturers.

With the coprocessor board, memory board, and 20-megabyte hard disk drive, the Turbo Chassis sells for $5475. You can also purchase the components separately or with an Amiga and color monitor. For more information, contact Computer System Associates, 7564 Trade St., San Diego, CA 92121, (619) 566-3911.

Inquiry 550.

The Amiga Turbo Chassis, with 68020 and 68881 processors.

Smalltalk-based Expert System Shell

Humble, a set of tools from Xerox for building expert systems, functions in the Smalltalk-80 environment. It's primarily a goal-directed expert system shell to which you can add rules and data definitions, from a browser window, to create systems for specific problems. You can also alter the certainty model. The rule language contains an "escape" to standard Smalltalk-80 code.

The program, which can deal with several hypotheses simultaneously, is capable of both backward and forward chaining. The former is automatic during execution; the latter can be specified at any time during rule execution. Because Humble supports multiple execution contexts, the same rules can be applied to several similar objects within a knowledge base. Any Smalltalk-80 application can interface to Humble knowledge bases.

Humble runs in Smalltalk-80 systems based on any licensed virtual image. It needs at least 200K bytes of memory after the Smalltalk image is loaded. A site license is $1500; per-machine price is $500. The package comes with source code for the shell and supporting windows. Contact Xerox Special Information Systems, 250 North Halstead St., P.O. Box 7018, Pasadena, CA 91109, (818) 351-2351.

Inquiry 551.

Spreadsheet-style Signal-Analysis Software

DSP Systems has developed technical-worksheet software that provides a spreadsheet-like environment for displaying and analyzing digital waveforms. DADiSP Worksheet has 150 data manipulation and analysis functions, including signal editing, signal arithmetic and calculus, waveform generation, FFTs, statistical analysis, and peak finding. You can also build other functions with macros.

You set up signal-processing steps by typing formulas into a window. The menu-driven program evaluates and displays the results of each step. Worksheets can be saved and used to build analysis templates.

DADiSP Worksheet supports real and complex arithmetic and carries engineering units through compound calculations. It can detect an 8087, supports various file formats, and has command files for automating data analysis. The program runs on the IBM PC series and compatibles with an EGA, IBM CGA, or Hercules graphics adapter. The package price of $795 includes six months of updates and support. A demo disk is $20. Contact DSP Systems, One Kendall Square, Cambridge, MA 02139, (617) 577-1133.

Inquiry 552.

Amiga Organizer

Order, a desktop organizer for Commodore's Amiga, uses the machine's multitasking, voice, graphics, sound, menu, and window capabilities. The package bundles a telephone directory that doubles as a mailing list and label printer; a talking alarm clock; a perpetual calendar; an appointment book; a screen dumper; and Doodler, a scratch pad for graphing and sketching. The software also contains a 37-function scientific calculator, which can print a tape of computations.

Retail price is $44.95. Con-

(continued)

tact the Northeast Software Group at ICS, 165 Dyerville Ave., Johnston, RI 02919, (401) 273-1001.
Inquiry 553.

Scientific Sourcebook

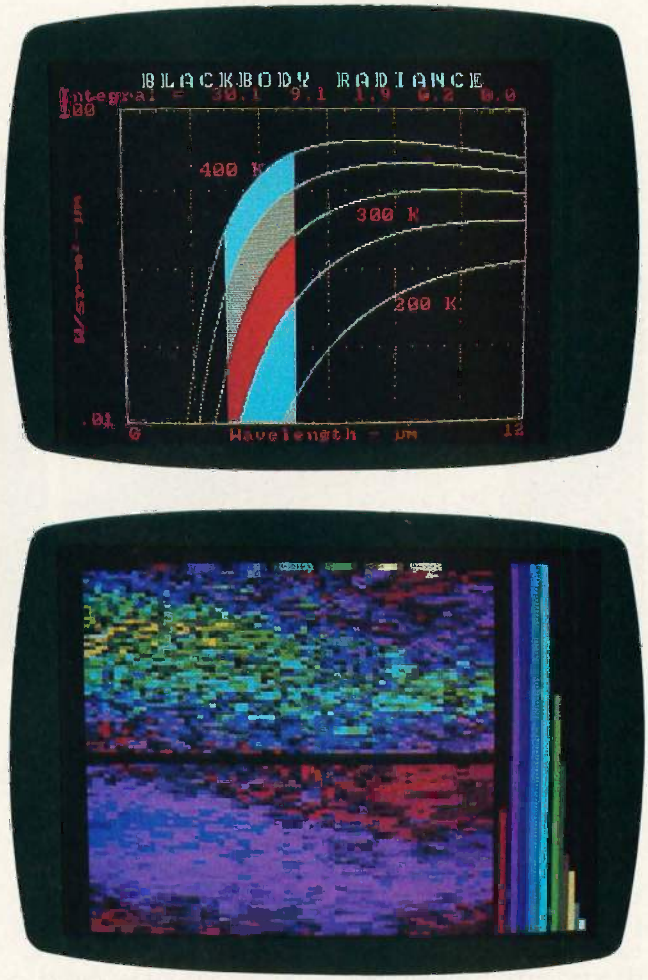
Advanced Scientific Analysis & Graphics is a sourcebook of techniques written in IBM PC BASICA. The 48 source code applications, which can be run alone or as modules in custom programs, are designed primarily for people involved in math, physics, and engineering. The programs on the disk are also listed in a handbook.

The sourcebook is broken down into four categories: graphics techniques, including programs for 3D surface plotting, contouring, and charting; imaging and transforms, including programs for FFTs, fractal structures, convolution, image enhancement, and optical ray tracing; probability and statistics, with programs for probability distributions, confidence bounds, Monte Carlo radiative transfer, and regression; and matrix operations, covering 3D perspective projections, symbolic multiplication, determinants, inversion, simultaneous equations, and eigenvalues and eigenvectors.

The package sells for $60. For more information, contact Simplication UnLtd., P.O. Box 654, Menlo Park, CA 94026, (415) 859-4244.
Inquiry 554.

Hard Disk Cards with up to 60 Megabytes

Express Systems introduced a series of Hard DiskCards for IBM PCs, ATs, and compatibles that range in capacity from 20 to 60 megabytes. The 40- and 60-megabyte cards, called the Express Double DiskCards, require two expansion slots; all others require one and a half slots.



A plot (top) and a pseudocode image generated with code from Simplication's sourcebook.

The 20-megabyte AT Backup DiskCard for the IBM PC AT ($449) comes with backup utilities and software that compresses binary, text, and database files by 30 to 90 percent of the original size. The drive performs file-by-file backup at the rate of 3 megabytes per minute. The Express Double DiskCards come with two hard disks. One disk can back up the other with the firm's automatic backup software, or the drives can be made to work as one with the company's Coalesce software.

In addition, the Coalese software ($95) permits you to combine any Express Hard DiskCard with an existing hard disk and have both disks act as one. The software can also divide a single drive into multiple units and lets you bypass the DOS file limitation of 32 megabytes.

The 20-megabyte Hard DiskCard sells for $595 or $495, with access speeds of 60 or 80 milliseconds, respectively. The 30-megabyte cards with 80- and 60-ms access speeds sell for $695 and $795. The 40-megabyte card (80 ms only) costs $995; the 60-megabyte card (60 ms only) costs $1095. For more information, contact Express Systems Inc., 1254 Remington Rd., Schaumburg, IL 60195, (800) 341-7549, ext. 3600; in Illinois, (312) 882-7733, ext. 3600.
Inquiry 555.

TI Graphics Design Kit

Texas Instruments is offering the TMS340 Graphics Design Kit for designing bit-mapped graphics systems. The $99 kit contains samples of components likely to be used in a graphics system, including the TMS4161 64K by 4 video RAM, the TMS34061 video system controller, and the TMS34070 color palette chip.

Other components include a 4-bit bidirectional universal shift register and a 68-pin plastic leaded chip carrier socket for the video system controller. Also packaged with the kit are user's guides, data sheets, and applications information. For more information, contact Texas Instruments Inc., Semiconductor Group (SC-618), P.O. Box 809066, Dallas, TX 75380-9066, (800) 232-3200, ext. 700.
Inquiry 556.

80386 Development Tool

American Computer & Peripheral has announced a software development tool to help programmers adapt to the 80386 microprocessor environment. The 386 Translator plugs into an 80286 PGA (pin grid array) socket in an IBM PC AT or compatible computer and transforms the system into an 80386 environment.

The 386 Translator costs $395 without an 80386 chip

(continued)

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Inquiry 140

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or $895 with an 80386. Intel offers PLM compilers, assemblers, and other MS-DOS software for 80386 program development. For more information, contact American Computer & Peripheral Inc., 2720 South Croddy Way, Santa Ana, CA 92704, (714) 545-2004.

Inquiry 557.

PC-compatible Laptop from STM Electronics

STM Electronics announced the STM LapTop, an IBM PC-compatible portable computer that can be equipped with an expansion unit called the LapMate. The LapMate, which connects to the computer through an interface on the back of the system unit, provides additional disk drives and other expansion options.

The computer runs on a 4.77-MHz 80C88 processor and can accommodate an 8087 math coprocessor. Priced at $2999, the standard model comes with 256K bytes of RAM (expandable to 640K) and an internal 720K-byte 3½-inch floppy disk drive.

Two display options are available. The electroluminescent display provides a resolution of 80 columns by 25 lines in text mode and 640 by 200 pixels in graphics mode. The backlit LCD screen offers the same text and graphics resolution. The LapTop also supports an PC-compatible color graphics adapter and includes as standard a parallel and serial port and a mouse port.

A ROM cartridge interface on the computer's backpanel accepts ROM cartridges available from STM or other manufacturers. A ROM cartridge without the ROM is priced at $39, and a cartridge with 128K bytes of EPROM sells for $115. The company also offers two optional ROM sockets for installing up to 256K bytes of applications software.

Among the other options are 384K bytes of internal bubble memory ($649), an internal 300/1200-bps modem ($299), two nickel-cadmium battery packs that power the unit for two hours ($149) or four hours ($249), a battery pack recharger/adapter ($19.50), and an AC adapter/charger ($149).

With a base price of $549, the LapMate unit contains a 5¼-inch and a 3½-inch floppy disk drive; a hard disk drive is optional. The unit also contains a half-length expansion slot that will accept an RGB adapter ($209) and has interfaces for an external PC-compatible keyboard, an external monitor, and a connector for additional expansion boxes. According to the company, the computer should be available this month. For more information, contact STM Electronics Corp., 444 Castro St., Mountain View, CA 94041, (415) 968-1790.

Inquiry 558.

The STM LapTop connects to the LapMate expansion unit.

Atari ST Development System

The Nexus EPROM Development System for the Atari ST consists of software and a 16-bit external EPROM programmer/simulator that plugs into the ST's cartridge port. The device enables you to program EPROMs of 8K and above and supports data transfer to and from the serial port and disk files in binary, hex-space and Motorola and Intel hex formats.

The unit has two sockets for programming and reading EPROMS, 64K bytes of CMOS simulator RAM, an external simulation socket, and a socket for further expansion. Internal (cartridge) simulation enables the unit's 64K of RAM to be treated as if it were 64K of EPROM. During external simulation, the ST is free for processing other tasks.

The system's software uses the GEM interface and provides windows for displaying RAM or EPROM contents. Its data manipulation features include edit, locate a value, block move, fill/clear RAM, calculate checksums, check for blank and programmable EPROMS, and verify EPROM against RAM.

The development system sells for £175. For more information, contact Nexus Technical Services Ltd., 38 Melrose Ave., Reading, Berkshire RG6 2BN, U.K., tel: (0734) 664559.

Inquiry 559.

3D Modeling Package for Mac

Phoenix 3D is a set of Macintosh tools for creating and viewing three-dimensional models. You can design models from all sides, using the mouse to rotate, twist, stretch, bend, explode, and shrink or enlarge the image. You can then view the drawing from any angle. Drawing tools let you remove hidden lines, shade with 64 levels of gray, smooth facets, and filter the resulting image. Drawings can be saved as MacPaint documents. With a conversion utility supplied on the disk, you can import models from other programs.

Models can have as many as 1200 polygons (with as many as 22 sides), spheres, cones, prisms, and surfaces of revolution. The package provides 55 methods of rendering algorithms for building wireframe, hidden-line, flat-shaded, or smooth-shaded models.

The program runs on the 512K Mac, Mac Plus, and Mac XL; supports HFS, Switcher, and Servant; and works with the Imagewriter and LaserWriter. Phoenix 3D costs $39.95. Contact Dreams of the Phoenix Inc., P.O. Box 10273, Jacksonville, FL 32247, (904) 396-6952.

Inquiry 560.

Apple-based System for Handicapped

Point to Pictures is a software/hardware system for persons with IQ levels of 20 to 80 or developmental ages of 6 months to 5 years. R. J. Cooper & Associates says it designed its package, based on research at a school for low-functioning 3- to 22-year-olds, to fulfill three goals: increase educational productivity, stimulate spontaneous

(continued)

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speech, and help with early acquisition of augmentative communication skills.

PTP uses a large graphics tablet (the Power Pad) with large pictures on its surface to allow low-functioning individuals to interact with the Apple IIe. The system employs graphic and verbal prompts (using the Echo+ speech synthesizer). An interface that hooks to the game port controls two switch-modified toys, which can correlate to pictures on the Power Pad.

Several configurations are available. Software prices range from $49.95 to $199.95. The Power Pad and the Echo+ sell for $150 each. For more information, contact R. J. Cooper & Associates, 2144 South 1100 E, Suite 150, Salt Lake City, UT 84106, (801) 263-1388.
Inquiry 561.

MacBus Holds PC Add-on Boards

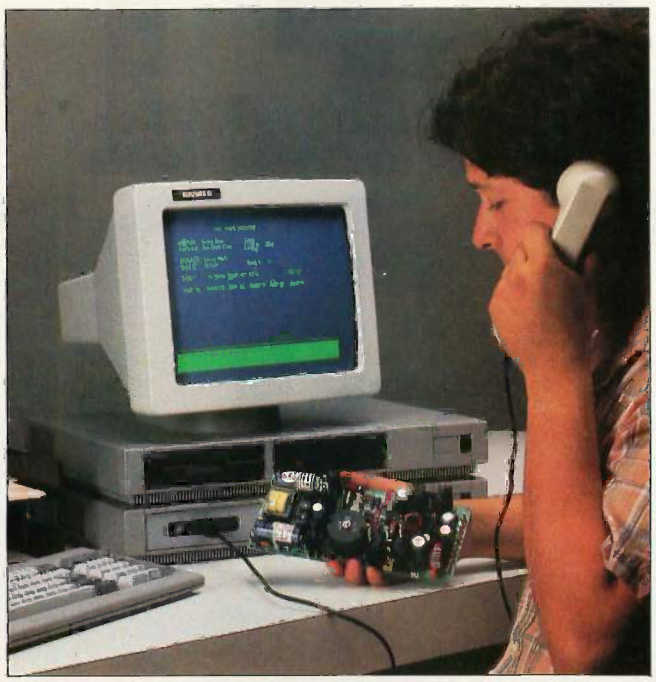
Designed for laboratory, instrumentation, and test and measurement applications, National Instruments' MacBus expansion unit provides a Macintosh Plus with a means of using IBM-compatible expansion cards.

The MacBus unit has five 16-bit PC AT expansion slots, two of which are occupied by a microcomputer card and an SCSI card that provides the communications link to the Mac. The three remaining slots can accommodate A/D converters, digital I/O, serial communication links, video frame grabbers, and other boards compatible with the IBM PC or PC AT.

Data acquisition and instrument control are performed by National Instruments' GPIB-V50 microcomputer card, which contains an 8-MHz, 16-bit microprocessor, circuits that control the AT-compatible bus, and an IEEE-488 interface. The card can also hold an optional 8-MHz math coprocessor. The operating system, contained in EPROM on the card, is a version of the company's IBCL (Instrument Bus Control Language), which provides commands for controlling GPIB instruments and a program development language.

The system's software includes an IEEE-488 bus control and configuration utilities and a driver for the MacBus hardware. Language interface libraries provide access to the IEEE-488 driver and the MacBus hardware from user-developed programs written in C and BASIC.

List price for the hardware is $1495; for the software, $200. Contact National Instruments Corp., 12109 Technology Blvd., Austin, TX 78727-6204, (800) 531-4742; in Texas, (800) 433-3488.
Inquiry 562.



The Kurzweil Voiceterminal acts as a terminal or stand-alone PC.

Kurzweil's Voiceterminal

Kurzweil Applied Intelligence introduced the Kurzweil Voiceterminal (KVT), a 1000-word intelligent terminal that enables you to use spoken words and phrases to control, enter data into, and retrieve data from mainframes and minicomputers. The terminal emulates ASCII or IBM 3270 terminals and also functions as a stand-alone computer that can run most IBM PC–compatible software.

Each Kurzweil Voiceterminal consists of an IBM PC XT–compatible computer with embedded voice recognition, a 10-megabyte hard disk drive, and a 360K-byte floppy disk drive. The system is also equipped with a monochrome display, two serial ports, and one parallel port.

The KVT connects to host systems via a hard-wired serial communications line or a modem. The system automatically translates voice commands and data into keyboard inputs; no modification to host applications is required. Multiple users can train the terminal to recognize their voices and tailor the vocabulary for particular applications. The company also offers predefined command sets for mainframe applications.

In a stand-alone configuration, the Voiceterminal costs $9500; with ASCII emulation, $9900; and with IBM 3270 emulation, $10,900. Contact Kurzweil Applied Intelligence, 411 Waverley Oaks Rd., Waltham, MA 02154, (617) 893-5151.
Inquiry 563.

Tallgrass File Servers

Tallgrass Technologies introduced two file server products that support a variety of local area network configurations and communications options. Both products use the VINES virtual networking software developed by Banyan Systems.

The TG-8000 is a 32-bit desktop network file server that provides wide-area networking, host access, server-to-server communications, and resource sharing for small networks. The TG-8000AT is a software-only version that enables an IBM PC AT or compatible to function as a network server.

Prices for the TG-8000 begin at $8495 for a configuration that includes 1 megabyte of RAM, a 50-megabyte hard disk, and 60-megabyte tape backup. The VINES software costs $1895. The TG-8000AT software, which is scheduled to ship in October, will also sell for $1895. Contact Tallgrass Technologies Corp., 11100 West 82nd St., Overland Park, KS 66214, (913) 492-6002.
Inquiry 564.

(continued)

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SYSTEMS

AT Compatible from Wyse

Wyse Technology announced the WYSEpc 286, an IBM PC AT–compatible computer that operates at 10 and 6 MHz. The computer offers up to 81.2 megabytes of disk storage, several display options, and a standard PC AT keyboard or an IBM Enhanced Personal Computer keyboard.

Standard features include 640K bytes of RAM, eight full-size PC AT expansion slots, a real-time clock with battery backup, an RS-232C serial port, and a parallel port. Also included as standard are MS-DOS 3.1 and GW-BASIC 3.1. The computer can be configured with a 1.2-megabyte half-height floppy disk drive, a 20-megabyte half-height hard disk drive, and a 40-megabyte full-height hard disk drive.

The company is also offering three monitors and two graphics adapter boards, all of which are PC-compatible, for use with the WYSEpc 286. The 14-inch monitors include the WY-530 monochrome monitor ($235), WY-630 color graphics monitor ($599) with 640 by 200 resolution, and WY-640 EGA-compatible monitor ($749) with 640 by 350 or 640 by 200 resolution. The WY-430 graphics board ($299) is compatible with the Hercules graphics adapter, IBM Color Graphics Adapter, and Plantronics display adapter. The WY-440 graphics board ($499) provides compatibility with IBM's Enhanced Graphics Adapter.

The computer can also be connected to Wyse terminals for use as a multiuser system. With a 1.2-megabyte floppy drive, the system sells for $2499; with a 20-megabyte hard drive, $2999; and with a 40-megabyte hard drive, $4199. Contact Wyse Technology, 3571 North First St., San Jose, CA 95134, (408) 433-1000.

Inquiry 565.

Zenith's Z-181, *an* IBM PC *compatible with* 640K *bytes of* RAM.

Two VMEbus Single-Board Systems

Force Computers' CPU-6 series of VMEbus boards is based on 68000 or 68010 processors and supports floating-point operations. The CPU-6 series offers 512K bytes of dedicated on-board DRAM permitting zero-wait-state operation at 8 MHz and one-wait-state operation at 12.5 MHz. A 68881 coprocessor at 8 or 12.5 MHz is optional.

Four 28-pin JEDEC sockets accommodate 27512 EPROMs for up to 256K bytes of user and system program area or 8-bit-wide SRAM devices. Three RS-232C serial ports and one parallel port are also incorporated. Other standard features include a real-time clock with battery backup and a 16K-byte monitor including a one-line assembler/disassembler.

The base board sells for $1845. Contact Force Computers Inc., 727 University Ave., Los Gatos, CA 95030, (408) 354-3410.

Inquiry 566.

Motorola introduced a 32-bit VMEbus-compatible board (Model MVME133) that incorporates a 12.5-MHz 68020, a 68881 floating-point coprocessor, and 1 megabyte of DRAM. A 16.67-MHz version (Model MVME133-1) is also available.

Among the other features of the single-board computer are a serial debug port and two RS-232C multiprotocol serial ports, three 8-bit timers, a real-time clock, and an A24/D32 VMEbus master interface with system controller capabilities.

With a 12.5-MHz processor, the board costs $1995. Contact Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036, (602) 438-3501.

Inquiry 567.

Zenith's Z-181 Laptop Computer

Zenith introduced the Z-181, an IBM PC–compatible laptop computer priced at $2399. Like the IBM PC Convertible, the Zenith machine uses a 4.77-MHz CMOS 8088 processor and features two 3½-inch floppy disk drives capable of storing 720K bytes of data each. Unlike the Convertible, the Z-181 is completely compatible with the ROM BIOS in the IBM PC, according to Zenith.

The Z-181's fold-up LCD screen uses what the company calls supertwisted birefringent crystals with electroluminescent backlighting to attain a claimed contrast ratio of 12 to 1. (Zenith claims that a standard monochrome CRT has a contrast ratio of 3 to 1.) In addition, the screen can display true shades of gray and has both brightness and contrast controls.

The 11.8-pound computer comes standard with 640K bytes of memory, connectors for RGB and composite monochrome monitors, and serial and parallel interfaces. The portable also comes with MS-DOS 3.2 (a BASIC interpreter is optional), a real-time clock, a nickel-cadmium battery that powers the unit for up to five hours, an AC charger, a socket for an 8087 math coprocessor, and a set of "desktop" software packages. Options include a 5¼-inch battery-powered disk drive, a 300/1200-bps internal modem, and an interface for a bar code reader.

For more information, contact Zenith Data Systems, 1000 Milwaukee Ave., Glenview, IL 60025, (800) 842-9000; in Illinois, (312) 391-8949.

Inquiry 568.

(continued)

Princeton is the best choice in PC monitors.

When you're looking for a personal computer monitor, look at Princeton Graphic Systems. Our growing family of high quality personal computer monitors delivers compatibility, brilliant colors, high resolution, and dependability. Whether you're designing sophisticated business graphics or number-crunching a financial spreadsheet. That's why Princeton is number one in the minds of more and more personal computer owners every year.

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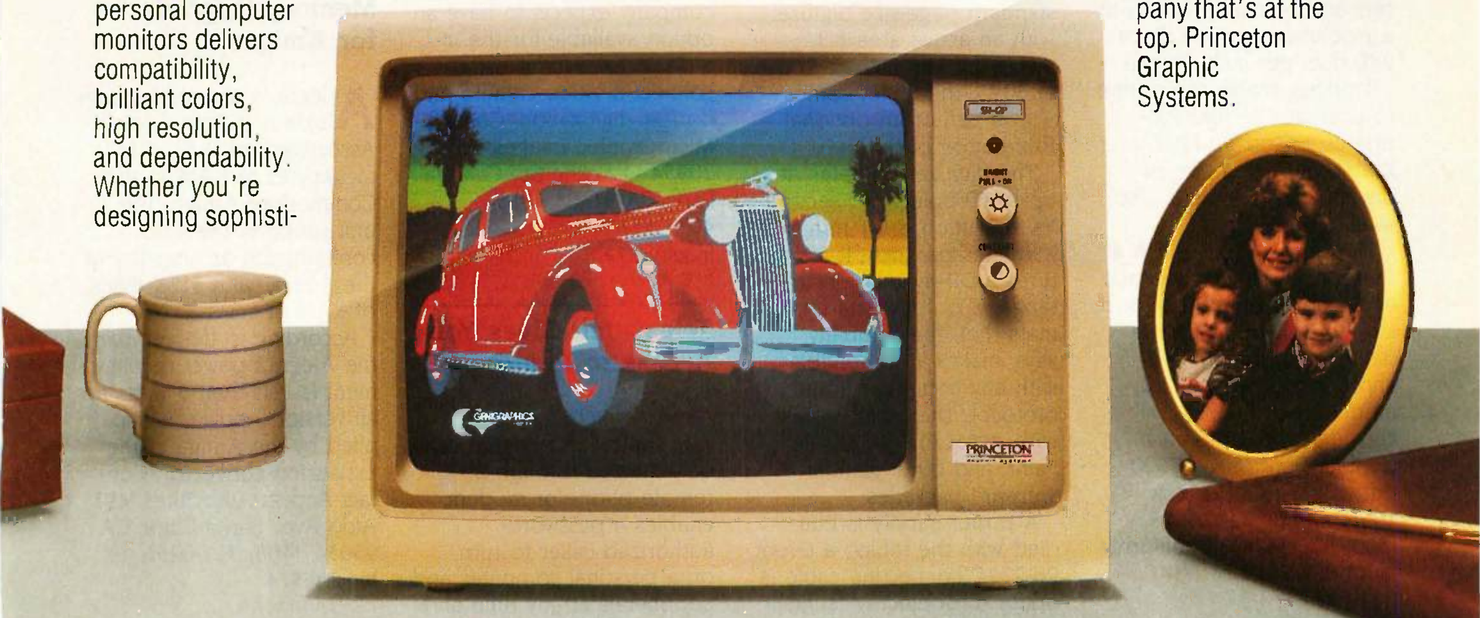

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SR-12. Super high resolution RGB monitor with a .31mm dot pitch. Compatible with Sigma Designs Color 400 board and others. Gives you 400 lines of resolution. Nonglare screen.

MAX-12. High resolution amber monitor. When used with an IBM-compatible monochrome adapter delivers 720 x 350 resolution. With an IBM-compatible color adapter, 640 x 200 resolution with 15 shades of amber. The monitor automatically adjusts to either card.

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PERIPHERALS

Line Printer for PCs

The Personal Line Printer from Printronix is designed for use with IBM PCs, XTs, ATs, and compatibles. The printer, which produces an entire line of dots at one time, operates in draft mode at 134 lines per minute and in near-letter-quality mode (with a character matrix of 18 by 35 dots) at 47 lines per minute. The printer is also capable of producing IBM block graphics characters and bit-map graphics at a resolution of 60, 120, or 240 dots per inch. Plug-in cartridges enable the printer to emulate the IBM Proprinter, Epson LQ-1500, and Diablo 630. A choice of downloadable fonts is also available.

The printer comes with a Centronics parallel interface and 2K-byte buffer. List price is $795, which includes a tractor and friction feed and two font/personality modules. Additional font cartridges cost $40 each. Contact Printronix, 17500 Cartwright Rd., P.O. Box 19559, Irvine, CA 92713, (800) 826-3874; in California, (800) 826-7559 or (714) 863-1900.
Inquiry 569.

300- to 9600-bps Modem

Fastcomm Data introduced a modem that transmits data at 300, 1200, 2400, and 9600 bps. The Fastcomm modem enables you to connect with another computer at lower speed, then switch to 9600 bps for downloading files.

Available in internal ($979), external ($999), and rack-mount ($979) models, the modem offers auto-dial/auto-answer capabilities and nonvolatile memory for storing communication parameters. The modem supports a superset of the Hayes AT command set, as well as the Bell 212A and CCITT V.22bis and V.29 standards. Contact EVI/Fastcomm Data Corp., 12347-E Sunrise Valley Dr., Reston, VA 22091, (703) 620-3900.
Inquiry 570.

Mitsubishi's Low-Cost Digitizer

The Grafnet Model-01 from Mitsubishi is a standard page-size digitizer with an active area 8.3 inches by 11.8 inches. Priced at $395, the tablet comes with a pen or an optional four-button puck.

The digitizer operates at up to 60 points per second; its resolution is 0.1 mm or 250 lines per inch. It features a DIP-switch-selectable range of output data formats that, the company says, makes it compatible with any computer input protocol. The tablet works with AutoCAD, P-CAD, PC-Paint, and other standard software packages.

A power supply is bundled with the tablet; a 6-foot RS-232C connecting cable is optional. Contact Mitsubishi International Corp., 520 Madison Ave., New York, NY 10022, (212) 605-2607.
Inquiry 571.

High-Resolution Display for Macintosh

MicroGraphic Images is offering MegaScreen, a graphics display interface for the Macintosh that provides a resolution of 1024 by 1024 pixels. The $1495 board includes 128K bytes of memory and fits inside the computer.

According to the company, the board can be modified to work with any monitor, including a video projector, an IBM monochrome monitor, a television, or a VCR at low resolution. For an additional $1500, MicroGraphic offers a 20-inch monitor with a resolution of 1024 by 980 that is said to be the same as the one offered with Sun computers.

The company claims that almost all Macintosh software that uses a "grow bar" can be grown to cover the entire high-resolution screen. By the end of the year, the company expects to have an option available for the interface that will let users connect a video camera and do fast digitization. Contact MicroGraphic Images Corp., 20954 Osborne St., Canoga Park, CA 91304, (818) 407-0571.
Inquiry 572.

Teleswitch Gives You Access to Remote PC

Teleswitch, a power-control device that can be activated through a remote phone or modem, enables a password-authorized caller to turn on a personal computer and peripherals at any time and from anywhere. The device keeps the system's power on for as long as the caller stays on-line. A time-delay circuit turns the power off five minutes after the caller disconnects the line.

To power a computer up, you dial the number, hang up the phone when the system answers, and then redial after about a minute or a sufficient interval to allow the computer to boot up. Redial and password validation must be completed within five minutes; otherwise, the device automatically turns the computer's power off.

The unit also features voltage spike and surge suppression for all devices plugged into its four power outlets. The device complements pcAnywhere, a remote-access communications program developed by Dynamic Microprocessor Associates that runs on IBM PCs. Suggested retail price for Teleswitch is $229. Contact EKD Computer Sales and Supply Corp., 764 Middle Country Rd., Selden, NY 11784, (516) 736-0500.
Inquiry 573.

Memory Upgrade for Amigas

Alegra, a memory expansion unit from Access Associates, adds 512K to 2 megabytes of RAM to the Commodore Amiga. The unit supports the autoconfiguration architecture of the Amiga; with 512K bytes of RAM, it costs $379.

According to the company, the Alegra's power requirement is less than 5 watts for all versions; power is supplied by the Amiga at the expansion connector. Contact Access Associates, 491 Aldo Ave., Santa Clara, CA 95054, (408) 727-0256.
Inquiry 574.

Streaming Tape Backup for Macs

Mirror Technologies' Magnum Tape 20 tape drive offers image, file-by-file, and incremental tape backup for the Macintosh computer. The drive uses tape cartridges ($29) with a capacity of 25 megabytes.

Priced at $1195, the drive connects to the SCSI port of a Mac Plus or to a Fat Mac equipped with the company's Fast Port option ($199). Contact Mirror Technologies, 2209 Phelps Rd., Box 304, Hugo, MN 55038, (612) 426-3276.
Inquiry 575.

(continued)

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ADD-INS

Internal Hard Drive for Tandy 1000

An internal 10-megabyte hard disk drive for the Tandy 1000 is available from J&M Systems. The $495 drive comes with a controller, cables, mounting hardware, and installation manual. The drive requires IBM PC-DOS 2.1 or later; its low power consumption, the company says, enables it to be powered by the Tandy 1000's power supply. For more information, contact J&M Systems Ltd., 15100-A Central SE, Albuquerque, NM 87123, (505) 292-4182.
Inquiry **576.**

PC Network for $250 per Computer

The Invisible Network, a local area network for IBM PCs and compatibles, can connect up to 45 computers at a maximum distance of 1300 feet. Each computer in the network is equipped with a plug-in board and linked with double twisted-pair wire and telephone jacks. The network requires one computer with a minimum of 320K bytes of RAM and a hard disk to be used as server; the company recommends an IBM PC AT.

The network transfers data at a rate of 700K bits per second. It requires the IBM PC Network program as the network operating system and can run PC- or MS-DOS 3.1 or later and multiuser NETBIOS programs such as dBASE III Plus, R:base 5000, and others.

Each plug-in board costs $249.95; a 30-foot cable sells for $10. A starter kit with two plug-in cards and a cable costs $499.90. For more information, contact Invisible Software Inc., 481 47th Ave., San Francisco, CA 94121, (415) 221-0916.
Inquiry **577.**

Plug-in ROM Simulator

The ROMSim from Grossman + Associates is a ROM simulator board designed to increase the efficiency of microprocessor development. According to the company, the board can be used in place of in-circuit emulators in most development applications.

The board occupies one slot in the IBM PC AT and compatibles and emulates 2716, 2732, 2764, 27128, and 27256 ROMs. ROM-based programs can execute from the board's RAM, and programs assembled on the computer can be loaded directly into the board. You can use the standard DEBUG utility to enter patches or changes to a program while debugging. The board also features address trapping and a processor address capture.

The ROMSim costs $650. For more information, contact Grossman + Associates, 749 Grayling Bay, Costa Mesa, CA 92626, (714) 662-7911.
Inquiry **578.**

4- and 8-Megabyte RAM Upgrades for RT PCs

Clearpoint released two memory expansion boards for the IBM RT PC. The RTRAM/4 offers up to 4 megabytes of RAM using 256K ZIP DRAMs, and the RTRAM/8 offers an 8-megabyte capacity using megabit DRAMs. Both boards support the RT's error detection and correction logic and have an access time of 150 nanoseconds.

The RTRAM/4 draws 1.9 amps, and the RTRAM/8 draws 1.4 amps because of the fewer number of DRAMs. List price for the 4-megabyte board is $1895; for the 8-megabyte board, $4395. For more information, contact Clearpoint Inc., 99 South St., Hopkinton, MA 01748, (617) 435-5395.
Inquiry **579.**

Definicon's 32-bit Coprocessors for PCs

Definicon Systems has developed two 32-bit coprocessor boards for IBM PC XTs, ATs, and compatible computers. The boards have an NS32032 processor operating at a minimum of 10 MHz, an NS32081 floating-point processor, and an NS32082 memory management unit for MS-DOS virtual memory functions. Both boards support multiuser tasks under AT&T's UNIX System V.

The basic board (DSE-32) can be equipped with up to 2 megabytes of dual-ported RAM. The DSI-32E comes with 2 or 4 megabytes of 120-ns RAM and features an expansion socket that accepts one or two half-size piggyback boards for up to 12 megabytes of RAM. The DSI-32E is also available with a clock speed option that boosts the clock rate to 15 MHz. Both boards include a 2681 DUART operating at 38,400 bps and two RS-232C serial ports via DB-25 and DB-9 connectors.

The boards' proprietary loader runs under MS-DOS 2.0 and later. For software development, the company offers C, Pascal, and FORTRAN compilers, as well as assemblers, linkers, loaders, library managers, symbolic debuggers, public domain FORTH and LISP, a graphics library for virtual screens, and utilities.

Prices for the DSI-32 begin at $1495; for the DSI-32E, $2295. A 4-megabyte add-on board costs $1795. For more information, contact Definicon Systems Inc., 31324 Via Colinas, Suite 108, Westlake Village, CA 91362, (818) 889-1646.
Inquiry **580.**

GPIB Interface for PCs from Philips

Philips introduced a GPIB interface that allows an IBM PC, AT, or compatible computer to connect to and control up to 15 instruments.

The PM 2201 board plugs into one of the computer's expansion slots and comes with supporting software and an installation and programming manual. The software enables you to call GPIB procedures through a high-level language addition to the computer's BASICA or GW-BASIC interpreter. Functions include bus initialization, sending commands, sending and receiving messages, remote and local instrument setting, serial polling, time-out setting, error reporting, and others.

The PM 2201 sells for $850. For more information, contact Philips Test and Measurement Instruments Inc., 85 McKee Dr., Mahwah, NJ 07430, (201) 529-3800.
Inquiry **581.**

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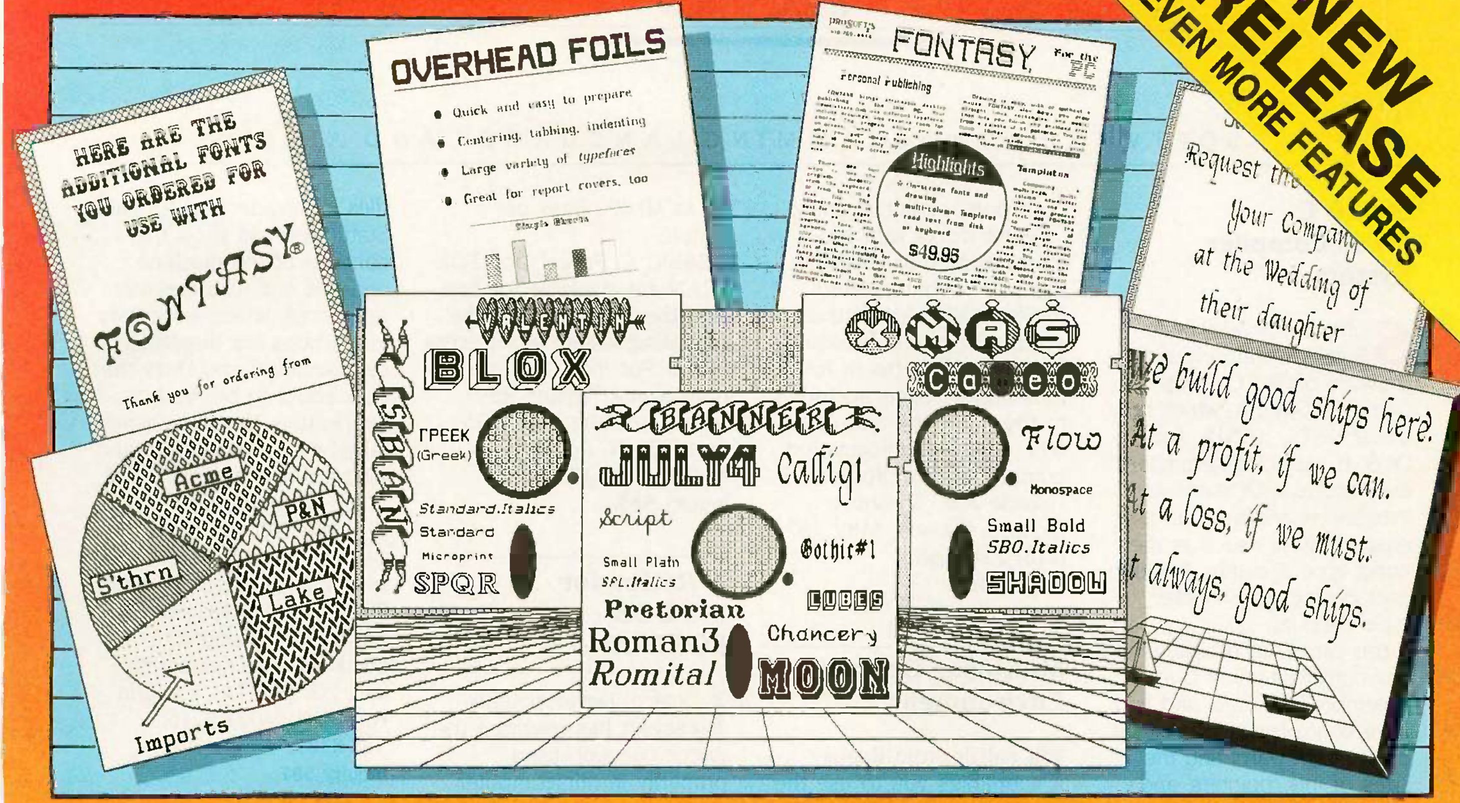

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Inquiry 281

SOFTWARE • PROGRAMMING LANGUAGES AND AIDS

68020 C Cross-Compiler System

Software Development Systems announced the UniWare 68020 C Cross-Compiler System, which runs under UNIX, XENIX, and DOS. It supports Kernighan and Ritchie with standard extensions and new language features such as the const type specifier, function prototyping, and lint-like type checking.

You can write programs in any combination of C and assembly language, and you have control over placement of program parts and the sizes of ints, pointers, and other types.

The package includes a 68020 assembler with macros. The DOS version sells for $595; XENIX for $1390; and UNIX for $2790. Contact Software Development Systems Inc., 3110 Woodcreek Dr., Downers Grove, IL 60515, (312) 971-8170.

Inquiry **582.**

Serial Async Communications

A serial asynchronous communications package, Dual Serial Port Manager from Akron Software provides an interface between an application program and the serial ports of an IBM PC, XT, AT, or compatible. It enables applications developers to write programs that communicate with external modems, computers, or other peripherals via the COM1 and COM2 ports.

The interface program is interrupt-driven, buffers all received and transmitted data, and enables developers to specify the size of each buffer. With DSPM, an application program can use both ports simultaneously.

DSPM works with programs written in Pascal, C, compiled or interpreted BASIC, FORTRAN, and assembly language. It requires less than 2K bytes of RAM plus buffer space, according to the company, and costs $99. For more information, contact Akron Software, 53 Hillside Ave., Toronto, Ontario, Canada, M8V 1S7, (416) 251-1866.

Inquiry **583.**

Multiuser Operating Environment

RealFile from Realia enables you to use the file-sharing capabilities of PC-DOS on the IBM PC Network. A central journal communicates task record locks, current positions, and block alterations.

The RealFile operating environment runs on IBM PCs, XTs, ATs, and compatibles running PC-DOS or MS-DOS 3.1 or higher. The program uses 8K bytes of RAM and costs $150. For more information, contact Realia, 10 South Riverside Plaza, Chicago, IL 60606, (312) 346-0642.

Inquiry **584.**

PDOS for 68020 Systems

Eyring Research Institute announced a version of PDOS for 68020-based systems. PDOS includes a real-time, multitasking kernel, file manager, editor, floating-point module, assembler, and linker. These require less than 32K bytes of RAM, according to Eyring.

The Institute reports that the macro assembler runs up to 40,000 lines per minute.

BASIC, C, Pascal, and FORTRAN are available for use with the 68020 PDOS. The operating system alone costs $1250. For more information, contact Eyring Research Institute Inc., 1455 West 820 N, Provo, UT 84601, (801) 375-2434.

Inquiry **585.**

A Ratfor for MS-DOS FORTRAN-77

Logical Developments says it has rewritten the Ratfor concept, used primarily in minicomputer applications, using C, enabling it to work with FORTRAN-77 compilers and personal computers.

RF77 is a translator program, with programs written in RF77 syntax and then converted into equivalent FORTRAN code. RF77 also accommodates FORTRAN's formatting requirements, enabling the programs to be compiled with any normal FORTRAN compiler.

RF77 adds WHILE, FOR, and REPEAT. . .UNTIL loop-control structures, which are not in FORTRAN.

The RF77 program requires an IBM PC or compatible running MS-DOS or PC-DOS 2.0 or higher. RF77 costs $65. For more information, contact Logical Developments, P.O. Box 55798, Houston, TX 77255, (800) 835-2246, ext. 41.

Inquiry **586.**

Simulator/Debuggers for MS-DOS Machines

Mecklenburg Engineering's simulator/debuggers enable you to test and debug software by loading files in hexadecimal format. Status displays show the contents of the machine registers and also memory references, where necessary. Instructions are displayed disassembled and show the data about to be read or overwritten. You can change target machine registers and memory from the keyboard.

The programs run on IBM PCs, XTs, ATs, and compatibles. Versions are available for the 6300, 6500, 6800, 8085, 8048, and Z80. Each is $75. Contact Mecklenburg Engineering Inc., P.O. Box 744, Chagrin Falls, OH 44022, (216) 338-8379.

Inquiry **587.**

Visual COBOL

Visual COBOL from mbp Software and Systems Technology is an enhanced version of its native code COBOL compiler. New features include full support of DOS path names, faster compilation speed, and a shrink utility that, according to the company, reduces the size of executable code.

This screen management system has an enhanced mask editor that creates a working-storage screen definition in the form of a COPY file. The enhanced mask editor also offers real-time numeric field validation and update capabilities with an ACCEPT statement.

Visual COBOL runs on IBM PCs, XTs, ATs, and compatibles with 192K-byte RAMs. The company recommends a hard disk. The package costs $1150. Contact mbp Software and Systems Technology Inc., 1131 Harbor Bay Parkway, Suite 260, Alameda, CA 94501, (415) 769-5333.

Inquiry **588.**

(continued)

TRANSEC NEW PRODUCTS

Program Review:

TRANSEC dANALYST™
CONVERTS ANY dBASE III®
TO dBASE III PLUS
$74.95

Makes d BASE Easier to Program, Reduces Logic Errors, Bugs

TranSec d ANALYST™ automatically converts any d BASE III program to d BASE III PLUS with true record and file locking for multi-user operation. Features include syntax/blocking analysis, tabbed file output, variable cross reference. Framework-type interface command windows, pop-up menus, graphic analysis REPORTS menu. Saves programmer's time to analyze and debug d BASE II, III, or PLUS. Supports multi-user Clipper and network version of WordTech. Not copy protected. Rated a "best buy."

TranSec dANALYST™	**$74.95 plus $5 s/h**
TO ORDER: 1-800-423-0772	**VISA/MC**
IN FL: 1-305-474-7548	

Program Review:

Simplify Naming, Finding Your Files with 32-Character File Names

TranSec PCEasy™ is a new easyto-use "office environment" file management system that allows anyone to easily organize large amounts of data on a hard disk. Expands DOS file name limit to 32 characters to name files naturally, the way you think. Use easily remembered plain words or numbers. The interface structure mimics the paper world, only it's faster, better and easier to use . . . by programmers, managers, secretaries, clerks. PCEasy immediately finds file cabinets, file drawers, file folders, spread sheets, reports in their own logical location. Automatic menu access to application programs. Works with all popular applications and utilities. Not copy protected. Rated "★★★★ for ease of use."

TranSec PCEasy™	**$74.95 plus $5 s/h**
TO ORDER: 1-800-423-0772	**VISA/MC**
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UNlock "copying" disk allows you to make "unprotected" DOS copies of popular original program disks. **Unprotected backup copies** perform perfectly, as do copies of these copies. UNlock copies **run on any hard disk,** including Bernoulli Boxes. No original required in drive "A." **Run on a RAM disk** simply and conveniently. **Also, copy DOS 5¼" programs to 3½" diskettes.** For IBM® PC, XT, AT, compatibles, 256K or more, DOS 2.1 or higher. Choice of the critics!

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- THINKTANK™ (2.0, 2.1)
- LOTUS 1-2-3™ (1.A-2.0)
- IBM WRITING ASSISTANT™ (1.01)
- IBM FILING ASSISTANT™ (1.0)
- IBM REPORTING ASSISTANT™ (1.0)
- GRAPHWRITER™ (4.3, 4.31)
- REALIA COBOL™ (1.2, 2.0)
- MULTILINK ADVANCED™ (3.02, 3.03)
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- CLIPPER™
- LOTUS 1-2-3 REPORT WRITER™ (1.0)
- DOUBLEDOS™
- smARTWORK™ (1.0 Rev. 8 thru 10 & 1.1)
- DISK OPTIMIZER™
- MANAGING YOUR MONEY™ (1.5, 1.51, 2.0)
- MICROSOFT WORD™ (1.15, 2.0, 2.01)
- PFS: ACCESS™ (1984 Ed.)
- PFS: PLAN™ (B)
- PFS: GRAPH™ (B)
- PFS: WRITE™ (1.01, C)
- PFS: REPORT™ (B, C)
- PFS: FILE™ (B, C)
- DATABASE MANAGER II—THE INTEGRATOR™ (2.0, 2.02)

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- SIGNMASTER™ (5. 1)
- DOLLARS & SENSE™ (2.0)
- LOTUS 1-2-3™ (1.A-2.0)
- SYMPHONY™ (1.1)
- LOTUS 1-2-3 REPORT WRITER™ (1.0)
- DOUBLEDOS™
- HARVARD TOTAL PROJECT MGR.™ (1.10)
- MANAGING YOUR MONEY™ (1.5, 1.51, 2.0)
- THINKTANK™ (2.0, 2.1)
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CHOICE OF THE CRITICS!

PERSONAL COMPUTING "UNlock has two particularly endearing characteristics: it works, and works simply. I was able to quickly produce unprotected copies of Lotus 1-2-3 release 2, Symphony 1.1, Microsoft Word 2.0, d Base III 1.1, and Framework II. These copies performed flawlessly, as did copies of these copies."
Christopher O'Malley,
PERSONAL COMPUTING, April '86

PC MAGAZINE "Because copy protection can interfere with the ability to back up a hard disk, business-oriented users may prefer programs like TranSec's UNlock series."
Winn L. Rosch, **PC MAGAZINE, May 27, 1986**

BYTE "UNlock 4.7 defeats the latest Prolok and SuperLock type of copy protection scheme. It's menu-driven and works fine on the programs it's supposed to work on: Lotus 1-2-3, d Base III, Framework, Symphony, Paradox, and several others."
Jerry Pournelle, **BYTE, Feb. '86**

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SOFTWARE • SCIENTIFIC AND ENGINEERING

Program for Robot Design

Kern International's MATMAN, a program for computer-aided design of robot arms written at Texas A&M, is based on the Stanford manipulator. The software can predict the degree-of-freedom motion of the manipulator when the control parameters of each link are specified, or it can tell what the control parameters should be for a particular movement. MATMAN symbolically handles the complex matrix manipulation.

The disk contains source code in BASIC for the IBM PC. The manual covers the theory of robot manipulator kinematics and the derivation of equations. MATMAN sells for $85. Contact Kern International Inc., 575 Washington St., Pembroke, MA 02359, (617) 826-0095.
Inquiry **589.**

Computer-aided Circuit Design

Esoft's electronic design tool, CompDes, is a menu-driven program with selections that range from basic electricity to circuit design.

The program calculates values of circuits for active and passive filters, attenuators, amplifiers, and power supplies. You can determine circuit values of resistance, reactance, resonance, and decibel ratios with the program's built-in calculators.

To use CompDes, you must have an IBM PC, XT, AT, or compatible with MS-DOS or PC-DOS 2.0 or higher and at least 128K bytes of RAM. The price is $49.95. Contact Esoft Software, P.O. Box 072134, Columbus, OH 43207, (614) 491-0832.
Inquiry **590.**

Least Squares Approximation

Alpha Applied Research announced R2, a least squares approximation software package with curve fitting and data correlation capabilities.

You can build mathematical models of scientific and engineering data using a variety of functions, including polynomials, exponentials, power functions, logarithmics, trigonometrics, inverse trigonometrics, hyperbolics, and inverse hyperbolics. You can test many functional forms, according to the company, with the addition of user-defined variables. You can also build linear and nonlinear equations in two to ten variables from experimental data.

To run R2 you must have an IBM PC XT or compatible running MS-DOS or PC-DOS 2.0 or higher, at least 256K bytes of RAM, and a single floppy disk drive. R2 costs $199 for the single-variable configuration; $298 for the multiple version. Contact Alpha Applied Research, 2355 McLean Blvd., Eugene, OR 97405, (503) 485-6841.
Inquiry **591.**

Signal Processing on the IBM PC

Tektronix announced Signal Processing and Display Programs, a waveform-processing, display, and data structure manipulation package.

SPD offers signal processing algorithms, enhanced graphics, flexible data structures, and software libraries. According to the company, SPD has more than 190 processing functions.

All of the waveform-processing graphic-display functions and data structure manipulation utilities are written in C. Some of these functions can be accessed through a BASIC interface as well.

Hardware requirements include an IBM PC, XT, AT, or compatible with 256K bytes of RAM, a hard disk, and color graphics adapter. The company recommends using an XT or AT with 640K RAM. For BASIC programming, you'll need an IBM BASIC version 1.0 compiler. For C programming, SPD is compatible with Lattice C version 2.15. The cost of the package is $950. Contact Tektronix Inc., P.O. Box 500, Beaverton, OR 97077, (800) 426-2200; in Oregon, (503) 627-9000.
Inquiry **592.**

Guide to Signal Processing

Moonshadow Software describes its SPIA as an interactive software guide for people who want to study signal processing. Using the program, you "build" functions by selecting from a library of predefined functions and mathematical operations. These operations include Fourier transforms, convolutions, and correlations. Each command is displayed graphically in up to three windows. SPIA also operates on user-acquired data.

The package runs on the IBM PC family and compatibles and supports several graphics adapters, including Hercules and IBM devices. It costs $99; "qualified students" can buy it for $25. Contact Moonshadow Software, 5016 Castlewood Dr., San Jose, CA 95129, (408) 446-2459.
Inquiry **593.**

SOFTWARE • BUSINESS AND OTHER

Linking XENIX Machines

MMB's TEAMate is a tool that enables groups of people to work together using their existing terminals, XENIX-based personal computers, and software.

TEAMate structures users' files into an outline form, from which members of the team can develop, reorganize, edit, or read documents. These can include text, spreadsheets, or graphs.

The software can also be used as an electronic messaging system and a computer conferencing system for both internal and external communication.

The user interface is curcursor-controlled. Other features include an on-line help facility, database access control, XMODEM support, and mappable keys for nonstandard terminal support. You can customize the commands, database, and screen and print formats for vertical applications.

TEAMate runs under SCO XENIX System V on the IBM PC AT and compatibles. Prices for TEAMate start at $1995. An upgrade kit, which includes SCO XENIX System V, a database system, a word-processing system, 2 megabytes of

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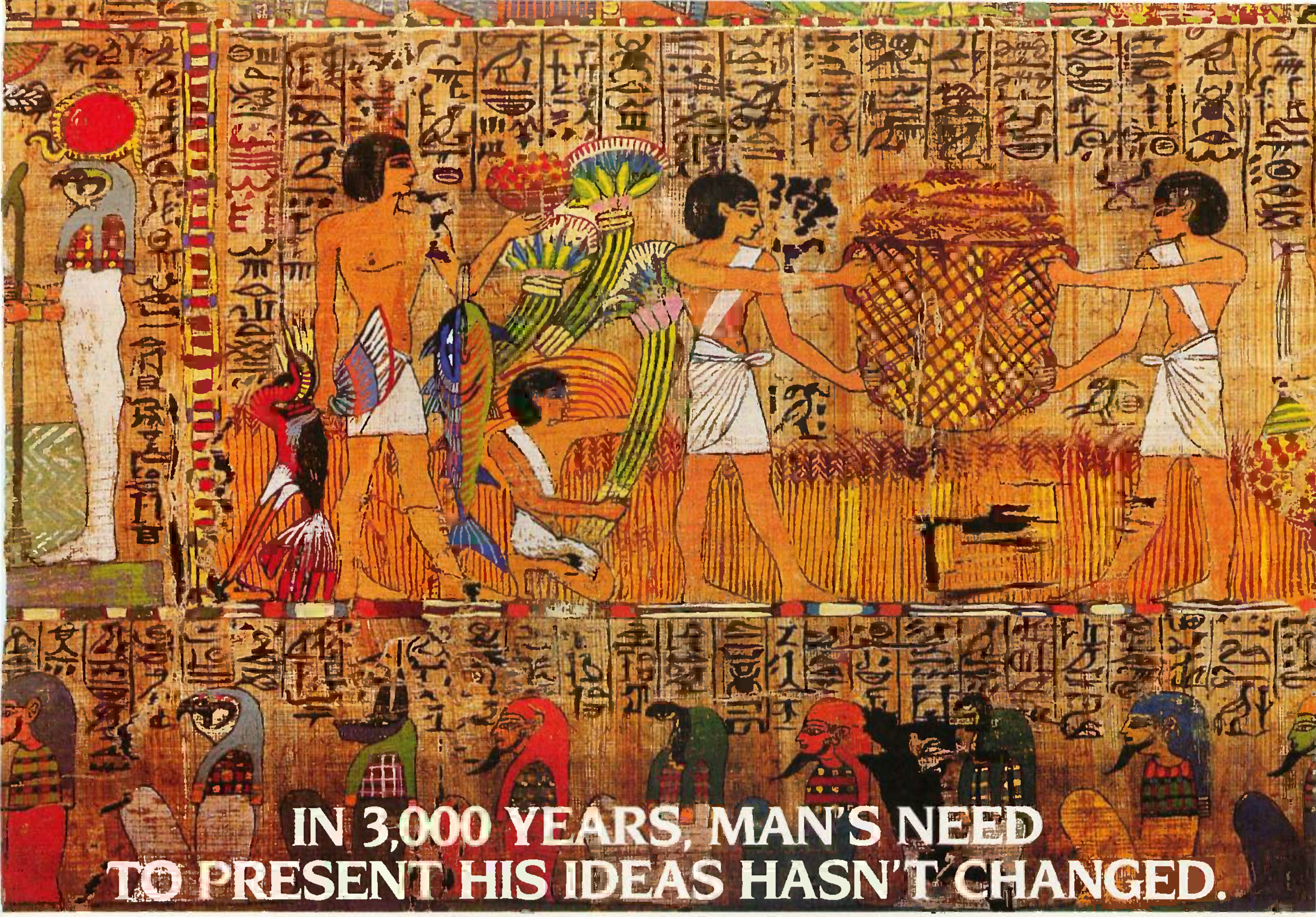

IN 3,000 YEARS, MAN'S NEED TO PRESENT HIS IDEAS HASN'T CHANGED. BUT HIS TOOLS HAVE.

Counting the corn and measuring the market used to demand artistic, as well as accounting, virtuosity. And before you could show your results to the powers that be, you had to wait for the ink to dry on the papyrus.

Today the whole procedure is cut and dried. Computers separate the wheat from the chaff. And printers present the results faster than an asp can strike.

Now, the new OKIDATA MICROLINE® 290 series goes beyond speed to give you graphic capabilities the ancient scribes would envy. The 292 model produces executive-quality correspondence at "need-it-yesterday" speed. The 293 prints just as fast on paper as wide as 16". And for lightning-fast, high-quality data processing, the 294 wide carriage simply can't be beat.

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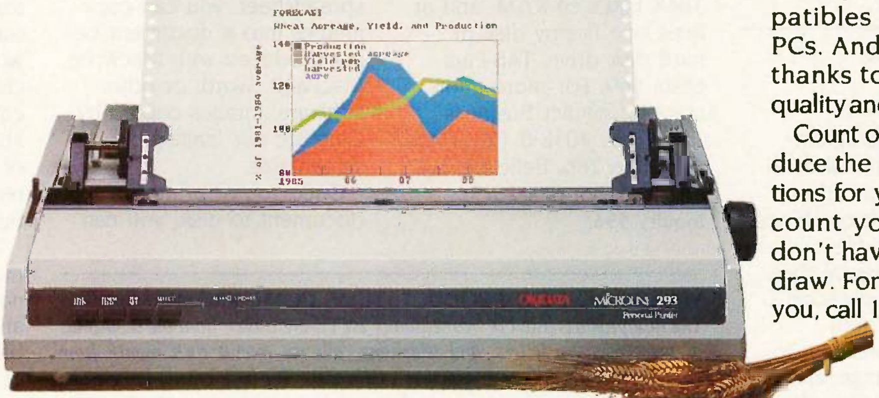

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memory, and four serial ports, costs $4500. For more information, contact MMB Development Corp., 753 Deep Valley Dr., Rolling Hills Estates, CA 90274, (213) 541-4504.
Inquiry 594.

Relational Database

Microrim announced R:base System V, a database management product for the IBM PC and compatibles. This relational database enables multiple users to perform data management and create programs to automate data management tasks in standalone or multiuser LAN environments.

R:base System V requires an IBM PC, XT, AT, or compatible, with PC-DOS or MS-DOS 2.0 or higher for single users, 3.1 or higher for multiusers. Single users need 512K bytes of RAM; multiusers need 640K. A hard disk is required. The price is $700. For more information, contact Microrim Inc., 3925 159th Ave. NE, P.O. Box 97022, Redmond, WA 98073-9722, (206) 885-2000.
Inquiry 595.

Database for IBM PCs

TAS-Plus, a programmable relational database, was announced by Business Tools. It combines the aspects of a file manager, a relational database, and an application development system.

TAS-Plus enables you to create, add, change, and delete database records without writing a program. Front-end facilities include pull-down menus and on-line help screens. You can display multiple records and manipulate data with the browse utility. The report writer organizes the data that you select into report formats that you define. Also, you can convert dBASE III files to TAS-Plus files with another utility. Up to 16 files can be open at the same time, and they can be updated as well. And you can chain to other programs or execute DOS commands without leaving TAS-Plus.

System requirements include an IBM PC, XT, AT, or compatible running MS-DOS or PC-DOS 2.0 or higher. You must also have a monochrome or color monitor, 384K bytes of RAM, and at least one floppy disk or hard disk drive. TAS-Plus costs $69. For more information, contact Business Tools Inc., 4038-B 128th Ave. SE, Suite 266, Bellevue, WA 98006, (206) 644-2015.
Inquiry 596.

```
Several commands display data from a database.

SELECT   Displays data from a table in rows and columns.
BROWSE   Displays data while scrolling up, down, left and right in the
         rows and columns of a table.
COMPUTE  Calculates the count, minimum, maximum, average, sum, number of
         rows, standard deviation, variance or all of these values
         for a column.
TALLY    Displays unique values with number of occurrences in a column.
CROSSTAB Cross-tabulates values in two columns.
LIST     Displays information about the structure of an open database or
         lists available databases on the current directory.
VIEW     Defines a view to look at data in multiple tables.

                         Choose a command
SELECT   BROWSE    COMPUTE   TALLY    CROSSTAB  LIST     VIEW
```

A *screen from Microrim's* R:*base System* V.

Graphics Glue

Glue is a Macintosh software package that enhances desktop-publishing programs, such as PageMaker and ReadySetGo, by letting you incorporate in a document graphics from most Mac applications. Solutions Inc. says its product also makes electronic distribution of documents (newsletters, for example) practical.

The program adds a print-to-disk capability to most Mac applications. After you've saved a graph or a spreadsheet, you can copy images into a document being produced with MacWrite, MacPaint, Word, or other software. Images copied by Glue are not limited by screen size.

Once you've printed a document to disk, you can send it through a network or e-mail system, using most communications packages, Solutions says.

Glue runs on any Mac and is HFS-compatible. Suggested retail price is $49. Contact Solutions Inc., P.O. Box 989, Montpelier, VT 05602, (802) 229-0368.
Inquiry 597.

Function Library Enhances Clipper

Communication Horizons announced five versions of its function libraries, which provide record- and file-locking capabilities for the Clipper dBASE III compiler from Nantucket.

NovelLib provides multiuser capabilities for Clipper running on the Novell Network and requires Novell's Netware 4.61 or higher. PCnetLib is for use with IBM's PC Network or Token Ring. MlinkLib works with The Software Link's MultiLink Advanced or LANLink. 3ComLib is for use with 3Com's EtherShare series. OrchidLib works with Alloy Computer Products' ATNX, RTNX, or NTNX and AST's PCnet.

All libraries share the same syntax and can be transported to another network with few program changes, according to the company. The multiuser libraries include a basic core of functions that parallel the record- and file-locking function of dBASE III Plus.

To use the libraries, you must have the appropriate network or multiuser system and an IBM PC or compatible with approximately 20K of free memory above the single-user program size. The libraries cost $99 each. Contact Communication Horizons, 701 Seventh Ave., Suite 900, New York, NY 10036, (212) 724-0150.
Inquiry 598.

WHERE DO NEW PRODUCT ITEMS COME FROM?

The new products listed in this section of BYTE *are chosen from the thousands of press releases, letters, and telephone calls we receive each month from manufacturers, distributors, designers, and readers. The basic criteria for selection for publication are:* (a) *does a product match our readers' interests? and* (b) *is it new or is it simply a reintroduction of an old item? Because of the volume of submissions we must sort through every month, the items we publish are based on vendors' statements and are not individually verified. If you want your product to be considered for publication (at no charge), send full information about it, including its price and an address and telephone number where a reader can get further information, to New Products Editor,* BYTE, *One Phoenix Mill Lane, Peterborough,* NH 03458.

Small Wonder.

Proof positive that good things come in small packages is the new 3.5-inch diskette.

And that's big news for anyone who uses an appropriately configured IBM PC, PC/XT, Personal Computer AT and the new IBM PC Convertible.

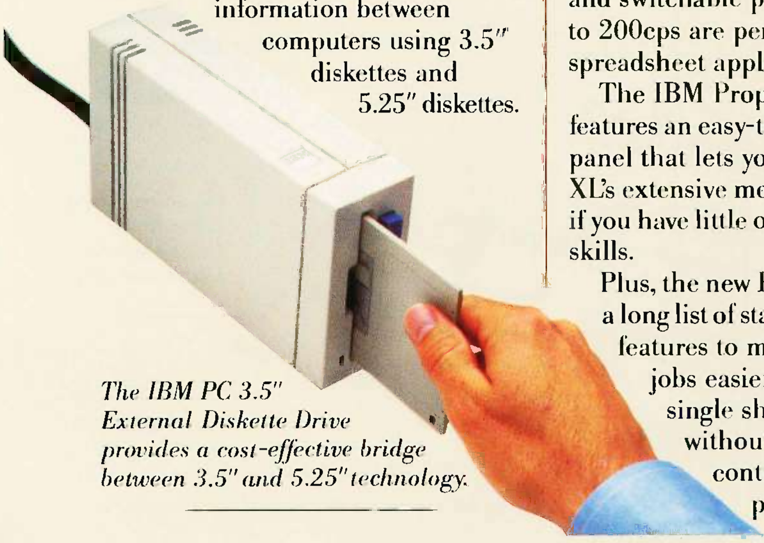
Durable 3.5" diskettes, allow you to carry over 350 standard typed pages (720KB) in your shirt pocket. That's twice as much information as on a 5.25" (360KB) diskette, in a much more rugged, portable form.

The new 3.5" diskette stores up to twice as much (720 KB) as a 5.25" (360KB) diskette.

Now IBM PC users have the option of using programs and data in either size, and the flexibility to work with other members of the IBM PC family using 3.5" diskettes.

Translation Services.

The new IBM Personal Computer 3.5" External Diskette Drive provides a vital bridge between your IBM PC and 3.5" technology. This compact unit makes it easy for you to share information between computers using 3.5" diskettes and 5.25" diskettes.



The IBM PC 3.5" External Diskette Drive provides a cost-effective bridge between 3.5" and 5.25" technology.

The new IBM PC Convertible is a f

The IBM Personal Computer 3.5" External Diskette Drive comes in two models, one for the IBM Personal Computer AT and one for the IBM PC, PC/XT or IBM PC Convertible.

Information and applications can be shared* between 3.5" diskette drive machines and an IBM PC running DOS 3.2 with the IBM Personal Computer 3.5" External Diskette Drive attached.

Transferring files and programs between 3.5" and 5.25" diskettes is as easy as making a backup copy of a diskette. So, you can very quickly have a "database to go" for your IBM PC Convertible. Or, a week's worth of sales call information in a ready-to-use form for your secretary when you return.

Print Evolution.

The new IBM Proprinter XL is especially designed to make life easier for those who work with accounting applications. Its wide carriage design and switchable printing speeds of up to 200cps are perfectly suited for spreadsheet applications.

The IBM Proprinter XL also features an easy-to-use front operator panel that lets you choose from the XL's extensive menu of features, even if you have little or no programming skills.

Plus, the new Proprinter XL offers a long list of standard, labor-saving features to make many printing jobs easier: easy printing of single sheets and envelopes without removing your continuous forms paper, power-assisted paper loading, all-points-addressable graphics capabilities, near-letter-quality printing (40cps), and emphasized text printing (100cps). Plus, you can set the printer in double high, double wide or emphasized print through the operator panel or through software.

Power To Go.

The new IBM PC Convertible can play two powerful roles in any businessperson's life.

In the office, with an optional IBM PC monochrome or color display and adapter, the PC Convertible fills the bill as a space-saving desktop PC.

But when you're ready to hit the road or runway, just attach the high quality, 80-column x 25-line detachable LCD display, and the PC Convertible is ready to travel, too.

Weighing in at a scant 12 pounds, the IBM PC Convertible delivers full-size PC performance in a portable computer with heavyweight features including:

A full-function keyboard with full-size keys and the same center-to-center key spacing as a standard IBM PC keyboard.

A fast, very efficient 80C88 microprocessor with up to 10 hours of non-stop computing power between battery recharges (with average use).

Up to 512KB of user storage (through 128KB expansion cards from a standard 256KB).

Dual 3.5" diskette drives supporting 720KB capacity 3.5" diskettes.

Additional IBM PC Convertible features help ensure that work done on the road doesn't get lost in transit.

READ ONLY

A review of the IBM Personal Computer Family. Vol. 3, No. 1

Welcome To *Read Only.*

Here's great news for IBM PC users. IBM has expanded its already expansive PC product line to bring even more power and flexibility to your desktop.

In this issue alone you'll be reading about new enhancements to the IBM PC/XT, the IBM Personal Computer AT,® the IBM PC Keyboard, the IBM Proprinter, the Mainframe Communications Assistant, and more.

And, as if that weren't enough, IBM has also found time to expand your computing horizons even more by introducing exciting new PC products. This issue of *Read Only* will tell you about the new IBM PC Convertible, new 3.5″ diskettes, the new IBM PC 3.5″ External Diskette Drive, and two new accounting software packages.

HARDWARE NEWS

The Right Touch.

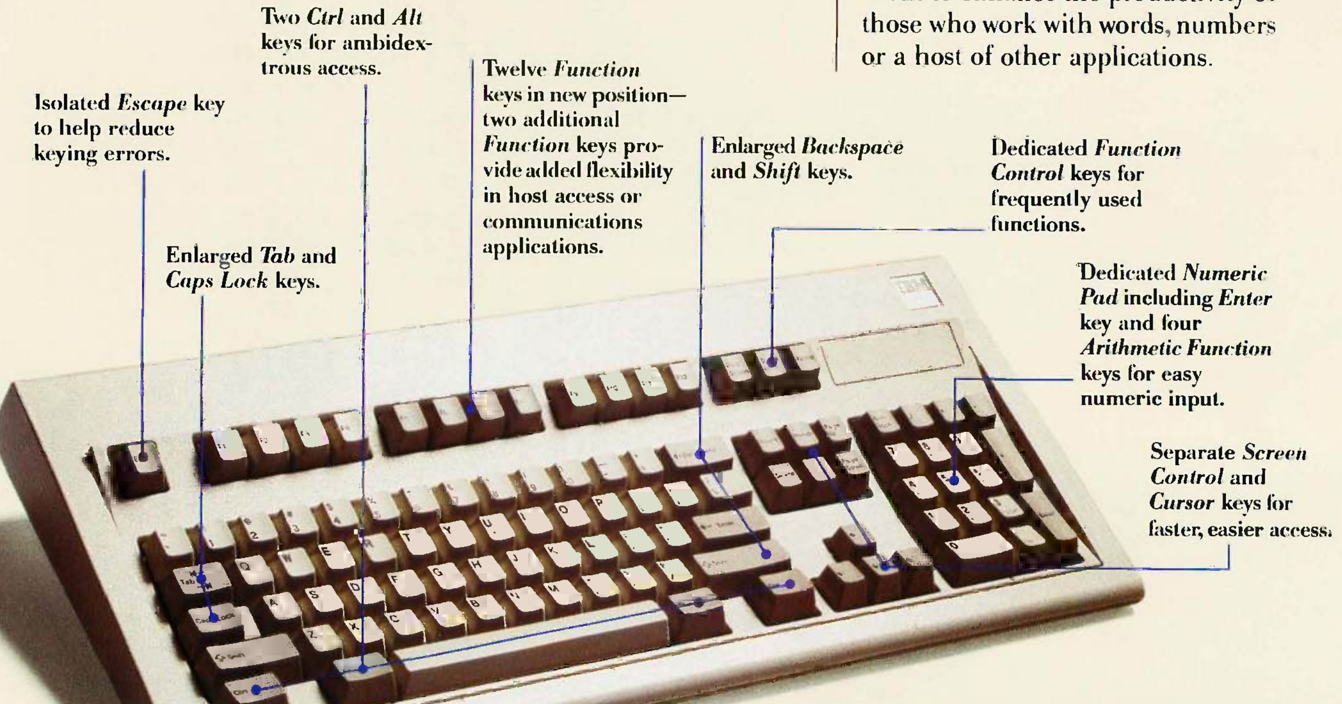
To make it easier than ever to work at an IBM PC/XT or Personal Computer AT, IBM has introduced the new IBM Enhanced Personal Computer Keyboard (shown below).

IBM redesigned its classic keyboard to better meet the needs of PC users, office system users, as well as users who communicate with larger computers.

To accomplish this, IBM included separate cursor and screen control keys, making it easier for users to dedicate the numeric keypad to numeric input when working with number-intense applications. Plus, the keypad can still be used for cursor and screen control when not in the num/lock mode.

IBM also increased the number of function keys from ten to twelve, arranged across the top of the keyboard. This gives users two additional keys for increased automatic operation.

All to enhance the productivity of those who work with words, numbers or a host of other applications.



The IBM Enhanced PC Keyboard to help you be more productive, faster.

wer PC that works wherever you do.

These optional features include:

An internal modem feature to let you communicate with other computers simply by plugging the PC Convertible into any standard modular phone outlet.

The IBM PC Convertible Printer for system battery powered, near-letter-quality printing anywhere.

Plus, the IBM PC Convertible can come with a helpful set of programs to get you up and running on the road to enhanced productivity. Fast.

Planned For Growth.

It's a classic case of a very good thing that just keeps getting better.

IBM has now introduced the *enhanced* PC/XT product family: increased flexibility in storage, memory and option configuration for maximum productivity today, and plenty of room to expand as your business does.

The new IBM PC/XT—enhanced power and flexibility for today. And tomorrow.

The XT is now available with a 20-megabyte hard file that can store up to 10,000 pages of information. There's also an easy, low cost way to increase memory to a full 640KB on the system board without tying up valuable expansion slots. And the XT now has 3.5" diskette capability, utilizing the new IBM Personal Computer 3.5" External Diskette Drive.

Plus, full IBM PC compatibility means that no matter which XT model you choose, you can benefit from the extensive IBM Personal Computer software library.

The new IBM PC/XTs, because one size should not have to fit all.

Power Play.

If you thought you'd seen all the IBM Personal Computer AT has to offer, think again. Twice.

IBM has increased processor speed in two new models of the IBM Personal Computer AT by an impressive 33% (from 6mhz to 8mhz). So, they're sure to become your fast friends if you work with large spreadsheets and volumes of data.

The new models offer a standard 30MB hard file and the option to add an additional 20MB or 30MB hard file. That's a grand total of 60MB, or approximately *30,000* pages of words and numbers.

These two newcomers are born communicators: Sharing files with other PCs from a variety of popular software programs. Working as a server for data storage and file processing in an IBM PC LAN running the IBM PC Local Area Network program. Utilizing IBM TopView™ and one of the IBM PC 3270 Emulation Programs to access mainframe information and to execute PC DOS and mainframe applications concurrently.

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Now the IBM Personal Computer AT offers a choice of hard files to meet your storage needs.

WHAT'S THE PROGRAM

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Keeping the books for a small business is a very big job. So, IBM thought you could use a friendly, versatile, highly skilled assistant. The new IBM Accounting Assistant Series.

This complete series of automated bookkeeping application programs for small to medium size businesses can help cut any job down to size. And, its modular design means that you can start out with just the programs you need today, then expand your series as your business grows.

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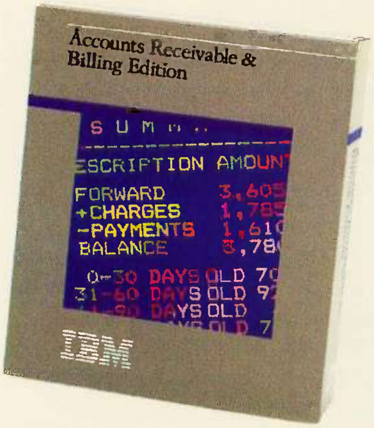

The IBM Accounting Assistant Series. Big help for small to medium size businesses.

Control and Purchasing, and Job Cost bidding software.

Plus, thanks to the IBM Accounting Assistant Series' user-friendly attributes and easy-to-follow instructions, you can start profiting from your system from day one.

High-Powered Advice.

Perhaps your business has progressed past the need for basic accounting software. Then you should consider getting powerful, sophisticated help: the IBM Business Advisor.

IBM Business Advisor PC accounting software takes integrated software to a new level of sophistication and ease-of-use.

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And when you make a change anywhere, consider it made everywhere it applies. Automatically, through Business Advisor's real-time posting feature.

This Business Advisor speaks your language, too. It uses business language instead of accounting language, and has over 80 easily customized financial report formats built in. And you don't have to keep this all to yourself, because in an IBM LAN different people at different PCs can work on the same file at the same time.

And you always go further when everyone is working together.

"NEWS" BRIEFS

The 3270 Emulation Programs, Entry Level, Version 2 and Version 3, give you an easy and inexpensive way to attach your IBM PC to your host computer.

Working at your IBM PC, standalone or in an IBM LAN, you can now utilize the local power and user-friendly attributes of your PC for DOS applications, plus have access to the vast memory, number-crunching capacities and other productivity-enhancing capabilities of your host computer.

The Entry Level product offers up to 40% faster file transfer between your PC and host computer. A "Hot Key"* for easy switching between host and PC applications. Keyboard remapping so you can always work in a familiar keyboard format. And much more.

IBM PC 3270 Emulation Products can put your IBM PC or IBM LAN in touch with the big time.

Versions 2 and 3 can provide an economical gateway which lets you share the wealth of host knowledge with the members of your IBM PC Network or Token-Ring Network.

Versions 2 and 3 support the new PC DOS 3.2, 3.5" media, the IBM Local Area Network program 1.10, a host of printers and the TopView 1.1 interface, for multitasking and windowing capabilities.

All of which adds up to added productivity for you and everyone on your IBM Local Area Network or token ring.

To find out more about the entire family of 3270 PC Emulation Programs, as well as a wide range of other IBM connectivity hardware and software, watch for the next *Read Only.*

Mainframe Communications Assistant enhancements include 3.5" media support and increased IBM PC family communications capabilities.

The IBM PC Voice Communications Option speaks for itself. This multifunction adapter card can allow your IBM PC to recognize and respond to voice commands, speak text that appears on the screen, initiate and receive/record/playback phone calls, provide remote, tone push button phone access to your PC (and host), and transmit voice and data simultaneously.

IBM®

For more information on any of the Personal Computer products discussed in this issue of *Read Only*, see your Authorized IBM Personal Computer Dealer. Or, call **800-447-4700.** In Alaska call **800-447-0890.**

*Before copying any software product, be sure to read, understand and comply with the specific software license agreement and installation instructions for that product.

EVENTS AND CLUBS

September 1986

Events

Midcon/86, Dallas, TX. Electronic Conventions Management Inc., 8110 Airport Blvd., Los Angeles, CA 90045, (800) 421-6816; in California, (800) 262-4208 or (213) 772-2965. *September 9–11*

ESC 86: Second European Simulation Congress, Antwerp, Belgium. The Society for Computer Simulation, P.O. Box 17900, San Diego, CA 92117-7900, or Ghislain C. Vansteenkiste, Professor of Engineering, University of Ghent, Coupure Links 653, B-9000 Ghent, Belgium, tel: 91-236961, ext. 400; telex: 12754 RUGENT. *September 9–12*

Software Engineering '86, Southampton University, United Kingdom. BISL Conference Dept. (SE '86), The British Computer Society, 13 Mansfield St., London W1M 0BP, United Kingdom, tel: 01 637 0471. *September 10–12*

The 39th Annual Conference on Engineering in Medicine and Biology, Baltimore, MD. The Alliance for Engineering in Medicine and Biology, 1101 Connecticut Ave. NW, Suite 700, Washington, DC 20036, (202) 857-1199. *September 13–16*

Euromicro 86: Twelfth Symposium on Microprocessing and Microprogramming, Venice, Italy. Mrs. Chiquita Snippe-Marlisa, p/a TH Twente, Dept. INF, Room A227, P.O. Box 217, 7500 AE Enschede, The Netherlands, tel: (31) (53) 338799; telex: 44200 THES. *September 15–18*

Fall National Design Engineering Show & Conference, Jacob K. Javits Convention Center, New York, NY. Fall National Design Engineering Show, Cahners Exposition Group, 999 Summer St., Stamford, CT 06905, (203) 964-0000. *September 16–18*

Third Annual International Forum on Micro-based CADD, Colorado State University, Fort Collins, CO. Office of Research, Development, and Training, Department of Industrial Sciences, Colorado State University, Fort Collins, CO 80523, (303) 491-5278. *September 17–19*

Canadian High Technology Week, Ottawa, Ontario. Canadian High Technology Week, 2487 Kaladar Ave., Suite 214, Ottawa, Ontario, Canada K1V 8B9, (613) 731-9850. *September 21–27*

1986 Nebraska Videodisc Symposium, Lincoln, NE. Videodisc Design/Production Group, KUON-TV/University of Nebraska, P.O. Box 83111, Lincoln, NE 68501-3111, (402) 472-3611. *September 22–25*

PDOS Interest Group Conference, Garden Grove, CA. Eyring Research Institute Inc., 1455 West 820 N, Provo, UT 84601, (801) 375-2434. *September 22–25*

Ultratech '86, Long Beach, CA. Gregg Balko, Society of Manufacturing Engineers, One SME Dr., P.O. Box 930, Dearborn, MI 48121, (313) 271-1500. *September 22–25*

Artificial Intelligence and Advanced Computer Technology Conference/Exhibition, Rhein-Main Halle, Wiesbaden, West Germany. Tower Conference Management Co., 331 West Wesley St., Wheaton, IL 60187, (312) 668-8100. In Europe, TCM Expositions Ltd., Exchange House, 33 Station Rd., Liphook, Hampshire GU30 7DN, United Kingdom, tel: (44) 0428-724660; telex: 859438 TOWER. *September 23–25*

The International Videotex Industry Exposition and Conference, New York, NY. Susan M. LeDonne, Cahners Exposition Group, 999 Summer St., Stamford, CT 06905, (203) 964-0000. *September 23–25*

ACC '86: 1986 Australian Computer Conference and Exhibitions, Melbourne, Australia. Peter Peterick, Riddell Exhibition Promotions Pty. Ltd., Riddell House, 137-141 Burnley St., Richmond, Victoria 3121, Australia. *September 23–26*

Interex/Hewlett-Packard Computer Users Conference, Detroit, MI. Interex, 680 Almanone Ave., Sunnyvale, CA 94086, (408) 738-4848. *September 29–October 3*

Northcon/86 Electronic Show and Convention, Seattle, WA. Electronic Conventions Management Inc., 8110 Airport Blvd., Los Angeles, CA 90045, (800) 421-6816; in California, (800) 262-4208 or (213) 772-2965. *September 30–October 2*

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

Clubs

The Amigan Apprentice and Journeyman, P.O. Box 411, Hatteras, NC 27943. For Amiga programmers.

North American Amiga Users Group (NAAUG), Box 376, Lemont, PA 16851.

MacInterested, Nashville Macintosh Users Group, c/o Clark Thomas, 2305 Ellison Place #C5, Nashville, TN 37203, (615) 327-1757.

Indy ST Computer Club, Box 2525, Indianapolis, IN 46206, (317) 898-9856.

Amiga Atlanta, Box 7724, Atlanta, GA 30357, (404) 676-0384 or 676-0411.

Space Coast Amiga Users Group, P.O. Box 2098, Merritt Island, FL 32952.

Toronto Atari Federation, 5647 Yonge St. #1527, Willowdale, Ontario, Canada M2M 4E9.

The Space Coast Macintosh Meeting and Drinking Society (MacMad), c/o Jamie Cox, 2604 Lewis St., Melbourne, FL 32901, (305) 723-7935.

Technology Update, Sensory Aids Foundation, 399 Sherman Ave. Suite 12, Palo Alto, CA 94306, (415) 329-0430. Technology for blind and partially sighted people.

Apple PugetSound Program Library Exchange, A.P.P.L.E. Co-op, 290 Southwest 43rd St., Renton, WA 98055.

Snap-n-Sketch Image Processing Users Group, P.O. Box 9506, Berkeley, CA 94709, (415) 841-7627.

KCS CompuClub, KCS Micro Computer Services, 8 Reynolds Cr., Belleville, Ontario, Canada K8P 2W7, (613) 966-8250.

Gavilan User Group, Robert Brown, 780 Manx Ave., Campbell, CA 95008, (408) 379-2774.

Milwaukee Area IBM PC Users Group, P.O. Box 2121, Milwaukee, WI 53201-2121.

Bahamas Bulletin Board System, Erik Russell, P.O. Box N1684, Nassau, Bahamas, (809) 326-5630. For Commodore 64 and 128 users. ■

A·S·K B·Y·T·E

Conducted by Steve Ciarcia

A SHARP APPLE

Dear Steve,

I am the owner of an Apple IIe and a Sharp PC-1350. I have learned that a modem and/or RS-232C interface is now available for the PC-1350 (perhaps for other Sharp PC machines as well).

However, I have been unable to locate information on how to hook my two computers together so they can communicate. Do you have any suggestions? Also, do you know of any users groups for Sharp PC-series computers or of any publications devoted specifically to these computers?

LARRY JONES
Manhattan Beach, CA

It would seem that the easiest approach to communication between your Sharp and Apple machines would be ASCII transfer through modems. Terminal programs in both machines would ease uploads and downloads and could allow format changes in files, allowing, for instance, BASIC program transfer. As these machines are widely dissimilar hardware-wise, this would seem to be the best way to go.

I am uncertain of the availability of a Sharp-specific publication or a users group in your area. A Sharp dealer would probably know of any such magazines. As to users groups, you might contact

The Silicon Valley Computer Society
P.O. Box 60506
Sunnyvale, CA 94088

They might be able to advise you of clubs in your area that are interested in Sharp computers. You might also pick up a copy of Computer Shopper *(available at many electronics and computer shops); they have listings of users groups that are updated monthly.*—Steve

8 OR 16?

Dear Steve,

As a relative newcomer to computer hardware systems, I am somewhat perplexed to find a large number of 16-bit computers that have only eight DRAM chips on the main processor card. Included in this list are many of the newer computers, like the Amiga and the Atari 520ST, as well as the Cypher, which sports a 68000 and a Z80—surely there must be some way of accessing a 16-bit-wide RAM bank with two reads or writes of the Z80 rather than slowing the 68000 down by forcing it to increment the address after each half-word.

For the benefit of any other tyro who may be perplexed by the anomaly of a "four-lane highway with a two-lane tollgate at the end," could you please explain the pros and cons of 8- versus 16-bit-wide RAM in a 16-bit processor system?

I cannot imagine that price has anything to do with it, since the Amiga and the 520ST are recently released machines, and 256K-bit DRAMs are available for less than $5 apiece.

Is it true that the NS32016 CPU has a CP/M subset of its coding? Does this mean that CP/M can be run directly on an NS32016?

CHRIS WENDT
Malvern, Victoria, Australia

There's a simple trade-off that governs whether or not a manufacturer will use a full 16-bit interface for a computer: Will the added performance add enough sales to outweigh the cost of the added hardware? As it turns out, fetching two bytes in sequence isn't a severe penalty with micros that are designed to use an 8-bit bus, so for most tasks the smaller bus wins out. The trick is that the 808x- and 680xx-class processors fetch instruction bytes before they're needed, whenever the bus isn't being used for anything else. In most cases, the prefetching hardware can keep up with the instruction execution hardware with little performance degradation.

Using both 16-bit and 8-bit processors on the same bus has some interesting consequences: If the memory is 16 bits wide, you must read and write two bytes at a time. How do you handle an 8-bit processor writing only one byte? In effect, the memory hardware must read two bytes, change one of them, then write them both back. Remember that a 16-bit memory can't be accessed byte by byte!

There are two reasons why you don't see 16-bit-wide RAMs, ROMs, and EPROMs. The first is pin count: 16 for data I/O, 1 each for power and ground, 2 for chip select and output enable, then 7 or 8 for a multiplexed address add up to 28 pins and a rather large (expensive) package. The second is economics: IC prices are determined in large part by sales volume. A 16-bit-wide IC could be used only in a 16-bit-wide system; an 8-bit-wide IC can be used in either a 16-bit or an 8-bit system. If you're a manufacturer, you'll always choose to produce a part that can be used in the most systems.

As far as I know, the National Semiconductor 32000 family isn't compatible with the Intel 8080 instruction set used by CP/M computers. You may be thinking of the new V20 processors from NEC that are pin-compatible with Intel 8088 ICs but can also emulate an 8080 when a special mode is used.—Steve

SOLENOIDS

Dear Steve,

I am a graduate student in water resources engineering at Texas A&M University. We are currently modeling water distribution networks (water supply system: pipes, elevated tanks, pumps, etc.) with a program written in BASIC. We need to be able to trigger electric solenoids to turn pumps, valves, etc., on and off from within the program. I haven't seen any solenoid-driver software or hardware advertised that could be operated with the

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

MICROSOFT LANGUAGES NEWSLETTER Vol. 1, No. 9

News about the Microsoft Language Family

Adding New Commands to Microsoft® QuickBASIC Version 2.00

The standard way to add separately compiled modules to a BASIC program has been through the use of a linker, but Microsoft QuickBASIC provides a second method as well. The Microsoft QuickBASIC BuildLib routine can be used to add separately compiled modules to the BASIC runtime file. You can create a new runtime file that includes software interrupt support by typing:

```
BUILDLIB USERLIB.OBJ, QB__BIOS.EXE;
```

This will create a new runtime file by the name QB__BIOS.EXE that can be used by Microsoft QuickBASIC. When you load Microsoft QuickBASIC, you must specify the new runtime file with the /L switch as follows:

```
QB/L QB__BIOS.EXE
```

This allows Microsoft QuickBASIC to support separately compiled modules without requiring the LINK step.

Using the mouse in Microsoft QuickBASIC Version 2.00 Programs

The software interrupt routines that you just added to Microsoft QuickBASIC can be used to access the ROM BIOS and DOS system service routines. These routines provide a range of mouse, keyboard, video, and DOS services that were previously unavailable to BASIC programs. The following example lets you draw in high resolution graphics mode with the mouse. The mouse driver (MOUSE. COM) must be installed before running this program.

```
DEFINT a-z                                              'everything is integer
        SCREEN 2                                        'high resolution graphics
        m0 = 0: m1 = 0: m2 = 0: m3 = 0: oldx = 0: oldy = 0
        CALL mouse( m0, m1, m2, m3 )                    'initialize mouse
        m0 = 1
        CALL mouse( m0, m1, m2, m3 )                    'turn on mouse cursor
        m0 = 3
        WHILE inkey$ = “”                               'exit when a key is pressed
                CALL mouse( m0, m1, m2, m3 )            'read mouse position
                IF m1 <> 0 THEN                         'if mouse button pressed
                   LINE(oldx,oldy)-( m2, m3 )           'draw a line to mouse position
                   oldx = m2: oldy = m3                 'save old position
                END IF
        WEND
END
'
        Call the mouse interrupt driver
SUB mouse( m0, m1, m2, m3 ) STATIC
DIM regs( 7 )
        regs( 0 ) = m0: regs( 1 ) = m1: regs( 2 ) = m2: regs( 3 ) = m3
        CALL INT86( 51, VARPTR( regs( 0 )), VARPTR( regs( 0 )))
        m0 = regs( 0 ): m1 = regs( 1 ): m2 = regs( 2 ): m3 = regs( 3 )
END SUB
```

In addition to INT86, the userlib.obj module also contains the INT86X and PTR86 routines. The INT86X routine should be used instead of INT86 when the system call requires segment registers. The PTR86 routine is used to convert the address of a large numeric array variable to a segment-offset value for use with INT86X. Access to the software interrupts adds tremendous flexibility to BASIC programs. However, care should be taken since BASIC does no error checking on interrupt calls.

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

Latest DOS Versions:

Microsoft C Compiler	4.00
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Microsoft Macro Assembler	4.00
Microsoft Pascal	3.31
Microsoft QuickBASIC	2.00

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

IBM PC or a compatible. It would be best if we could operate the solenoids from within BASIC. Can you offer any suggestions?

FRANK BELL
College Station, TX

Some boards available for the IBM PC for control and instrumentation applications may satisfy your needs. These generally won't drive solenoids directly but can be buffered with transistors or solid-state relays as appropriate. A couple of sources are

Analog Devices
P.O. Box 280
Norwood, MA 02062
(617) 329-4700

Burr-Brown
P.O. Box 11400
Tucson, AZ 85734
(602) 746-1111

Metrabyte Corporation
440 Myles Standish Blvd.
Taunton, MA 02780
(617) 880-3000

It is also fairly simple to use a printer port to control your solenoids, if you can get by with eight channels. The output lines should be connected to latches or flip-flops to hold the solenoids on, since the printer ports are set up to output short pulses. You could use one line to signal the latches when to turn on or off or use the flip-flop to alternately turn the solenoid on or off each time it receives a signal.

The method for doing this in BASIC is to do LPRINT CHR$(n), *where* n *is the series sum* $(X_i * 2\hat{\ }i)$ *for* $i=0$ *to 7 and* X_i *is 0 or 1, depending on whether solenoid number i is to be turned on. For example, if solenoids 0 and 2 are to be switched, you would send* CHR$(1*2^0 + 0*2^1 + 1*2^2 +0) *or* CHR$(5) *(binary 00000101).*—Steve

BOOTING PROBLEMS

Dear Steve,

I recently purchased Orchid Technology's PCturbo 186 board and an AST multifunction card for my IBM PC XT-compatible machine. When I boot the machine with both cards in it, I get a "bad checksum" error from the PCturbo 186 board. The boards work fine on their own. I have tried everything I can think of, including removing the game ports and changing the direct memory access channel. Have you any idea what might be the problem?

Also, why won't the 80186 work with the 8087 on the PC motherboard?

PERUEZ BHATHENA
Dammam, Saudi Arabia

I talked to Howard Pitchon at Orchid Technology about your problem. He says that the most likely cause is a conflict between the printer interrupt on the multifunction card and the interrupt used by the PCturbo 186.

The PCturbo 186 board uses IRQ 7, which is normally assigned to the printer. There is little software on the market that uses the printer interrupts, so you probably won't have any trouble if you disable it. (And you'll surely have none if you don't have a printer connected to the port!)

There may be a jumper on the multifunction card that disables IRQ 7. If not, you will have to cut the trace that connects the circuitry to pin B21 on the

(continued)

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4. Deposit Program Compiled DBase to list and total cash, check, bank card for bank deposit and keeps history - Developed for our corporate use - Super Program! (source code available). **Retail value $40.**

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Q&A	Call for price
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Think Tank	92
Wordtech DBase 3 compiler	419

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Multimate 3.31	Call
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card's edge connector. First try the jumper, then resort to surgery if it still fails.

To locate B21, lay the multifunction card down with the ICs underneath (the solder traces on top) and the edge connector pointing toward you. Count edge-connector contacts starting from B1 on the left near the mounting bracket: pin B21 is the twenty-first contact. Use a sharp knife or an awl to scrape a gap into the printed circuit trace coming from the pin; be careful not to damage any other traces, but be sure to cut through completely.

I doubt that the DMA channel is a problem, but you should try both allowed settings to see what happens. Start with the default of direct memory access channel 3 after you modify the multifunction card. Remember that you have to tell the software which DMA channel is being used. The details for that are in the instructions, and I suspect that you're already familiar with them.

Howard also mentions that game adapters have given some trouble in the past, so you may want to remove that option if you can. When you get things working without it, you can try installing it again to see if it contributed to the troubles.

The PCturbo 186 board does not use any of the PC's RAM space, so removing RAM chips won't solve any of the problems. Do make sure that you've got the multifunction card's switches set to indicate the starting address at 256K bytes and six installed banks with a length of 384K bytes when you reinstall the RAM chips.

The reason that the 80186 on the PCturbo 186 board can't use the 8087 on the PC's system board is, sad to say, because the PC wasn't designed to have a complete computer system on an I/O card! The original IBM PC was intended to have the "computer" part (the 8088 and 8087) on the system board and the "I/O" part (printer ports and the like) on the cards. IBM didn't include the circuitry that would allow the PCturbo 186 board to connect to the 8087, so you won't get any benefit from an 8087 when you're running the PCturbo 186 board.

If your programs include 8087 support, you might want to find out which version is faster: 8087 running on the PC or non-8087 running on the PCturbo 186 board. The results may be surprising!
—Steve

COMPUTER GENERATIONS

Dear Steve,

What were the first five generations of computers, and what would you imagine might be the next five?

What role do you see virtual devices playing throughout these generations?

RICHARD WILLIS
Palma de Mallorca, Spain

It all depends on how you count, but the first five computer hardware generations seem to be

1. Electromechanical calculators
2. Vacuum tube computers (mid 1940s to late 1950s)
3. Transistor computers (early 1960s to mid 1960s)
4. Integrated circuit computers (late 1960s to mid 1980s)
5. VLSI computers (mid 1980s onward)

The popular use of the term "Fifth Generation Computers" comes from the Japanese effort to produce machines that are much easier to use and capable of

(continued)

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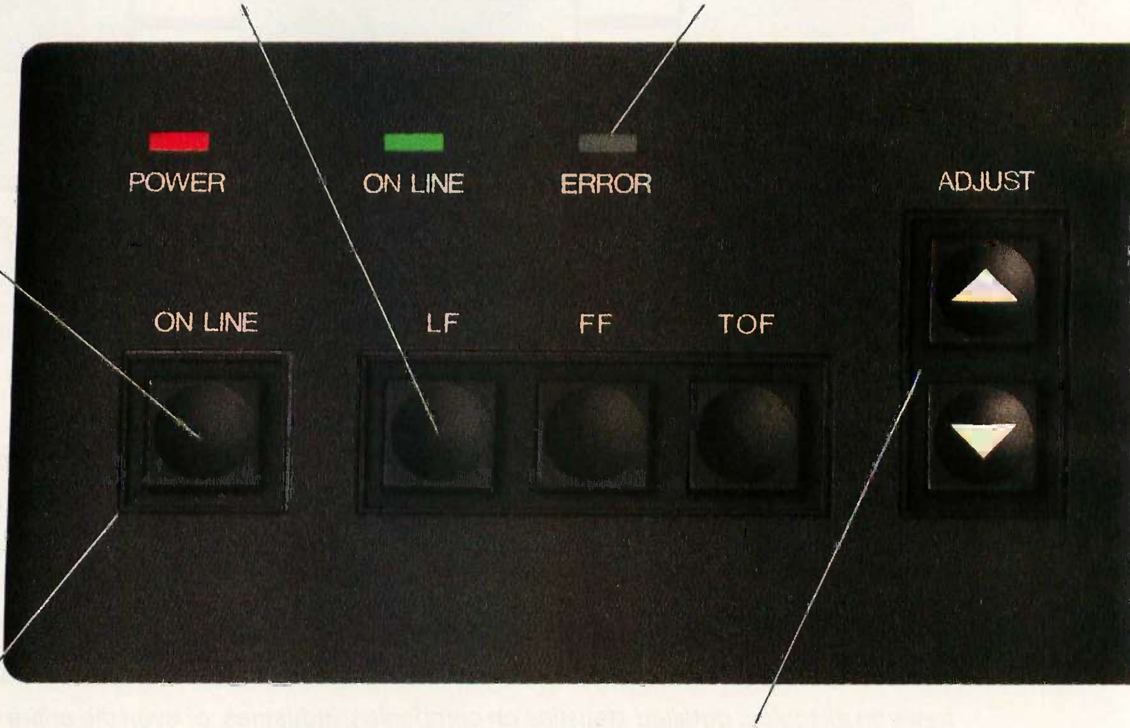

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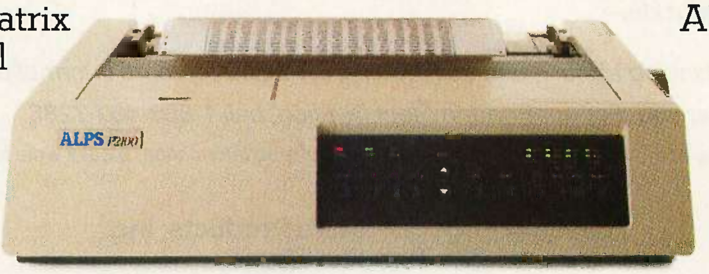
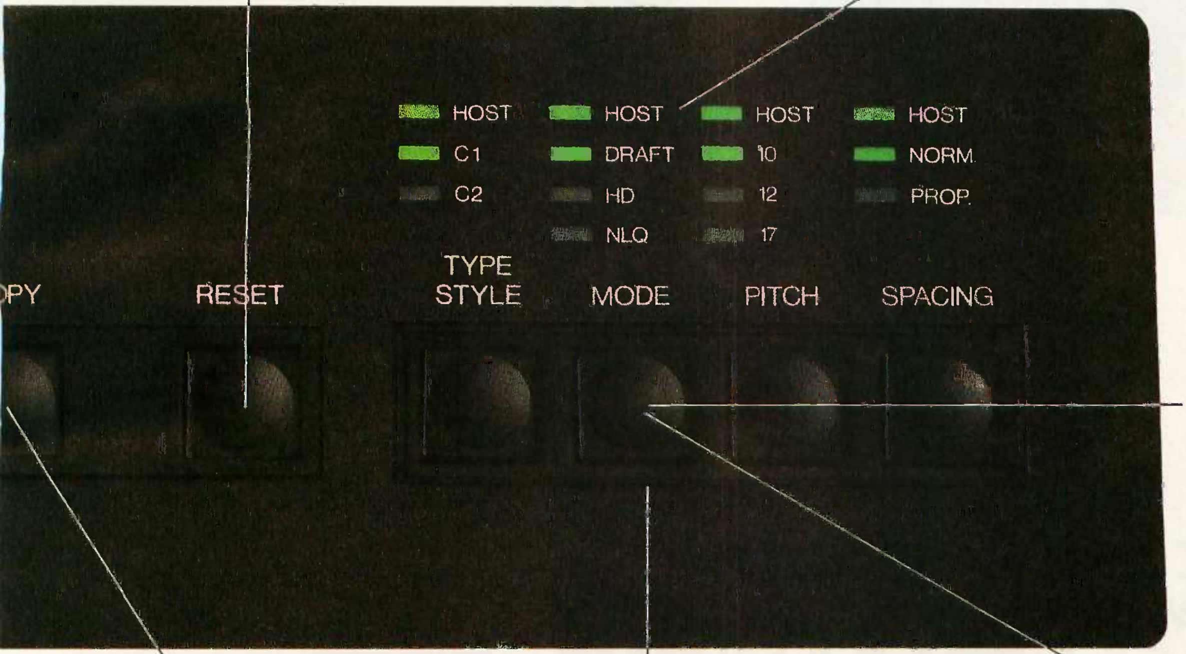


OUR HED PANEL.



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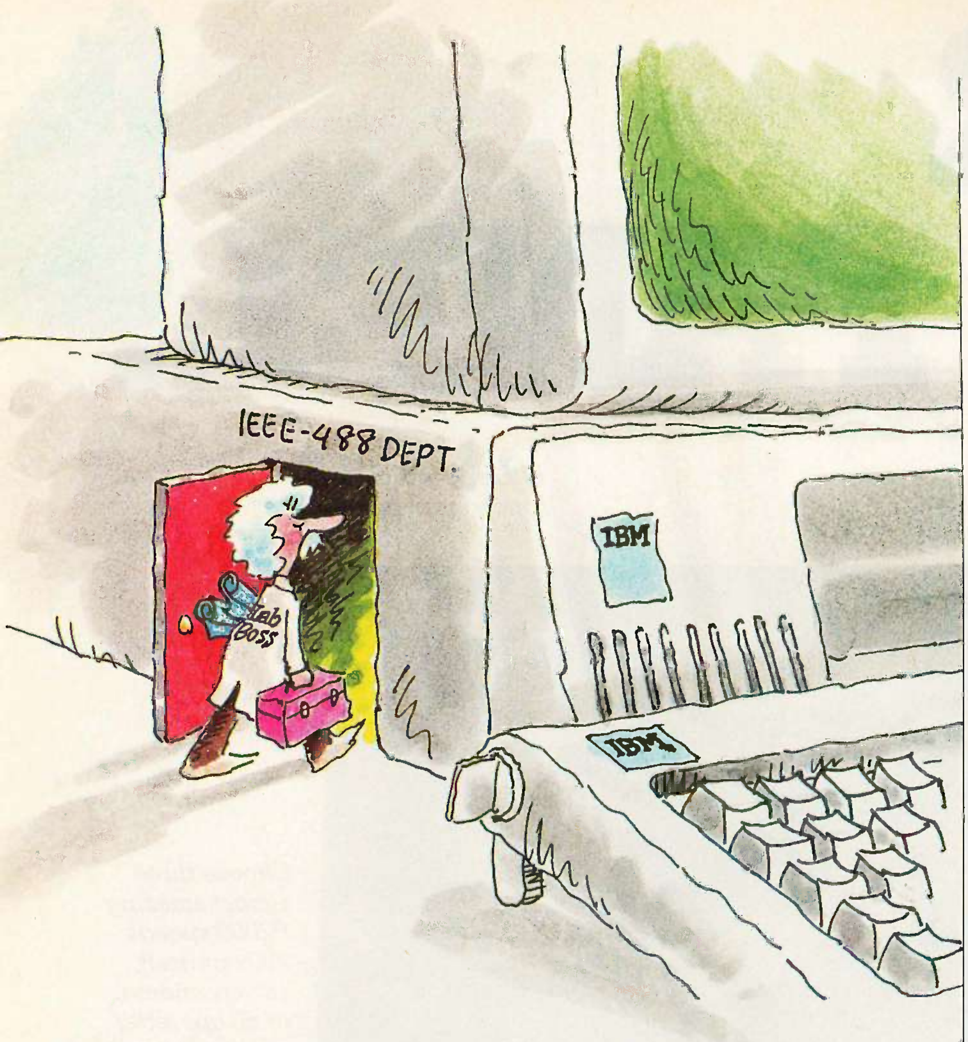

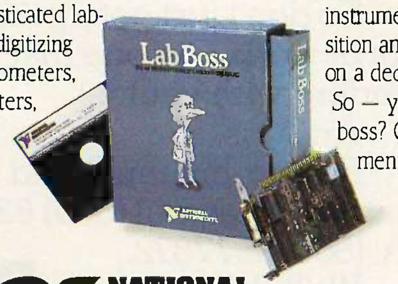

handling much more difficult problems than the current generation. It's not clear how software generations should be counted, but this list seems reasonable:

1. *Machine language binary programs (not even assembly language!)*
2. *Assembly language programs*
3. *FORTRAN, ALGOL, and similar high-level languages*
4. *Application-specific languages and simple AI*
5. *Programs capable of reasoning in the real world*

Particularly with respect to the hardware generations, it seems that each one took us quite by surprise. So beyond speculating on the likelihood of bioelectronics and three-dimensional circuitry, I'm willing to be surprised like everyone else. One thing is certain, though: The software is the hardest part of the job!

I don't think that virtual devices are related to particular computer generations. A virtual device is simply a subprogram that translates a standardized I/O device command set into the specific commands required by a particular I/O device. For example, a virtual device interface to two different graphics displays would allow a single program to run unchanged on either one: Only the virtual device code would be changed.—Steve

CIRCUIT CELLAR FEEDBACK

PROGRAM CONVERSION

Dear Steve,

I built the scrolling alphanumeric display you described in the April 1984 Circuit Cellar, and it worked great using the Z8 board. However, I no longer have use of the Z8 board. I do, however, have an Apple II computer at my disposal. I was wondering if it is at all possible to convert the Z8-BASIC system controller assembly language instructions for use by the 6502 microprocessor on the Apple II.

If you could provide me with some help in converting these programs, I would be more than grateful.

JAVIER PELAYO
Los Angeles, CA

The Z8671 microprocessor used in the Z8 controller and the 6502 used in the Apple II have completely different architectures and instruction sets. Because of this, a one-to-one translation of the assembly language source listing is im-

(continued)

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Inquiry 218

possible. With some 6502 assembly language experience, it should be possible for you to create a program for the Apple that will permit it to control the scrolling display. You need three output bits: data, clock, and clear. It would be easy to use the "annunciator" outputs on the Apple's game controller socket for this purpose.

The following are some books that give full explanations of the workings of the annunciators:

Sather, James. Understanding the Apple II *(Quality Software, 1983)*

Gayler, Winston D. The Apple II Circuit Description *(Howard W. Sams, 1983)*

Several good Apple II and 6502 assembly language programming books are available. These can provide the information you need to create your program. Two of these books are

De Jong, Marvin L. Apple II Assembly Language *(Howard W. Sams, 1982)*

Leventhal, Lance. Assembly Language Programming: 6502 *(Osborne/McGraw-Hill, 1979)*

—Steve

PEOPLE DETECTION

Dear Steve,

I want to improve a home-lighting control system I installed in 1980. One of my requirements is to control the level of lighting in one of our rooms.

I currently use six reflector spots at regular intervals around the walls to give plenty of light where it's required. At about half power, the lamps give adequate illumination for background purposes, but for reading you need to bring the lamp closest to where you are sitting to full power.

My problem is correctly detecting the location of a person. Movement detection would have to be very sensitive if you are sitting still reading. Similarly, body heat detection would also need careful calibration to avoid permanently illuminating a radiator. Also, any scanning system would have to be quiet in operation, since the whir of a rotating scanner would be most annoying.

I have even considered installing floor-pressure switches under the carpet. If you have any suggestions, I would be pleased to hear them.

RODERICK SPARKSFIELD
Sandy, Bedfordshire, United Kingdom

One of the best methods for detecting people in a room is to use infrared motion detectors. These are commonly used

(continued)

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—Christopher Skelly, Computer Language Magazine, Feb. 1986

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Sieve Benchmark on Different PC's

Macintosh™		Apple IIe, IIc	
ZBasic™	7.4 sec.	ZBasic™	486 sec.
Mbasic™	684 sec.	Applesoft™	5,401 sec.
IBM® PC (8088)		Z-80 (CP/M™-80, TRS-80™)	
ZBasic™	13.7 sec.	ZBasic™	30 sec.
BASICA™	2,190 sec.	Mbasic™	2,520 sec.

10 iterations of the Sieve from Byte, January, 1983

Compiler Speed/Interpreter Ease.
Like a BASIC interpreter, ZBasic allows you to write and execute your programs immediately! No messy "Linkers," "Loaders," or clumsy "Subroutine Packages" like most other compilers. To compile and edit, simply type "RUN." Debugging works the same as the interpreter, too. Just type "BREAK" or "CTRL C" to get back to the editor.

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Works the Same on All Computers.
If you're tired of throwing away your old programs everytime you switch to a new computer, ZBasic is for you. Source code is portable from one computer to another, and since ZBasic uses Device Independent Graphics and Disk File commands, your programs automatically "Adapt" to any other computer. And the ZBASIC editor is the same on all versions—regardless of the computer.

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"The 387 page ZBasic manual is a model of clarity and organization. The documentation is superb, solidifying our impression that someone worked incredibly hard to make ZBasic a benchmark for all other BASIC Compilers."
PC WEEK, Nov. 12, 1985

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ZBasic helps you "Structure" your programs in a way that's easy and simple...you may use GOSUB or GOTO with names or line numbers. Supports multi-line LONG IFs and LONG FNs. LIST programs with—or without—line numbers! ZBasic automatically indents loops and *structures in* LISTings, too.

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J.R. CPA
Seymour, MO

"....fast, generates stand alone programs, requires only modest amounts of memory, has outstanding compilation speeds and...was bug free and felt solid. And the price is very attractive."
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"ZBasic is a powerful offering for BASIC programmers. It provides the flexibility of Turbo Pascal and the speed of compiled BASIC, all at a price that can't be matched. Kudos to Zedcor and to all users who make wise decisions to use ZBasic to the fullest."
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PC WEEK

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in security and alarm systems and are quite sensitive. They work by dividing the area in their view into a series of discrete slices and then monitoring the infrared level in each slice. When a moving warm body disturbs the normal pattern that the detector sees, it trips a relay. It does not take a great deal of motion to trigger the detector, depending on where it is located.

In your situation, you could try using several detectors, each one aimed at the area that you want it to control. I don't know what type of system you are using to control your lights, but I'm sure that you could find a way to interface the detectors to your system.

I am currently using a number of these detectors around my home to control lighting. They are connected to my Home Run Control System (April to June 1985 BYTE). When one of the detectors sees motion, HCS senses it and turns the light or lights on. As long as someone remains in view of the detector, HCS keeps resetting the time-out. When the person leaves the room, HCS will turn the lights off.—Steve

PROPERTY PROTECTION

Dear Steve,

Some time ago, I believe you mentioned a company that provides property-protection devices. I am looking at the Home Run Control System, and I would like to use this company's passive infrared motion detectors. Can you give me the name of this company?

WILLIAM P. DRESCHER
Lansing, MI

The company is

Mountain West
P.O. Box 10780
Phoenix, AZ 85064-0780
(800) 528-6169

Its catalog contains a variety of security devices and reference books. Several application notes for the various devices are also included.—Steve ■

Over the years I have presented many different projects in BYTE. I know many of you have built them and are making use of them in many ways.

I am interested in hearing from any of you telling me what you've done with these projects or how you may have been influenced by the basic ideas. Write me at Circuit Cellar Feedback, P.O. Box 582, Glastonbury, CT 06033, and fill me in on your applications. All letters and photographs become the property of Steve Ciarcia and cannot be returned.

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MSBASIC™ 2.1 Interpreter	684.0	0.
Softworks™ C Compiler	8.8	445.
Aztec™ C Compiler	6.5	240.
MS™ FORTRAN Compiler	6.8	180.
TML™ Pascal Compiler	6.6	120.

*10 iterations of Sieve Benchmark from *Byte*, Jan. 1983. TML speed from *MacUser*, June 1986. C speeds from *Byte*, Nov. 1985 (non-register). MS-FORTRAN speed from *MACWORLD*-June 1986. Softworks BASIC time from *MacTutor*-June 1986.

**Compile from editor to stand-alone application. RAM disks not used.

***True BASIC™ program was not a stand-alone double-click application—This requires an optional ($500) runtime license. Compile time was taken from interactive mode.

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As reviewed in **BYTE**, May 1986

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Designed as a "portable language," ZBasic is available on many popular computers including: IBM® (MS-DOS™) and compatibles, CP/M™80, Apple®IIe, IIc and TRS-80™. This allows you to easily create programs to work on many other machines.

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- Modem and Printer serial port commands
- Enhanced Integer range of ±2,147,483,647
- From 8-240 digits of configurable BCD Accuracy
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- Memory management (SEGMENT) commands
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SOME OF THE SPECIAL MAC COMMANDS

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BUTTON
MENU
DEFMOUSE
TIMER ON
MOUSE OFF
FILES$
EJECT
SCROLL BUTTON
WINDOW OFF
ALERT WINDOWS
DIALOG OFF
EDIT FIELD
MENU ON/OFF
APPLE MENU
TIMER
ON TIMER (n)
MOUSE (n)
SOUND
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FINDERINFO
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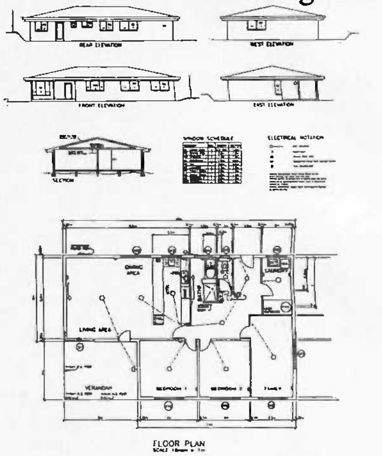

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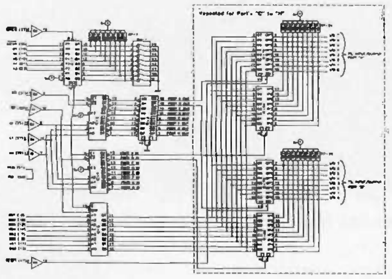

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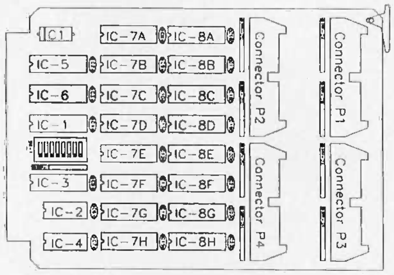

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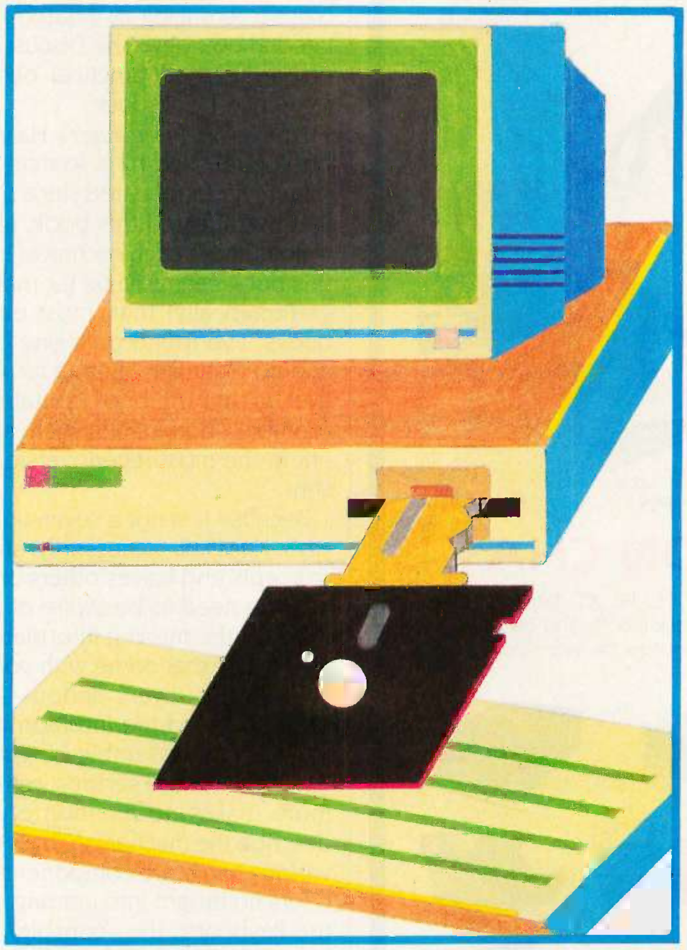
BOOK REVIEWS

AMIGA PROGRAMMER'S HANDBOOK
Eugene F. Mortimore
Sybex
Berkeley, CA: 1986
529 pages, $24.95

TECHNICAL TOPICS FOR MOTOROLA MC68000-BASED MICROCOMPUTERS: An Annotated Bibliography of Recent Books

AMIGA PROGRAMMER'S HANDBOOK

Reviewed by
Gregg Williams



Many people find the Commodore Amiga interesting because of its tremendous processing power. Unfortunately, very little of that power is accessible without the proper computer program. Because of this, many users of a new machine like the Amiga are hungry for the detailed technical documentation that unlocks the computer's capabilities. Although the official Commodore seven-book technical reference set was available much sooner than is usual for a new computer, at $100 it is expensive for the interested (but not professional) user. The quality and price of Eugene F. Mortimore's *Amiga Programmer's Handbook* make it a good buy for such people, but it isn't a substitute for the full reference set.

ORGANIZATION

The *Amiga Programmer's Handbook* is essentially an overview of the Amiga as seen from the programming point of view. After a brief explanation of needed background information about program development (register usage, include files, and structures), Mortimore presents seven chapters, each of which covers a class of functions: the Exec functions (resource management), graphics display and drawing, animation, text, Layer functions (which manipulate Amiga "screens"), Intuition (the user interface), and Workbench (the Amiga's operating environment).

Each chapter is structured like the book itself—an overview describing important concepts followed by detailed information. Within the chapters, the detailed information is a collection of alphabetized entries covering all the software routines designed for programmers' use. (These names—like AreaDraw, SetSoftStyle, and SetDMRequest—are important because they are called by name in whatever language you are using to develop a program.)

Each entry follows the same format: the syntax of the function, a description of its purpose, descriptions of all its inputs, and a discussion section that describes the context of the function's use. This last section contains useful information that is not in the Amiga reference books. It begins by listing all the other related functions in the chapter; for example, the discussion of AreaDraw lists the other five functions that manipulate areas. It then describes the context in which the function is used, sometimes listing other functions that must be called, suggesting alternative methods, and warning of possible pitfalls. The entries are usually between one and two pages long.

The book ends with two appendixes, a glossary of terms, and some notes on advanced video topics (the dual-play-

(continued)

field, double-buffering, hold-and-modify, and extra-half-bright modes).

STRENGTHS AND WEAKNESSES

As an intermediate C programmer with some knowledge of the Amiga's internal details, I am beginning to appreciate the way Mortimore organized functions and cross-references. Although I still have to go to the reference manuals to get detailed information, I am often at a loss as to what information I need and where to find it. This book's dictionary-like organization and thesaurus-like cross-referencing of related functions gave me a much-needed overview. The Discussion section includes the sort of hard-earned practical observations and advice that reference books lack.

The *Amiga Programmer's Handbook* was the first technical book published by a source outside Commodore-Amiga (others have appeared since then), and the rush to publish first has affected this book, although not as adversely as it does most such technical books. On the positive side, this book seems to be far more accurate (technically and grammatically) than most early books and many other books; I've found only one or two typographical errors and no technical ones so far. One serious drawback, however, is that the book contains no figures and only a few examples, both of which are sorely needed (they are present in the most recent version of the technical reference set).

Because it is not a seven-volume set, the *Amiga Programmer's Handbook* necessarily summarizes some important concepts and leaves others out entirely. That's not a fault, but you need to be aware of it. The book points out that much of the missing information is documented in the include files that come with your assembler or C compiler. This is true—every serious Amiga programmer should print and read the Intuition include file (include.h for C, include.i for assembly language).

Another, more serious weakness is an omission: Mortimore makes no mention of devices (the word used to describe the mechanism by which the Amiga interacts with various hardware components). This means that the book offers no insight into (among others) the audio subsystem, the keyboard, the "console" (video text output) device, the game ports (mouse and joystick interface hardware), the serial and parallel ports, the "narrator" device (which handles Amiga's human-speech output), and the printer-driver software.

A final criticism, reported by a Commodore Amiga technical person, is that the book mixes information from both versions 1.0 and 1.1 of the Amiga Workbench. (Yet another version, 1.2, may be out by the time you read this.) Although I have not seen any examples of this during my use of the book, I'm sure they're there—so be warned, and double-check with the official Amiga documentation.

I said earlier that you couldn't develop Amiga software with this book alone. Actually, by studying the include files and several of the numerous C source code files in the public domain, you could get by with just this book, but

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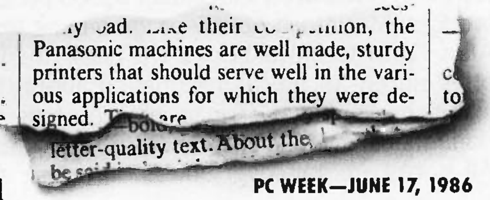
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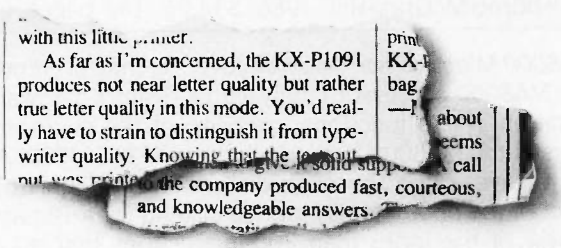
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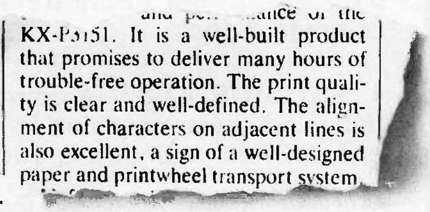
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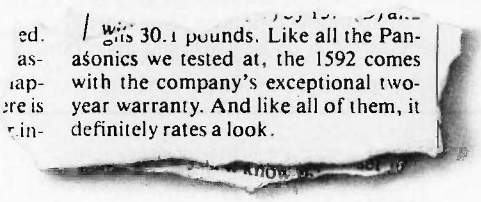
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it would be like trying to use a one-disk computer—you can do it, but it's a lot of extra work.

CONCLUSION

The *Amiga Programmer's Handbook* is an accurate, well-organized reference book for the Amiga's internal software, though it omits needed material about the software interface to several input and output devices. It doesn't offer the technical depth you'll sometimes need, but it provides several kinds of contextual information that the manuals don't. It is nevertheless a useful addition to an Amiga technical library.

Gregg Williams is a senior technical editor at BYTE *who worked on the Amiga cover story* (August 1985). *He can be reached at* BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

TECHNICAL TOPICS FOR MOTOROLA MC68000-BASED MICROCOMPUTERS:

An Annotated Bibliography of Recent Books

Compiled by Donald Evan Crabb

Observing the progress of the Motorola MC68000 processor chip, I felt that a survey of some of the current books on the subject was needed. By eliminating monographs and manuals, I focused on four areas: 68000 technical references, Macintosh 68000 programming references, Macintosh 68000 programming textbooks, and Atari 520ST technical books. The books mentioned below offer current technical information about the MC68000 and its implementation in several computers. This collection reflects my bias and cannot be considered inclusive. All books are softcover unless otherwise specified.

68000 TECHNICAL REFERENCES

Cramer, William, and Jerry Kane. *68000 Microprocessor Handbook: Includes 68008, 68010, & 68020*, 2nd ed. Berkeley, CA: Osborne/McGraw-Hill, 1986. $34.95. 142 pages.

The *68000 Microprocessor Handbook* covers technical criteria of the M68000 processor family with a distinct hardware orientation. It is a functional overview of the microprocessors of the M68000 family, including the MC68020. As such, it leaves out a thorough discussion of the instruction set of the 68000 family, opting instead for a 10-page overview of the more than 300 instructions that make these microprocessors work. William Cramer and Jerry Kane have condensed the instruction set discussion into a general synopsis about the basic format of instructions and their use. Topics familiar to readers of other 68000 books include addressing modes, timing and bus operations, exception processing, and I/O interfacing. The consistent hardware orientation is based on the configuration of the M68000 family and how its architecture and operations can support systems and applications software. As a hardware handbook, the *68000 Microprocessor Handbook*

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Fortgang, Karen Skrable, ed. *M68000 8-/16-/32-Bit Microprocessors Programmer's Reference Manual*, 5th ed. Englewood Cliffs, NJ: Prentice-Hall, 1986. $18.95. 240 pages.

This is *the* reference manual for the M68000 processor family (MC68000, MC68008, MC68010, MC68012). It is written by Motorola engineers for anyone interested in serious assembly language programming of the 68000 family. The latest version adds a discussion of the MC68012 extended virtual memory processor to the material presented in the 4th edition. This book will not, however, teach you 68000 assembly language programming. It is strictly a reference for the 68000 family.

The information is straightforward and delivered in the no-nonsense style that is so familiar to readers of electrical engineering texts. The book's audience is narrowly defined—M68000 programmers, system implementers, and computer designers—but readers should find the coverage of the M68000 family's architecture, data organization and addressing, instruction set, microprocessor operations, and exception processing definitive.

Most of the book concentrates on the MC68000, but it also explains the architectural and instruction set differences of the MC68008 processor (8-bit data bus, 20 address bits), the MC68010 processor (virtual memory version of the MC68000), and the MC68012 (extended virtual memory version of the MC68010). The full 32-bit MC68020 processor is mentioned only briefly.

Kelly-Bootle, Stan, and Bob Fowler. *68000, 68010, 68020 Primer*. Indianapolis, IN: Howard W. Sams & Co., 1986. $21.95. 368 pages.

This Waite Group book bridges the gap between an M68000 processor reference manual and an M68000 assembly language textbook. Coauthored by a recognized computer pioneer (Stan Kelly-Bootle) and a principal in the Alpha Micro User's Society (Bob Fowler), the *68000, 68010, 68020 Primer* is useful to experienced microcomputer programmers who want a quick introduction to the M68000 family. Novice programmers who don't know much about micros (and least of all the 8-bit microprocessors that preceded the M68000 family) will also find the book informative. The authors provide numerous examples of the M68000 instruction set, discussing the purpose of each instruction and its intended use.

Kelly-Bootle and Fowler have chosen a structure that emphasizes familiarity with the basic concepts of the M68000 early on. From there, they accelerate their discussion through the various levels of microprogramming and finally discuss individual differences between processors of the family. They also include several appendixes that cover the M68000 instruction sets and the various addressing modes. The book is filled with useful illustrations and tables and includes a handy tear-out reference card.

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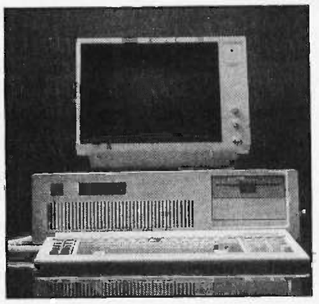

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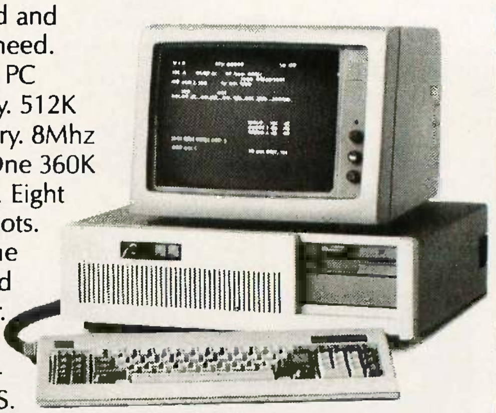

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Triebel, Walter A., and Avtar Singh. *The 68000 Microprocessor: Architecture, Software, and Interfacing Techniques*. Englewood Cliffs, NJ: Prentice-Hall, 1986. Hardcover. $34.95. 366 pages.

This book is challenging, both to read and to understand. But if you make the effort and read it carefully, you can come away with a balanced view of both the M68000 microprocessor family and how microcomputers are designed to use these chips. This hardbound textbook would be at home in both electrical engineering/computer science microprogramming and design courses. Walter A. Triebel and Avtar Singh cover the material extensively, with particular emphasis on the memory and I/O interfaces of the MC68000 microprocessor.

The 68000 Microprocessor also covers the internal architecture of the processor, including a complete discussion of the control and execution of instructions. Triebel and Singh jump into circuit design issues as well, covering such topics as address maps, I/O interface circuits, and interrupt circuits. The software side of the 68000 is not left out, either: Two full chapters break down technical topics like addressing modes, the 68000 instruction set, and the analysis and writing of assembly language programs.

MACINTOSH 68000 PROGRAMMING REFERENCES

Chernicoff, Stephen. *Macintosh Revealed, Volume One: Unlocking the Toolbox*. Berkeley, CA: Hayden Book Co., 1985. $25.95. 516 pages. (A full review of this book can be found in November 1985 BYTE, page 57).

Chernicoff, Stephen. *Macintosh Revealed, Volume Two: Programming with the Toolbox*. Berkeley, CA: Hayden Book Co., 1985. $29.95. 626 pages. A disk of the programming examples in volumes one and two is available from Hayden for $19.95. (For a full review, see April BYTE, page 67.)

Inside Macintosh: Promotional Edition. San Jose, CA: Apple Computer Inc., 1985 (published as documentation). $25. 1000-plus pages. Also published as a three-volume series by Addison-Wesley, Reading, MA, 1985, at $24.95 each.

Inside Macintosh is the ultimate reference for Macintosh program developers. Published in a phone-book format on newsprint-type stock, it appears as authoritative as it is indispensable. Written by a team of Apple programmers and writers, *Inside Macintosh* offers definitive information about how the Macintosh works: its ROM, RAM, disk drive, microprocessor, ports, keyboard, mouse, and all the rest. The information is densely packed and not particularly easy to get at, but most of what you need is there.

MACINTOSH 68000 PROGRAMMING TEXTBOOKS

Commander, Jake. *Macintosh Assembly Language Programming*. Blue Ridge Summit, PA: Tab Books, 1985. $16.95. 198 pages.

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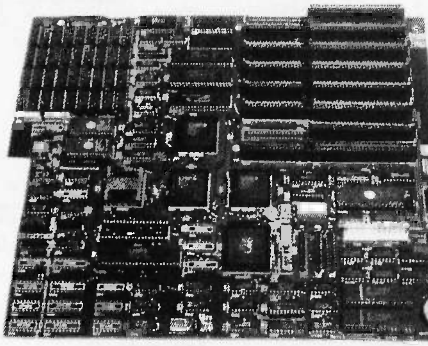

Macintosh Assembly Language Programming is a surprisingly good book. Ignore its shortcomings—design, execution, and illustrations—and you will be rewarded with a lucid, effective, and easy-to-understand discussion of Macintosh assembly programming. The author, a microcomputer software writer, has concentrated on the most important aspects of Macintosh assembly language programming (program specification and design, using the 68000 assembly language development system, the Macintosh operating system, etc.), so that novice assembly language programmers have enough hooks to latch onto.

Rosenzweig, Edwin, and Harland Harrison. *Programming the 68000: Macintosh Assembly Language*. Hasbrouck Heights, NJ: Hayden Book Co., 1986. $24.95. 399 pages.

This book attempts to cover assembly language programming of the MC68000 chip on the Macintosh. I found detailed chapters on difficult material written by both authors to be praiseworthy in their clarity.

Programming the 68000 covers the territory of a self-taught Macintosh assembly language programming textbook quite well. It provides most of the information you need to know to become a Mac assembly and Toolbox programmer. The authors begin with a discussion of the addressing modes of the 68000 and move through the 68000 instruction set on to the Mac Toolbox and ROM calls.

Takatsuka, Jim, David Burnard, and Fred Huxham. *Using the Macintosh Toolbox with C*. Berkeley, CA: Sybex, 1986. $22.95. 559 pages.

This book is handy if you're planning to program in C on the Macintosh. Regardless of which C compiler you use, it provides the interfacing information you'll need to make your programs work with the Toolbox. The tutorial approach is reasonably successful. *Using the Macintosh Toolbox with C* details how to use dialog and alert boxes, windows, text editing, menus, screen graphics and icons, and much more from your C programs.

Ward, Terry A. *Programming C on the Macintosh*. Glenview, IL: Scott, Foresman and Co., 1986. $21.95. 411 pages.

Terry A. Ward's book is important to programmers who want to become part of that software development effort but lack the knowledge about C on the Mac.

Ward begins by moving from a discussion of the ubiquitous Macintosh user interface through a short description of the syntax and properties of C. *Programming C on the Macintosh* goes on to cover five different Mac C compilers, QuickDraw routines, menus, the event manager of the Mac, and the Mac's TextEdit routines. The book is filled with example programs, illustrations, and charts, and is pleasant to read. The index is thin, but the appendixes and a table of contents are helpful.

Williams, Steve. *Programming the Macintosh in Assembly Lan-*

(continued)

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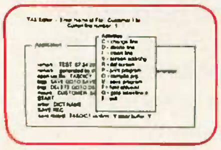

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guage. Berkeley, CA: Sybex, 1986. $24.95. 779 pages.

Programming the Macintosh in Assembly Language is a massive book for experienced programmers. Novices would be overwhelmed by the detailed presentation of 68000 chip architecture, instruction sets, and the Macintosh Toolbox.

The presentation of the Macintosh programming environment is the strongest aspect of the book. The discussion of interfacing issues will help you get your own programs working with the Toolbox quickly, using the appropriate screen and mouse features. The book also has copious listings of the source code discussed throughout.

ATARI 520ST TECHNICAL REFERENCES

Editors of *Compute!*. *Compute!'s ST Programmer's Guide*. Greensboro, NC: Compute! Publications, 1986. $16.95. 356 pages.

One-third of this reference book is a discussion of the Atari 520ST implementation of BASIC. The other two-thirds cover Logo programming, GEM and TOS, and writing GEM applications. As one of the first books on the ST, it attempts to cover as many different audiences as it covers programming topics, for the most part successfully.

Later chapters will be of more interest to advanced programmers due to the discussions of TOS, the GEM desktop, the GEM Virtual Device Interface (VDI), and Application Environment Services (AES). The detail is such that an advanced programmer can learn to write GEM applications in C. But just when you expect the book to discuss application implementation under GEM with C, the book ends. *Compute!'s ST Programmer's Guide* also fails to discuss any aspects of assembly language programming for the ST, another serious drawback to the book's ultimate usefulness.

Szczepanowski, Norbert, and Bernd Gunther. *Atari ST GEM Programmer's Reference*. Grand Rapids, MI: Abacus Software, 1986. $19.95. 414 pages.

Despite its title, the *Atari ST GEM Programmer's Reference* is really a complete programming handbook for the ST. The book covers much of the same ground as *Compute!'s ST Programmer's Guide*, but it does so in much more detail, with more emphasis on implementing user applications with C.

The bulk of this handbook is taken up with the discussion of GEM's Virtual Device Interface (VDI) and how to use it in your programs to create graphics. A fair number of programming examples are provided to help you implement your own code. Like *Compute!'s ST Programmer's Guide*, this book is dry reading, chock full of assembly language routines and C language definitions, without some more invigorating text to break the monotony.

Donald Evan Crabb is director of instruction and laboratories at the University of Chicago (Department of Computer Science, Ryerson Hall 260, 1100 East 58th St., Chicago, IL 60637). He is on the review board of InfoWorld. ■

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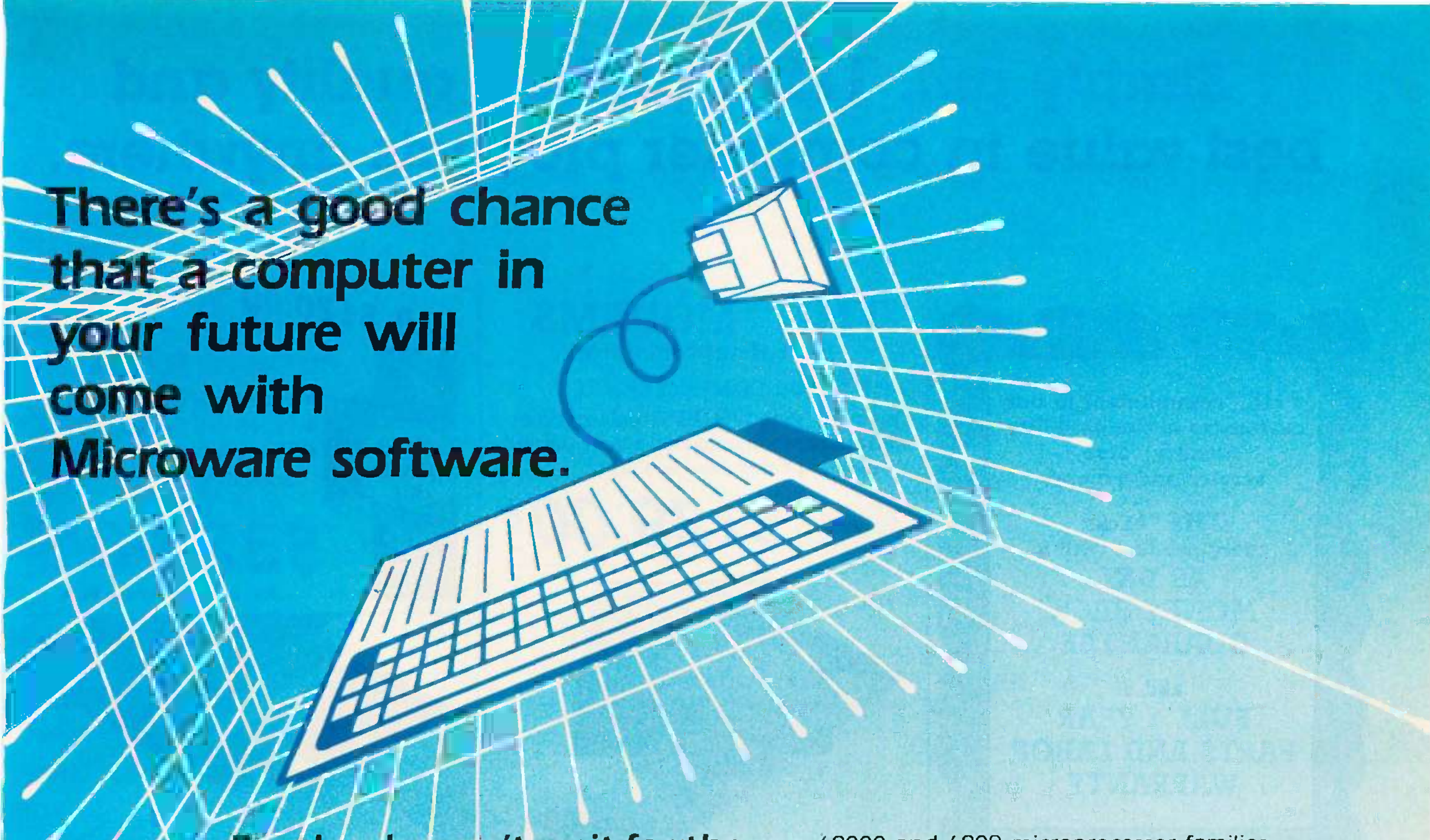

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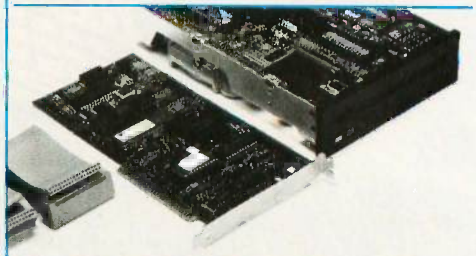

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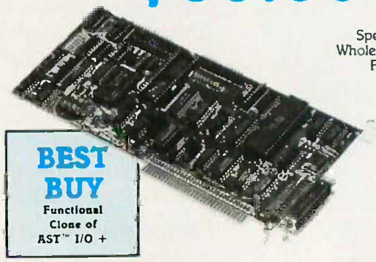

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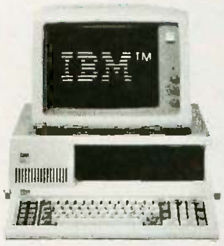

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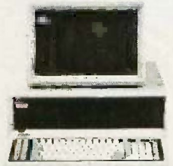

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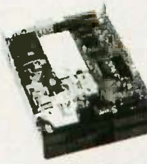

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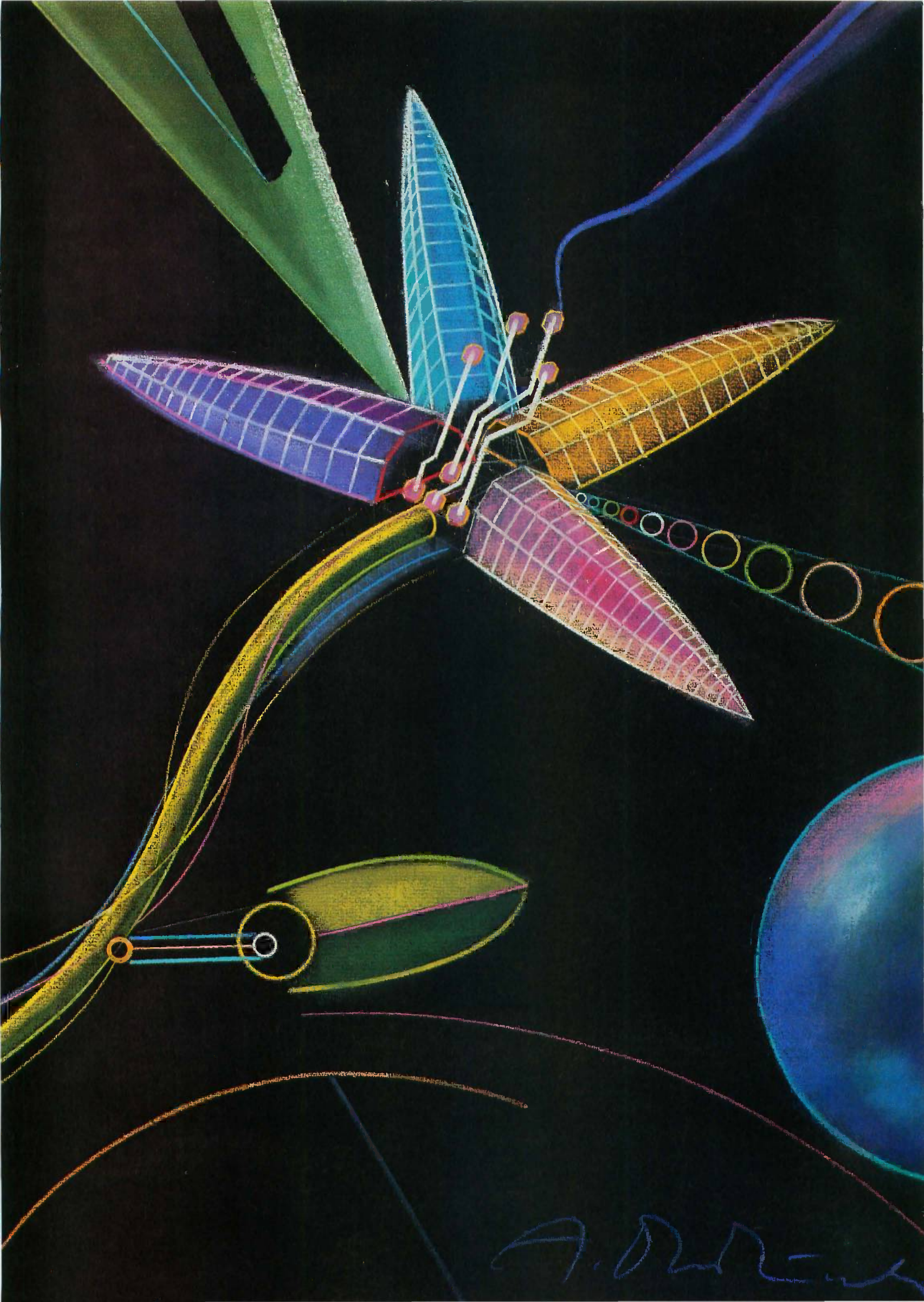


Features

IF THE VIOLATION of private electronic communication is a subject that arouses your ire, Steve Ciarcia's article on data encryption will interest you. Fortunately, there are ways to prevent electronic Peeping Toms. The Circuit Cellar data encryptor is easy to understand, easy to build, and easy to use, but it is very difficult to break. When Steve began this project, he knew little about the subject. Because many of you probably share this lack of knowledge, Steve presents more background material than he ordinarily might.

In this month's Product Preview, BYTE senior technical editors G. Michael Vose and Gregg Williams provide an advance look at LabVIEW, the last four letters of which stand for Virtual Instrument Engineering Workbench. The National Instruments product enables scientists and engineers to create virtual instruments that turn the Mactinosh into a general-purpose laboratory tool.

"Calculating CRCs by Bits and Bytes," our Programming Project for September, explains how to use the XOR function to implement modulo 2 division when calculating cyclic redundancy checks. Author Greg Morse provides a lucid description of his method for those who have difficulty understanding the math behind CRC calculations.

When Edward Batutis discovered that the DEBUG program provided with IBM PC-DOS had no break-out switch, he devised a program to provide the capability. "Breaking Out," this month's Programming Insight, explains the routine.

Maintaining data on disk can be a challenging aspect of programming for beginners and experts alike. In "Keyed File Access in BASIC," Stephen C. Perry presents several BASIC routines that provide fast and efficient keyed access to data files.

Our last feature, "Real Time Under Real Pascal" by James Feldman, explains two ways to interface a machine language routine to Pascal. Such a technique is useful for those rare times in a high-level program when you must descend into the depths to achieve timing, communications, or any other operation for which machine language is the sine qua non.

LabVIEW: Laboratory Virtual Instrument Engineering Workbench

An executable block-diagram environment exploiting Macintosh graphics

Editor's note: The following is a BYTE *product preview. It is not a review. We provide an advance look at this product because we feel that it is significant. A complete review will follow in a subsequent issue.*

Scientists and engineers do not deny that computers are important tools in the laboratory. However, they often wish they didn't have to become computer wizards to exploit the potential of the computer. Extending the graphics power of the Macintosh, National Instruments' Laboratory Virtual Instrument Engineering Workbench (LabVIEW) offers a computer programming environment that closely resembles the way scientists and engineers work. Using graphic front panels controlled by executable block diagrams, LabVIEW gives laboratory users a way to create virtual instruments that turn the Macintosh into a general-purpose laboratory tool.

LabVIEW requires a 512K-byte Macintosh and costs $1995. It works with stand-alone instruments connected to the Macintosh's serial port, and it supports National Instruments' $595 GPIB-MAC interface box and the $1495 MacBus box (see the text box "Using LabVIEW in the Real World" on page 92).

The intended user base for LabVIEW includes engineers and scientists with no programming experience or limited experience with a simple language like BASIC. The components of LabVIEW are the front panel and block-diagram panes for the creation of virtual instruments; a graphic programming language for building front panels and block diagrams; mechanisms for connecting virtual instruments to one another and for linking them to existing C, assembly language, or FORTRAN code modules; built-in I/O functions for reading and writing data to disks or communication ports; and built-in functions for statistical and matrix operations.

VIRTUAL INSTRUMENTS

A virtual instrument (abbreviated as "instrument" for the rest of the article) in the LabVIEW system consists of two items: a front panel and a block diagram. The front panel contains the input and output controls (e.g., dials, switches, and output screens) that represent the data coming into and going out of the instrument (a control's appearance changes when the user manipulates it). The block diagram contains the program that the instrument executes. Each control is represented by an icon in the block-diagram window, and the program appears as a collection of "black box" icons connected in logic-diagram fashion (see the right half of figure 1). If an instrument is to be used inside another instrument, it must also have an instrument icon, which allows the smaller instrument to be used as a black box in the block diagram of the larger instrument.

A SIMPLE EXAMPLE

We will demonstrate the LabVIEW system with a simple example. Let's say

BY G. MICHAEL VOSE AND GREGG WILLIAMS

we want to generate, graph, and store sets of random data points in the range of (0, *s*). (We can store multiple runs of data with the instrument and recall them later, perhaps for use as test data for another instrument.)

Before we start planning the example itself, remember that the random-number function supplied with LabVIEW generates numbers in the range (−1, 1). We need a separate virtual instrument that scales a number from the range (−1, 1) to (0, *s*), where *s* is an arbitrary positive scaling factor. Our first task, then, is to create a scaling virtual instrument.

To create a virtual instrument that scales a number from the range (−1, 1) to (0, *s*), we first have to understand how we are going to calculate this transformation. If we think of the number as a signal to be processed, we might come up with a block diagram for our virtual instrument like the one in figure 2.

First we must add the appropriate controls to the front-panel window (see the left half of figure 1). In standard Macintosh fashion, we call these items up from menu selections in the Controls menu and the dialog boxes that subsequently appear. By clicking on the open-hand icon in the tool palette at the top of the display, the cursor changes to the hand shape, called the Grabber, while it is in the front-panel window. We can then move (and in some cases resize) these controls by using the Grabber. In this example, we use a slider switch to represent the input number to be scaled, an input-only digital readout for the scaling factor *s*, and an output-only digital readout for the scaled result.

When we add controls to the front-panel window, the block-diagram window (which appears when you execute Open Diagram from the File menu) gains corresponding icons. We create the instrument's design in the block-diagram window in figure 1, using icons called by the Functions menu. Again, we use the Grabber to move icons, and the wiring tool (the spool-of-wire icon in the top row) to draw the connections between icons.

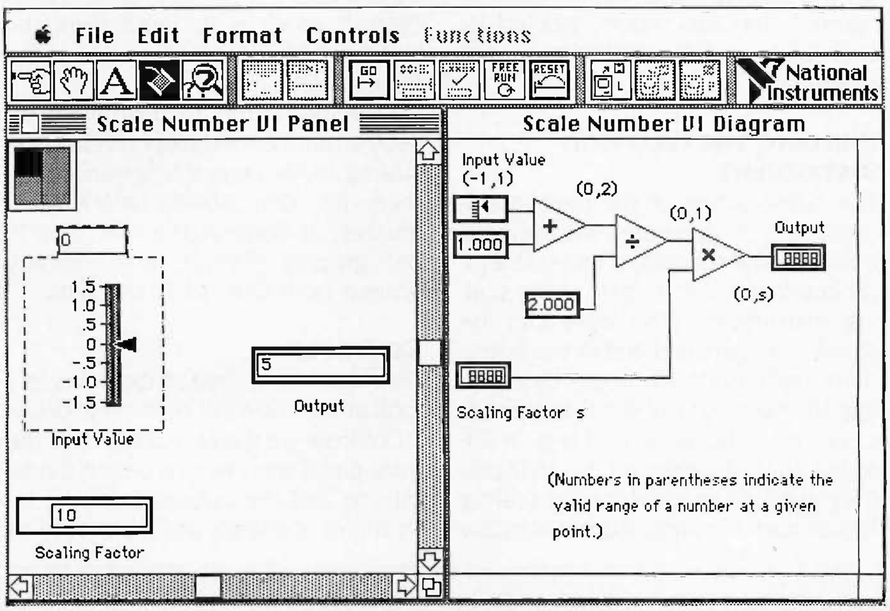
The scaling instrument is now complete. We can test it by using the operate tool (pointing finger) to move the slider switch (thus changing its value) and edit the scale value. When we click on the Go icon on the menu bar, LabVIEW executes the program defined by the block-diagram window and puts the result in the front-panel window. Note that the input value 0, which is in the middle of the interval (−1, 1), translates to 5 on a scale of (0, 10).

The two remaining tools in the tool palette are the labeling tool, which is an I-beam cursor acquired by clicking on the large A icon, and the magnifying-glass-shaped help tool, which displays tutorial information on whatever feature of LabVIEW it is used to click on.

This instrument can be saved, recalled, and run as is. However, we must do one more thing to use it in-

(continued)

G. Michael Vose and Gregg Williams are senior technical editors for BYTE. *They can be contacted at* BYTE, *One Phoenix Mill Lane, Peterborough,* NH 03458.



(Numbers in parentheses indicate the valid range of a number at a given point.)

Figure 1: *The Scale Number virtual instrument. The left half of this figure contains the front panel for this instrument; it contains two input variables, or controls, and one output control. The block diagram in figure 2 translates directly to the block diagram shown in the right half of this figure. The Input Value slider switch (dashed line) is associated with the upper left corner (blackened) of the instrument's icon.*

side other instruments: create a distinctive icon for it. Through selections in the Format menu, you can draw an arbitrary icon, divide its area into rectangular regions, and associate each region with an input or output control. Then within a larger instrument, wires that connect to these regions will be taken as sending or receiving values consistent with the corresponding controls.

The screen dump of figure 1 was taken while the connection points on the scaling instrument's icon were being defined. The icon is represented here by the dark square in the upper left corner of the front-panel window. At this particular moment, the upper left corner of the icon (blackened) is associated with the slider switch (outlined with dashes). The finished icon for the scaling instrument, visible in figure 3, has two inputs, labeled IN and SCA (scale), and an output labeled OUT.

BUILDING THE GRAPHING INSTRUMENT

The construction of the final instrument, which generates the random numbers and scales and graphs them, proceeds similarly to that of the scaling instrument. (The data can be saved in a step unrelated to the instrument definition.) We begin by creating an input control for the number of points to be generated (e.g., a different kind of slider switch), an input-only numeric window for the scaling factor, and a graphic-output window (see the left half of figure 3).

The block-diagram window contains several new items. The icon marked IN/OUT/SCA represents the scaling instrument we just designed. The icon with the graphed points is another predefined instrument that takes a list of numbers, pairs the entries with the numbers 0, 1, 2, . . . , and outputs them as a composite structure of data (note the thick striped line) suitable for use by the graphic control. The triangle with the two dice in it is the random-number-generating function.

The most important item in the block-diagram window is the large box that looks like a stack of stationery; in the LabVIEW system, this represents a FOR loop. The contents of the box will be executed a set number of times. The box labeled N determines the number of iterations (here it receives its input from the Number of Points slider switch on the front panel).

As before, to run this instrument, we set the number of data points and the scaling factor using the operator tool, then hit Go. When LabVIEW is finished, it displays the new data in the graphic control, automatically scaling both axes to fit the data.

CONTROLS

Now that we've seen an example, let's look at the LabVIEW controls in detail.

Controls are the components of the front-panel window that define the inputs to and the outputs from the instrument. Controls are input-only or output-only, meaning that they will receive values from the front panel or display them.

We have seen numeric controls as both input and output controls. At any time, the user can change the control's appearance, the range of valid values, and other characteristics. (LabVIEW also offers a strip-chart numeric control that displays a running history of the variable's values as they scroll off to the left.) String controls differ from numeric controls in that they hold character strings as values; they usually appear as boxes within which text can appear. Binary controls contain a simple 1-bit value; they can appear as a variety of toggle switches, buttons, and indicator lamps whose appearances change when their states change.

Numeric, string, and binary controls all share the ability to be multidimensional; that is, a single control can represent more than one value. For example, an indicator lamp can be declared as a 2 by 4 by 3 array of binary values. Such a control appears on the front panel as an indicator lamp with three boxes beside it that contain the indexes of the value currently being displayed. By changing the values inside the boxes, you can look at the values of individual elements in the array. LabVIEW supports controls that have up to eight dimensions.

Graphic controls are simpler; as output, they display an ordered set of *x,y* pairs as a line graph. National Instruments plans for the graphic controls

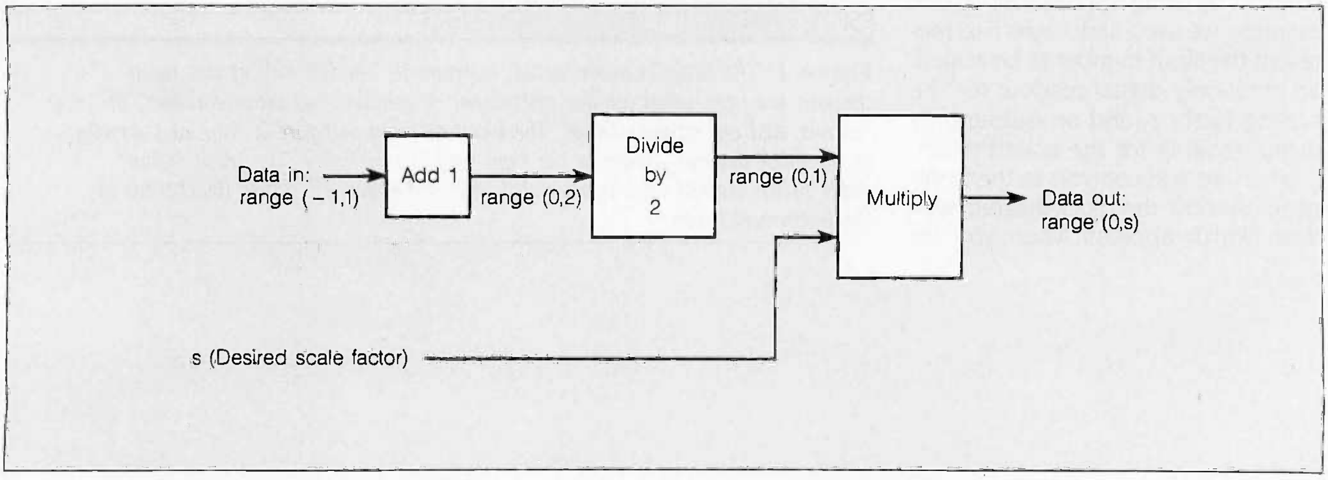


Figure 2: *Designing the block diagram. This diagram shows one way to scale a number from the range* (−1, 1) *to the range* (0, *s*).

to have additional options in the finished product.

The last type of control is a cluster control, which allows you to group an arbitrary collection of data items together so that they can be represented as a single line in the block-diagram window instead of as multiple lines. For example, the *X*(*i*)-versus-*i* instrument in figure 3 contains a single cluster that transforms the list of *X*(*i*) data and an internally generated list of *i* values into the data structure that the graphic-output control requires.

COMPILED INSTRUMENTS

The designers of LabVIEW realize that you may need functions that cannot be accomplished with high-level user-defined instruments. They also realize that you may already have data acquisition routines written in a high-level compiled language that you do not want to give up. To meet this situation, LabVIEW has the ability to link the parameters of a compiled subroutine (called, in Macintosh terminology, a code resource file) to front-panel controls. In this way you can tie your routine to an instrument icon and use it anywhere in the LabVIEW system. National Instruments plans to offer Macintosh users the ability to link to routines written in C, assembly language, and FORTRAN, with links to other compiled languages possible in the future.

G—THE GRAPHICS PROGRAMMING LANGUAGE

LabVIEW's programming language, called G, uses icons in place of keywords but tosses in a few textural compromises to overcome the intrinsic limitations of a pictographic lexicon. The LabVIEW programmer uses the icons to build the block diagrams that define the function of a virtual instrument.

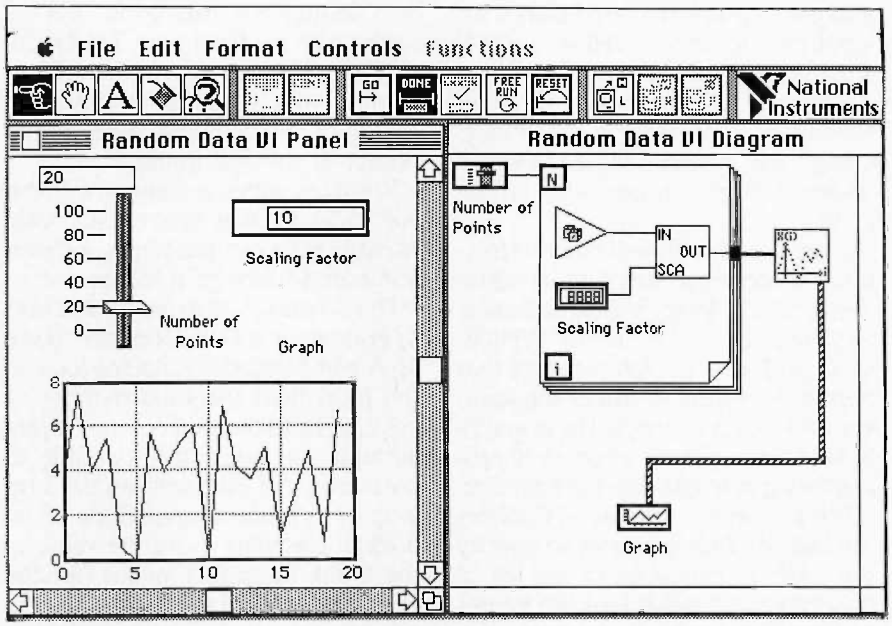


Figure 3: *The Random Data virtual instrument. The Scale Number instrument of figure 1 is visible here as the square icon marked* IN/OUT/SCA. *The Number of Points input drives a* FOR *loop that scales a random number (the triangular icon) to the range given by the Scaling Factor input control. The instrument then collects the data, scales it, and graphs it.*

Table 1: *Built-in functions in LabVIEW.*

Arithmetic: +, –, *, /, **(exponentiation), min, max, neg, abs, inv, AND, OR, XOR

Comparative: =, not =, >, > =, <, < =, = 0, not = 0, > 0, > = 0, < 0, < = 0

Transcendental: sin, cos, tan, asin, acos, atan, sinh, cosh, tanh, log, exp, sqrt, ln

String: string concatenation, substring, parse string, string to numeric, numeric to string, string compare, string length, null-string detection, ASCII-string detection

Statistical: mean, variance, standard deviation, histogram, mode, median, moments, residues

Matrix: transposition of dimension, lesser-dimension subsets, subarrays, individual element manipulation, dot product, cross product, matrix multiply, inversion

Curve fitting: linear, polynomial, exponential

Signal processing: FFT, inverse FFT, convolution, correlation, power spectrum, integration, differentiation

The language offers a special set of flow-of-control structures and a wiring mechanism to connect them. These wired structures define the flow of data among the parts of a block diagram. In addition, the language provides standard and special arithmetic functions plus a broad array of special functions for input/output, string manipulation, and scientific and engineering tasks (see table 1 for a list of specific functions available). The compromises to the iconic scheme of the language include a calculator that permits the use of formulas within virtual instruments and a provision for linking traditional program code to existing instruments.

BUILDING BLOCKS

Computer science theorists have shown that any algorithm can be built

(continued)

successfully with three structures: an iterative loop, an IF. . .THEN . . . ELSE structure, and a DO. . .WHILE loop. Any system with these structures can be called a programming language. Using these criteria, LabVIEW's iconic underpinnings can be called a language.

G provides five flow-of-control structures: a sequence structure; an iterative, or FOR, loop; a case selection structure; an indefinite, or WHILE, loop; and a set of shift registers that permit the recursive use of the iterative and indefinite loops. These graphic structures permit structured programming in a data-flow environment.

The sequence structure of G allows the LabVIEW programmer to specify the order of execution of any set of operations. Icons that look like frames of film (see figure 4) represent the separate ordered steps in a series of sequential operations. A number in the upper middle area of each frame displays the sequence number of the frame currently selected.

An instrument's sequence frames execute in strict order; that is, frame one must finish execution before frame two can begin. Interestingly, structures within a frame, such as a FOR structure, can execute in parallel with other such structures. Sequences, however, like nodes in a traditional data-flow model, cannot execute until a prior condition is satisfied, namely, the arrival of dependent data. Sequences help, in fact, to defeat LabVIEW's inherent parallelism. For example, in a three-sequence instrument, you cannot specify that execution begins with the second frame in the sequence; execution always begins with the first frame. The execution signal for the start of the second frame in the sequence is the availability of all outgoing data at the border of the first frame.

Variables within a sequence frame are local to that frame, but local variable data can pass from a lower-numbered frame to a higher one.

The G control structure for iterative operations is a FOR loop (see figure 4). A pair of special variables local to the loop hold the total number of iterations and the value of the current iteration, or index. It is possible to pass arrays of data into an iterative loop or to perform operations on indivdual elements using the value of the index to extract values. All the operations placed inside the icon representing the loop execute for every iteration of the loop.

The case selection structure in G permits you to the execute several operations within the structure by using a selector value to determine the operation to be performed. The selector value must be an integer between 0 and *n*. You must use the case structure to perform the equivalent of IF. . .THEN . . . ELSE comparisons in G.

The indefinite, or WHILE, loop is similar to the FOR loop with one major difference. Loop execution depends on a test of a specified condition, usually a Boolean conditional. As with FOR loops, you can pass data arrays into the loop. You can also pass individual array elements into an indefinite loop. Even though the LabVIEW manuals call this a WHILE loop, it is actually an UNTIL loop that always executes at least once, even when the conditional is set at zero.

The shift registers of G allow an iterative or indefinite loop to execute recursively. A shift-register set includes a leaf node and two or more root nodes. You can use multiple sets of shift registers. Since many programming situations demand the use of past, or existing, data, G's shift registers offer a method for accumulating this data. The data shifts from register to register, with the initial value of the leaf node passing to the first root node and that node's value passing to the second root node.

CONNECTING THE PARTS

Since the underlying programming model for G is data flow, the connections between control structures, constants, variables, and input/output controls are extremely important. The iconic representation of the paths on which data flows among the G components is wire. The wiring tool is used to connect block-diagram parts. The appearance of a wire reveals details of the type of the data that travels that path. For example, a thin wire represents a flow of single numbers, while a medium-size wire with a hatched border represents a multidimensional array of strings (see figure 5). A dashed wire denotes a bad connection, which is a data path that is not possible.

When G programmers connect two G program structures together with the wiring tool, they do not have to know what kind of wire to use. G chooses the appropriate data type for

(continued)

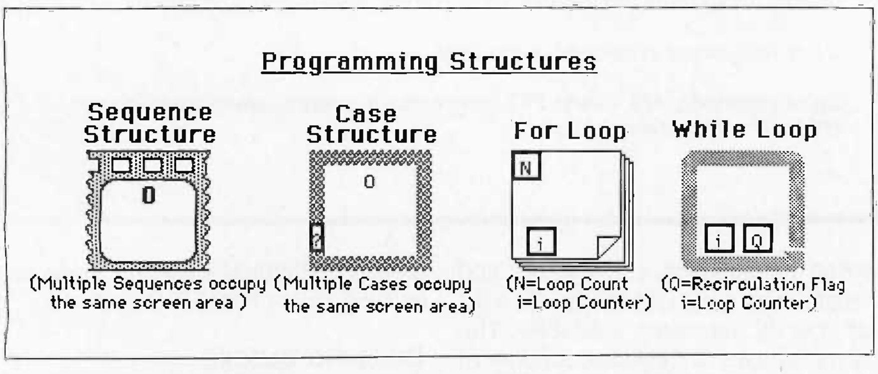


Figure 4: *The flow-of-control structures of* G, *LabVIEW's underlying iconic programming language.*

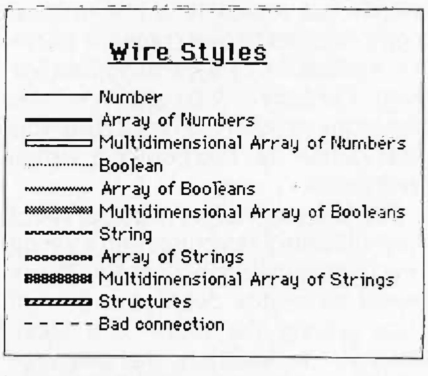


Figure 5: *The wire types of* G *and their associated data types.*

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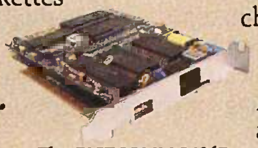

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the data path based on the kind of structures that are being connected. G knows, for example, that plotting values on a graph means that the data flowing to the graph will be at least a two-dimensional array of numbers.

The appearance of the wires often changes at the border of a control structure due to data transformations taking place at the border. The values that a FOR loop's operations generate, for example, accumulate into an array at the loop border, and this array of values travels along a data path to another component. In this way the change in the appearance of the wire from a thin line to a thicker line signals that a data transformation has occurred.

LabVIEW programmers have four basic data types at their disposal: real numbers and arrays of reals, Booleans and arrays of Booleans, strings and arrays of strings, and structures that are analogous to structures in C.

CONSTANTS, VARIABLES, AND ARITHMETIC FUNCTIONS

You load G program variable values into controls on an instrument's front panel. The controls represent variables on the underlying block diagram, and these values are then used when the program, the virtual instrument, runs. Constants function similarly except that you load their values at the block-diagram level.

Arithmetic functions in G are as rich as in any other imperative language. Addition, subtraction, multiplication, and division are supplemented by complex functions such as exponentiation, binary and logical functions, transcendentals, and special functions like square root and random-number generation. Table 1 lists the full set of available functions.

A calculator solves the problem of screen clutter for implementing complicated formulas or equations in G. One of the calculator's inputs takes a string containing one or more formulas and uses this formula string to process up to five numeric inputs to produce up to four numeric outputs. The calculator is itself a virtual instrument, and its underlying block diagram can be displayed to aid in the debugging of entered formulas.

INPUT/OUTPUT, STRING, AND OTHER FUNCTIONS

The LabVIEW system's design targets scientists and engineers as primary users. The system's designers have incorporated within the G language a number of specialized functions aimed specifically at these users.

In addition to standard file input/output functions, LabVIEW provides built-in functions to manage GPIB communications between a Macintosh and stand-alone instruments or board-level devices. These functions go beyond merely passing ASCII strings containing GPIB commands, providing functions to reset the bus, triggering instrument events, and giving GPIB status information.

A variety of signal-processing functions, like fast Fourier transform, convolution, correlation, power spectrum, integration, and differentiation are planned in the release version of LabVIEW, although they were not in the software we worked with. National Instruments also promises statistical functions, matrix manipulation functions, and curve-fitting routines in the initial release of LabVIEW.

CAVEATS

When we wrote this article, there were a number of claimed features for LabVIEW that were not yet complete so we cannot describe exactly how they will work. We worked with at least three pre-beta versions of LabVIEW over a period of three months in compiling this preview, the last of which was version 0.35. We found that the mechanism for programmable data retrieval of past instrument runs was unreliable. The Options function for choosing certain features of input/output controls wasn't working, and several of the planned built-in func-

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tions were not yet available. Some of the alternate graph styles were not yet added. These alternate graphs will include polar plots and scattergrams as well as the ability to plot multiple sets of data on one graph.

CONCLUSIONS

Many of LabVIEW's features show great promise. Its pop-up menus are context-sensitive; the menu you get depends on the icon you are touching when you call for it. These contextual menus make creating front panels and block diagrams easier and less prone to error. Pop-up menus are consistent with the Macintosh user interface and are usually better than the dialog boxes that they replace.

The amount of housekeeping that LabVIEW performs—letting the programmer forget about data types, for example—makes the system easy to use by not requiring you to be a programmer. LabVIEW does type-checking automatically, and there is essentially no such thing as a syntax error (dashed lines representing improper wiring connections excepted) when using icons for programming. LabVIEW initializes and maintains loops automatically, and its block diagrams make programs self-documenting.

The metaphor of the front panel and its underlying block diagram is intuitive and creates a comfortable user interface. The different versions of LabVIEW that we've seen show a good design sense with the addition of new features when necessary.

Logical debugging of block diagrams can be tedious, however. The program's multiple cursors (tools) can be confusing, such as deciding whether to use the Grabber tool or the Pointer. The system is also constrained by its application being limited to engineering uses and by its existence on a Macintosh in a world dominated by IBM PCs.

There are some intrinsic contradictions in LabVIEW. What LabVIEW calls a WHILE loop is actually an *UNTIL* statement. The case icon must be used for an IF. . .THEN . . . ELSE construct.

The screen space within a block diagram may be a limiting factor in LabVIEW's practical application. A single virtual instrument can't be very complex since there's room for only a finite number of operations within a single screen. You can nest virtual intruments without limit, but this doesn't guarantee that you can build complex structures with 10 or 20 branches versus the 2 to 3 branches that can easily fit on a screen.

LabVIEW uses the Macintosh's SANE math library, providing full IEEE-754 floating-point compatibility. SANE yields 80-bit precision for floating-point operations and gives a dynamic range of $-1.7E-4932$ to $1.1E+4932$. Loop counters are always cast to integers and are currently limited to the range 0 to 2^{32}.

National Instruments claims that LabVIEW's performance is equal to BASIC's, but many laboratory applications may require better performance than that. However, the capability to link code resources to virtual instruments may negate this performance limitation.

Overall, using LabVIEW is an exciting experience that may give us a peek into the future. Will the data-flow programming model and object-oriented programming techniques merge into an iconic language of the future? Maybe LabVIEW is a step in that direction. ■

USING LABVIEW IN THE REAL WORLD

National Instruments specializes in computer and GPIB hardware interfaces and software. They developed LabVIEW as the next generation of software to help users of data acquisition equipment to control this equipment with computers. They now have one product, the GPIB-MAC interface box, which will work on a 512K Macintosh or Macintosh Plus, and another product under development that will connect to a Macintosh Plus through its SCSI port.

National Instruments has been shipping the $595 GPIB-MAC interface since November. It plugs into the modem port on the Macintosh and makes a GPIB plug available for one or more instruments. (GPIB plugs can stack on top of each other, allowing instruments to be connected in a star pattern.) Currently, custom programs can send GPIB commands and receive results as if through a modem. From LabVIEW, however, the virtual instrument designer can use six different GPIB-related icons in the block-diagram window, including one that passes an arbitrary string to the GPIB bus.

MacBus is a $1495 hardware and software combination that provides a GPIB interface, five IBM PC AT–compatible interface card slots, and various necessary software packages. Its card cage connects to a Macintosh Plus through its SCSI port. Two slots are taken up by the GPIB interface card and a microcomputer card containing the NEC V50 chip, which coordinates the Macintosh Plus and the GPIB interface. Backplane circuitry is reported to generate a subset of the IBM PC AT bus. The V50 chip controls the GPIB circuitry through a FORTH-like extensible proprietary language called IBCL, and National Instruments supplies interface routines that allow the user to control and program MacBus from Megamax C or Microsoft BASIC. Although details are not final, users will be able to access existing IBM PC and PC AT cards by some sort of memory mapping; this method will require a custom device driver to interact with the LabVIEW system.

However, even when users have the hardware and software connections to GPIB, their job may not be finished. GPIB commands are terse and cryptic (e.g., rd #16 5 reads up to 16 bytes from the device at address 5), and many users have difficulty writing the correct commands for a given task. Because of this, National Instruments thinks that virtual instruments could be useful as front ends that take a command from the front panel and build and execute the proper GPIB string. National Instruments may supply front-end virtual instruments for selected popular GPIB instruments. Customers could then use these virtual instruments as is or modify them to fit a similar piece of equipment.

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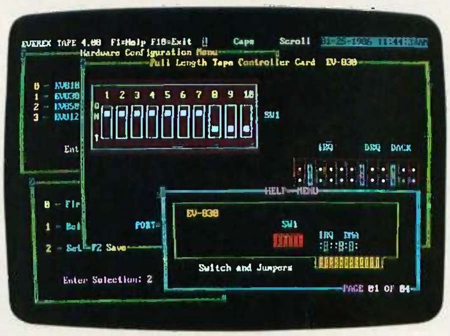
- Escape to DOS while in backup/restore operation.

```
EVEREX TAPE 4.00  F1=Help F10:Exit      Caps      Scroll

0291  1-24-86   8:16p     24910 C:\EVTAPE\SCHEDULE.EXE
0292  1-24-86   8:16p     22420 C:\EVTAPE\INSTALL.EXE
0293  1-24-86   8:16p     40668 C:\EVTAPE\DIAG.EXE
0294  1-24-86   8:16p        78 C:\EVTAPE\TAPE.CFG
0295  1-24-86   8:16p     33668 C:\EVTAPE\TAPE.MEN
0296  1-24-86   8:16p      5768 C:\EVTAPE\TAPE.ERR
0297  1-24-86   8:16p     62192 C:\EVTAPE\TAPE.HLP
0298  1-21-86   5:09p     64332 C:\IRESTORE\IRESTORE.EXE
0299  1-25-86  11:27a      7239 C:\IRESTORE\IRESTORE.MEN
0300  1-07-86   9:04a      7112 C:\IRESTORE\IRESTORE.HLP

                     Tape Header Information
Group  Number:  0022304400         Dataset  Number:  0000000002
Order  Number:  1                  Dataset   Label:  TAPE SOFTWARE
Tape   Number:  0022304400         Dataset    Type:  FILE
Tape    Label:  EVEREX SYSTEMS     Date  and  Time:  01-25-1986 11:40:17AM
```

Automatic Scheduler



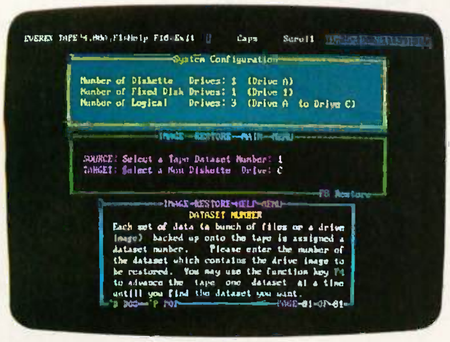
```
EVEREX TAPE 4.00  F1=Help F10=Exit      Caps      Scroll  01-25-1986 11:44
      Hardware Configuration Menu
           Full Length Tape Controller Card  EV-830
0 - EV810
1 - EV830     1  2  3  4  5  6  7  8  9  10
2 - EV850                                       SW1
3 - EV012
                                          IRQ      DRQ  DACK
  Ent

                              HELP MENU
0 - Fir           PORT-   EV-830
1 - Bol                                SW1
2 - Sel  F2 Save                              IRQ  DMA

                           Switch and Jumpers
    Enter Selection: 2
                                               PAGE 01 OF 04
```

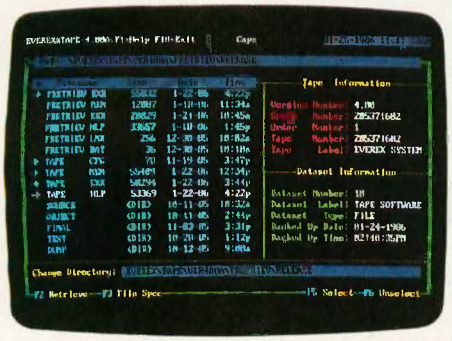
Nestable, Movable Windows

find...



```
EVEREX TAPE 4.000,F1-Help F10-Exit      Caps     Scroll
                    System Configuration
   Number of Diskette   Drives: 1  (Drive A)
   Number of Fixed Disk Drives: 1  (Drive 1)
   Number of Logical    Drives: 3  (Drive A  to Drive C)
                 IMAGE--RESTORE--MAIN--MENU
   SOURCE: Select a Tape Dataset Number: 1
   TARGET: Select a Non Diskette  Drive: C
                                                F8 Restore
            IMAGE-RESTORE-HELP-MENU
                 DATASET NUMBER
      Each set of data (a bunch of files or a drive
      image) backed up onto the tape is assigned a
      dataset number.   Please enter the number of
      the dataset which contains the drive image to
      be restored.  You may use the function key F4
      to advance the  tape  one  dataset  at a time
      untill you find the dataset you want.
      ^D DOS--^P POP                     PAGE-01-OF-01
```

Backup with Multiple Datasets



```
                          Tape  Information
   Version Number: 4.00
   Group   Number: 2053371602
   Order   Number: 1
   Tape    Number: 2053371602
   Tape     Label: EVEREX SYSTEM
                        Dataset Information
   Dataset Number: 10
   Dataset  Label: TAPE SOFTWARE
   Dataset   Type: FILE
   Backed Up Date: 01-24-1986
```

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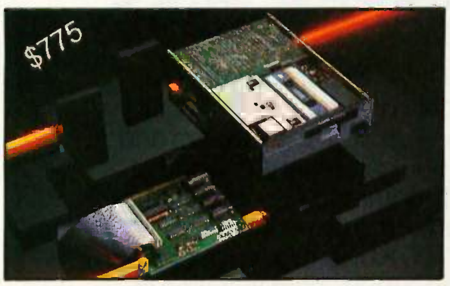

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Inquiry 340

BUILD A HARDWARE DATA ENCRYPTOR

BY STEVE CIARCIA

This easy-to-build device is extremely difficult to crack

It's 4:00 a.m. Do you know who has logged on to your electronic messaging system? Theophilus Cracker has spent all night trying to get into the files on your latest research project, and he has finally made it. All your efforts and careful planning are about to go down the drain, as the contents of the stolen library are listed on his screen.

But wait, what is this? Why the blank expression on his face? Has he been thwarted by a little black box? Will he go sleepless and hungry trying to figure out why it all looks like trash?

Whether gaining access to sensitive data presents an interesting challenge to the cracker or whether there's a malicious ulterior motive in mind, the violation of your private electronic communication is the same. Fortunately, it can be prevented.

The Circuit Cellar data encryptor is intended to provide an additional level of privacy. With the feverish rush to install the latest and best electronic data and messaging systems, individuals and companies frequently overlook who has access to sensitive materials until something turns up in the wrong place. Rather than requiring password access to all materials of a certain security level within a computer system, data encryption allows individually designated data access. The delivery of a message "For Mr. Jones's eyes only" becomes an easily achieved reality merely by controlling the dissemination of the encryption keys.

Electronic data should be managed and protected with the same attention given to your bank account. The electronic messaging system that you just installed to coordinate all your branch offices with your on-the-road field service personnel might actually be a comprehensive accounting of your business's current vulnerabilities in the hands of a competitor. Or someone may accidentally log on to a very sensitive memo to the branch managers about recent pay scales.

I'm not attempting to be a harbinger of doom. I'm just trying to point out some things that you may have overlooked. I could hardly have kept your attention if I described anything less than a worst-case scenario.

In reality, vulnerability is a function of access and content. More simply stated, this translates to "who can get their hands on

(continued)

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, you can write to him at P.O. Box 582, Glastonbury, CT 06033.

what." Even the simple one-line telephone bulletin board has a system operator. If installed in a moderate-size business, a few other people would probably have complete access to the electronic database.

At the point where the number of "whos" who should have access to all the "whats" is greater than 0, you have to think about alternatives.

Because there are more programmers than hardware designers, the predominant approach to system security has been in application software. The techniques most frequently employed to improve computer security are reducing the "whos," individually categorizing the "whos" (passwords), limiting the posting of the sensitive "whats," or individually categorizing (more passwords) or encrypting the "whats."

These methods have had relative success in minicomputers and mainframes, where there is enough horsepower to maintain a menu-driven, stratified security level, password-

CRYPTOGRAPHY BACKGROUND

After World War I broke out, American Telephone & Telegraph realized that a system was needed to guard messages sent between its new printing telegraphs. These early teletypes used Baudot code to transmit the 26 letters of the alphabet, the 10 digits, an assortment of punctuation marks, carriage return, line feed, shift-to-figures, and shift-to-letters. There were 32 different combinations of marks (1s) and spaces (0s) making up the 5-bit code.

Gilbert S. Vernam solved the problem in December 1917 with a system that now bears his name and that is the heart of most stream-encryption systems in use today. Vernam sought a system where a key is combined with a plaintext character to produce a cipher character in a reversible way such that if the same key were combined with the cipher character, the original plaintext character would be recovered. The system he employed to combine the plaintext character with the key is an exclusive-OR of each pair of bits to form the ciphertext character. A truth table of the exclusive-OR function will show that the system is reversible, as shown in figure A.

A key bit of 1 causes a plaintext bit to reverse to form a ciphertext bit. Applying the same key bit again would reverse the ciphertext bit to recreate the original plaintext bit. A key bit of 0 causes the plaintext bit and ciphertext bits to remain unchanged.

The Vernam system drew a lot of interest, particularly from the Navy, because it was the first encryption system that did not need a cipher clerk and the first to encrypt on-line without any delays. But it had a flaw, which the engineers who worked around Vernam discovered.

During early development, key tapes were short loops of tape bearing characters picked from a hat. It didn't take the engineers long to discover that the Vernam system was polyalphabetic, permitting a Kasinsky solution. One of the engineers, Lyman F. Morehouse, solved this problem by combining two short key tapes of slightly different lengths (in effect encrypting the message twice). If one key tape was 1001 characters long and the second was 999 characters long, the resulting key would be 999,999 characters long. The cipher is still polyalphabetic, but it has 999,999 alphabets.

Vernam's system was patented in July 1919, but it did not gain wide acceptance until the Army started using it when World War II broke out.

		plaintext		
		1	0	
key	1	0	1	ciphertext
	0	1	0	

		ciphertext		
		1	0	
key	1	0	1	plaintext
	0	1	0	

Figure A: *A key bit of 1 causes a plaintext bit to reverse to form a ciphertext bit. Applying the same key bit again would reverse the ciphertext bit to recreate the original plaintext bit. A key bit of 0 causes the plaintext bit and ciphertext bits to remain unchanged.*

HOW SECURE IS MY ENCRYPTOR?

Generating every possible key is not a practical way to break the Circuit Cellar data encryptor because the key is a pseudorandom bit stream that repeats every 18,014,396,353,609,729 bits. Once it is initialized with a user key, the key sequencer is stepped eight times each time a character is encrypted. Not knowing what the initial bit pattern in the sequencer was would require that every possible pattern be tried to decode a message. With each trial, part of the message would be decrypted by using the trial key and examining the results for meaningful words or numbers. Generating the trial key is easy. Testing to see if the decrypted text is meaningful would require some clever programming.

Another technique, the most-probable-word method, is more or less a reverse of the previous one. Instead of guessing at the key and looking for strings of characters that look like words or numbers, a string of characters is assumed to be at a certain location in the text. For instance, it might be assumed that the sender has sent a letter and put "Dear Sir," at the beginning. Knowing this, and assuming its exact location in the message, the key that encrypted that word can be determined.

In reality, this is just part of the solution. The real work is trying to determine the rest of the key from this small segment of the key. This cracking scheme is further complicated by the technique called diffusion, which makes it almost impossible to regenerate the pseudorandom bit streams from even a large sequence of known key bits.

directed communication maze. Unfortunately, most of the recently introduced low-cost microcomputer-based electronic messaging systems and bulletin boards cannot offer this much security, and the user must resort to other means if portions of the database are to be truly protected. The most secure and cost-effective solution is hardware data encryption.

A DESIGNER'S DILEMMA

This article presents an encryption device that is easy to understand, easy to build, easy to use, but which is very difficult to break.

In building this project, I faced a dilemma regarding the hardware. As with any complex task, there are a multitude of solutions that are usually a trade-off of time and materials. Unlike most designers, who do a one-of-a-kind project and document its use, most of my projects end up being manufactured. While this absolutely demonstrates that the published design indeed works, sometimes the design that is best to manufacture is not the best to use as the basis of an article.

Engineers with lots of manufacturing experience (and the responsibility for making a product successful) instinctively know the algorithm that compares R&D, production costs, and volume. Hardware solutions, while low on initial R&D expense, can be infinitely more expensive to manufacture than a well-thought-out hybrid microcomputer-based hardware/software approach.

The solve-it-quick-it's-only-an-article hardware encryptor is a real kludge. It requires at least 25 TTL chips just to perform the encryption, takes a lot of printed-circuit-board real estate, and is fairly inflexible to functional modification. On the positive side, the building-block SSI/MSI-level interconnections provide convenient functional separations allowing easier explanation.

If I merely wrote articles and never wanted people to use the designs, the answer would be easy (I'll never live down not having PC boards for my serial EPROM programmer. Next month I'll do it right). Rather than redo the encryptor to make it manufacturable, I looked very carefully at its component count and performance objectives. The conclusion I came to was to describe and produce the one design that was actually worth building.

ENCRYPTION TECHNIQUES

Many techniques for encrypting data are available: the RSA public-key encryption system, Lucifer, DES (the data-encryption standard), and variations on the Vernam cipher.

DES, considered among the most effective, is the system chosen by the government and the military. Lucifer and DES are very similar and complex enough to make them difficult to implement on a small computer without dedicated VLSI encryption logic. RSA, developed at MIT in 1977 by Ron Rivest, Adi Shamir, and Len Adleman, is copyrighted; its users must pay a royalty to the copyright owners. This system is not suitable for implementation on a small computer because it involves a lot of large-integer arithmetic.

RSA, Lucifer, and DES are block ciphers, meaning that a block of characters (64 bits or 8 characters for DES, 100 characters for RSA) are encrypted together so that each output block is a functional combination of the complete key and input block.

The Vernam cipher is a stream cipher, meaning that each bit of the encrypted data is a function of only 1 bit of the original data and 1 bit of the key. If the signal gets distorted and causes a bit to be misinterpreted, only that bit will be incorrect in the deciphered text. If a bit is misinterpreted when using a block cipher, the avalanche effect will cause the entire block to be affected. In any encryption system, however, if a whole character is lost or added, the rest of the message will be garbled unless some special text-blocking system is employed to resynchronize the decryptor. Then, only one block will be garbled.

THE VERNAM CIPHER

I chose the Vernam cipher over DES for this project because it is easy to implement in hardware or in software and it offers adequate security for anything but the most sensitive communication. While it might seem more intriguing to build a DES-based encryptor, such an endeavor involves either expensive DES encryption chips or bureaucratic involvement in licensing arrangements. I like Circuit Cellar projects to be buildable, and warning labels with abbreviations like NSA and CIA only complicate the task.

If a cracker tested 10 million keys per second, it would take 28 years to find the correct one.

While my encryptor could conceivably be used for DES encryption in addition to or instead of the Vernam cipher, I have decided to presently stay with the latter as a published presentation (if the entanglements are resolved, the additional features can be implemented by simply changing an EPROM). Even though the Vernam cipher is simple, it is an effective cipher. The most obvious technique for breaking a cipher is by trying every possible key. The key in this implementation is a pseudorandom bit stream almost 1.8 × 10^{16} bits long. If an attacker were able to generate and test 10 million keys per second, it would take 28 years, on the average, to discover the key. (See "Cryptography Background" on page 98.)

CONNECTING AN ENCRYPTOR

Two of the primary design objectives of my data encryptor were that its operation should be transparent to the terminal or computer that it was connected to and that it would be usable with any system. The data encryptor connects to your computer through a serial port (see figure 1). A second encryptor, functioning in decryption mode, is needed wherever

(continued)

the scrambled data is received and used (except in loopback mode to encrypt data files on a single system).

The transmitter converts the data output from your computer or terminal to encrypted binary or encrypted ASCII data for transmission to another system. The receiver section takes encrypted text and deciphers it into plaintext that is then presented to your computer or terminal. Both transmitter and receiver sections have serial ports that share a common baud rate and configuration settings; otherwise, they are independent channels. You can encrypt data in one key and decrypt in another as well as send encrypted text while receiving plaintext or vice versa.

If messages are being encrypted for storage on either your own disk drive (figure 1a) or on the storage facilities of an information service (figure 1b), only you need to know the key. If, however, messages are being encrypted and transmitted to a second party (figure 1c), both persons must have the key before the message can be decrypted. The key must thus be delivered to the receiving party by secure electronic communication or manual delivery. It is advisable to change keys occasionally, in case someone discovers it and uses it.

THE BRUTE-FORCE APPROACH

My first encryptor design used the brute-force hardware approach because it easily explained Vernam cipher encrypting. However, this approach was dismissed early. It was not prototyped nor was the schematic fully completed. I caution you that, while parts of it are shown as schematics, these should be treated more as functional block diagrams with connecting wires. They are included merely to explain the internal logic of an encryptor and the cost benefit of performing the same functions in software where applicable.

Figure 2 shows a functional block diagram of a typical hardware-implemented Vernam cipher encryption device (when the terms "encryptor" or "encryption" are used to specify a complete device, they also usually in-

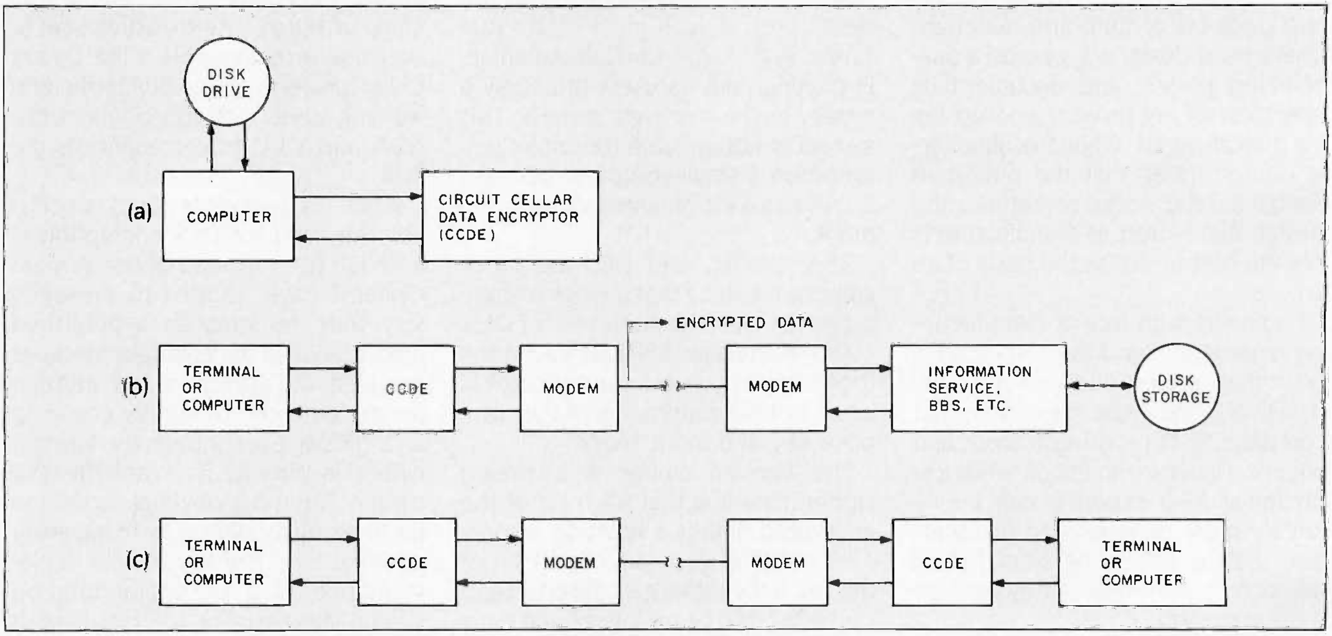


Figure 1: (a) *The data encryptor connected in loopback mode. Data is encrypted before being stored on disk.* (b) *A single-ended data-encryption system. Data is encrypted before being stored on the information system disk.* (c) *Two data encryptors connected as a two-party secure data-transmission system. Both parties must have the key to encrypt and decrypt data.*

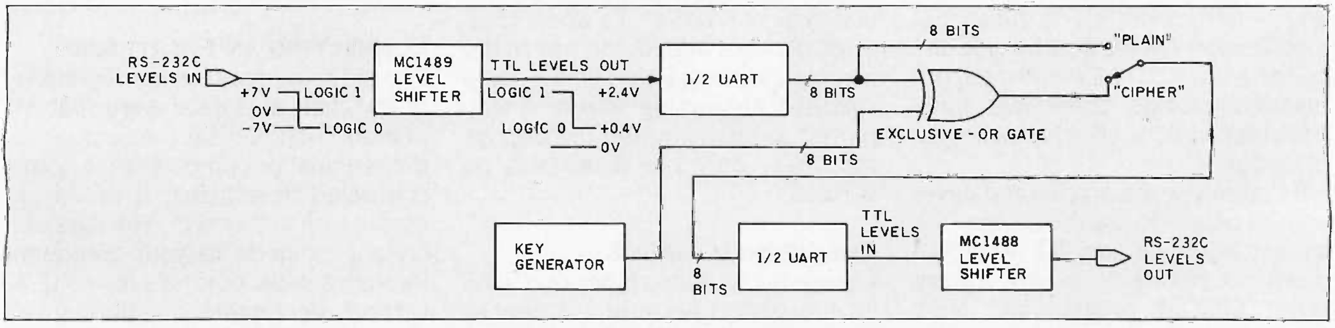


Figure 2: A *functional block diagram of the basic Vernam cipher encryptor, as used in the Circuit Cellar data encryptor.*

clude the decryption function).

The signal to be encrypted enters from the left. The RS-232C signal has its voltage levels (nominally +7, −7 volts DC) shifted to TTL voltage levels (nominally +2.4, +0.4 V), passes to a UART, and exits the UART as 8 data bits in parallel. If plaintext is selected, the data passes back into a UART and is serialized and level-shifted from TTL to RS-232C. In the plaintext position, the key generator remains inactive.

If ciphertext is selected, the key generator originates 8 bits of the key every time a character is received. Using an exclusive-OR function, the key is combined with the data coming from the receiving UART and is then fed to the sending UART.

Key generation is accomplished directly in hardware (see figure 3). The technique used here is to combine the output of two pseudorandom sequencers to produce one pseudorandom bit stream. The pseudorandom bit stream must produce 8 new bits every time a character is received by the UART. Many imaginative techniques for generating pseudorandom bit streams have been devised, but the security of a system must depend not on how complex this technique is, but on how many bits are produced before the cycle repeats.

RELATIVE PRIMES

One possible method is to use an exceptionally long sequencer, but even this makes the most-probable-word method of cryptanalysis (code cracking) only minimally less successful. A significantly more secure method combines bits from two pseudorandom sequencers. The resulting diffusion makes the most-probable-word cracking very difficult. When combining two bit streams, however, it is important that the lengths of the two component streams be relative primes (they must not have any factors in common). The numbers 14 (2 × 7) and 15 (3 × 5) are relative primes. Put another way, their greatest common denominator (GCD) must turn out to be 1.

The length of the bit stream gen-

(continued)

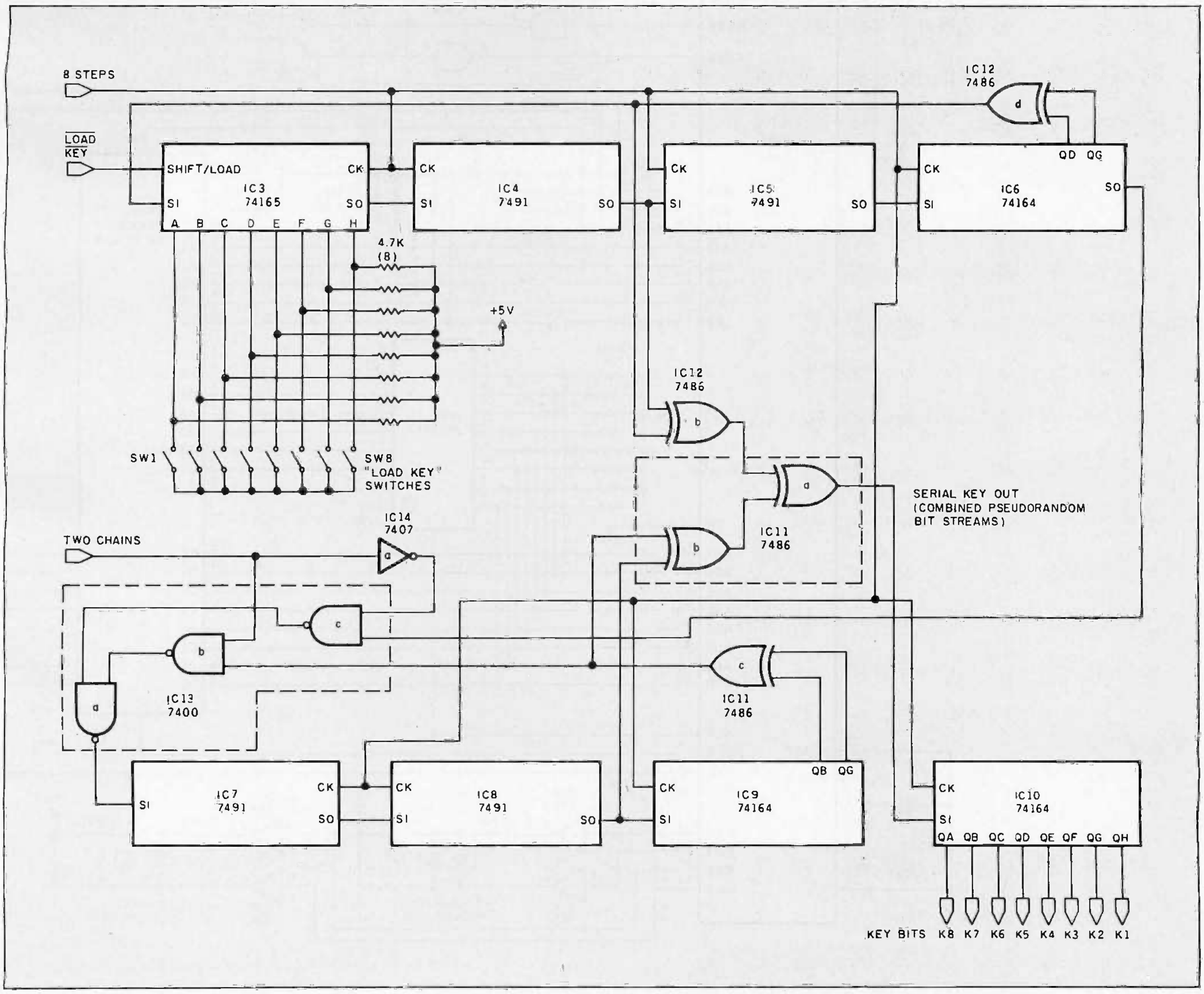


Figure 3: *Key-generator logic.*

erated by the top four shift registers in figure 3 is $2^{31} - 1$ or 2,147,483,647. The length of the bit stream of the lower three shift registers is $2^{23} - 1$ or 8,388,607. The last bit in both bit chains is not used, even though using these bits would almost quadruple the length of the combined bit stream produced, because $2^{24} - 1$ and $2^{23} - 1$ are not relative primes. Their GCD is 255, producing a key length of $(2^{32} - 1) \times (2^{24} - 1) / 255$.

MERSENNE NUMBERS

The integer $2^n - 1$ is called a Mersenne number after Marin Mersenne, who determined that two integers, 2^m-1 and 2^n-1, are not relative primes if m and n are not relative primes.

The numbers above ($2^{32} - 1$ and $2^{24} - 1$) are not relative primes because 32 and 24 are not relative primes. A shift register of length n can be turned into a pseudorandom sequencer of length $2^n - 1$ by providing feedback using a combination of exclusive-ORs. ICs 3, 4, 5, and 6 (in figure 3) form a sequencer with a length of $2^{31} - 1$ by tapping the twenty-eighth and thirty-

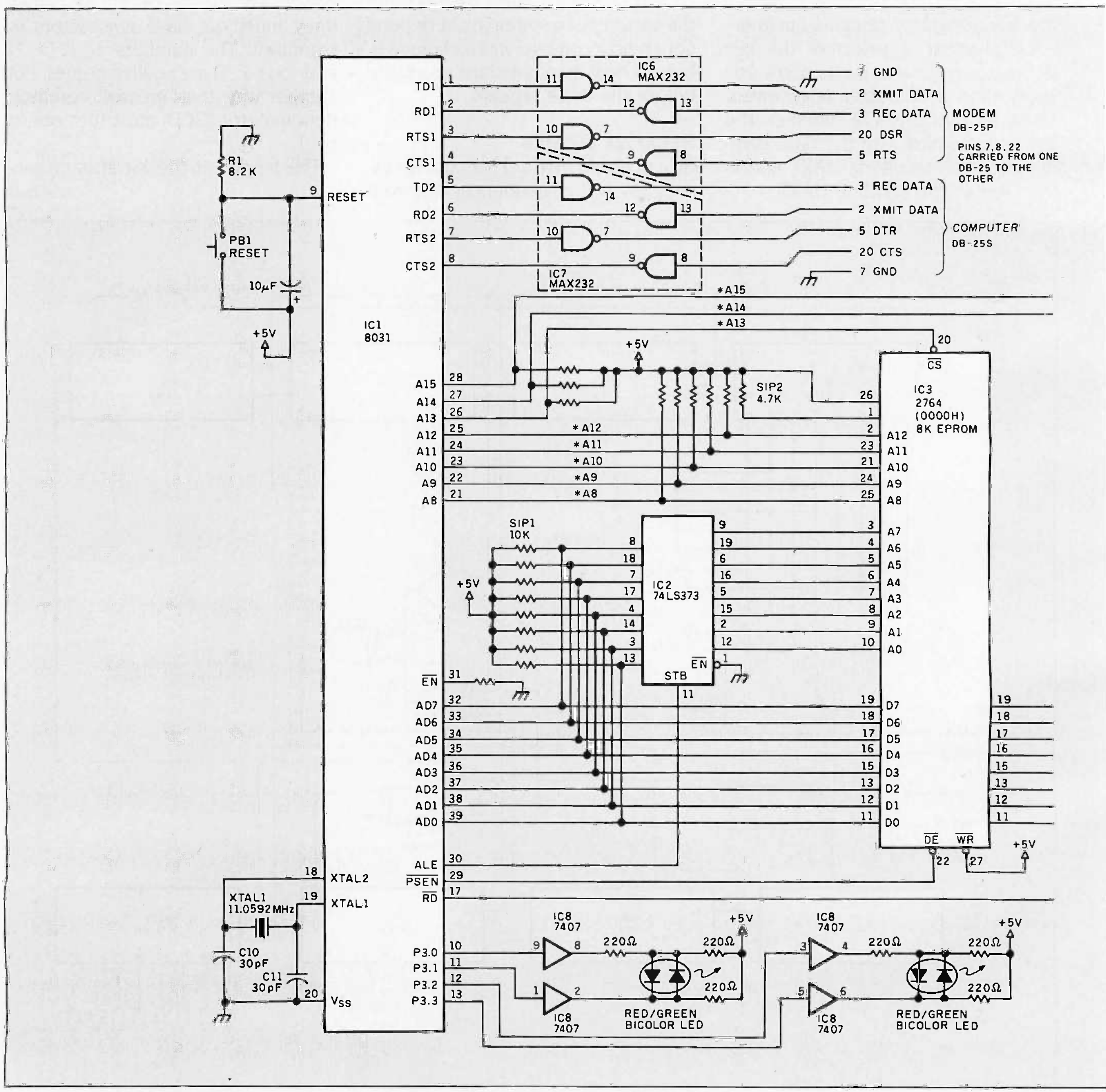
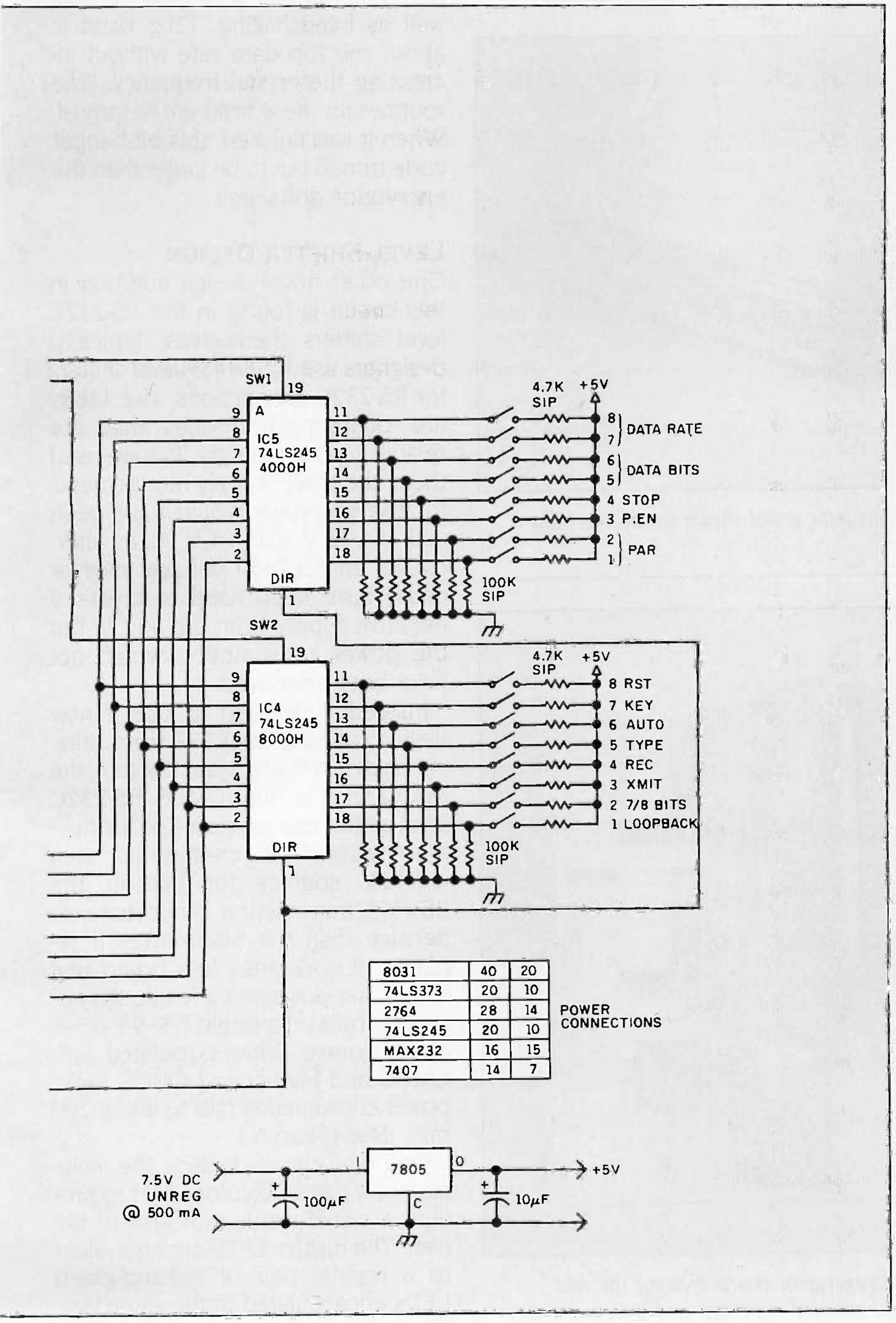


Figure 4: A *schematic diagram of the microcomputer-based* Circuit Cellar *data encryptor.*

first bits of the shift register with IC12a.

ICs 7, 8, and 9 form a sequencer with a length of $2^{24} - 1$ by tapping the eighteenth and twenty-third bits of the shift register with IC11c. Each sequencer is tapped at two places (IC12b and IC11b), and the bit streams from each tap are combined together, using an exclusive-OR, by IC11a and fed to another shift register where the result becomes the key. This is the diffusion that makes the most-probable-word method difficult. Even if a bit of the key were known, the three exclusive-ORs, acting together like a parity generator, tell whether there was an odd or even number of 1s at the four taps—and no more. Out of 16 possible combinations of 1s and 0s that could be at the taps, the key bit narrows the choice down to no less than 8.



A HARDWARE SUBSTITUTE

Most of these functions, including the encryption itself, can be synthesized using a microprocessor and software. The task of producing a cost-effective encryptor then ultimately becomes an exercise in configuring an efficient, low-cost microcomputer. A side benefit of such an approach is that it allows future performance enhancements by merely upgrading the software (to include DES encryption, for example).

The design I finally settled on uses an Intel 8031 microcomputer and only seven additional chips. The eight-chip circuit (shown schematically in figure 4 and in photos 1, 2, and 3) includes two full-duplex serial ports and two parallel ports with configuration DIP switches and bicolor LED channel-status indicators. The encryption and operating system software is contained in an 8K-byte 2764-type EPROM, IC3. Total power consumption is approximately 300 milliamperes if populated with NMOS devices (at somewhat greater cost, consumption can be lowered to about 110 mA if CMOS devices are used throughout).

The 8031, IC1, is a single-chip microcomputer with internal RAM and parallel I/O. The 8031 is capable of addressing 64K bytes of data memory and 64K bytes of code memory via a multiplexed 16-bit address bus. However, only 8K bytes of program memory (IC3) starting at 0000 hexadecimal are required for this application. The rest of the address range provides convenient memory-mapped address space for two 8-bit input ports used to read the configuration switches.

Input buffer IC5 is connected to DIP switch SW1 (addressed at 4000 hexadecimal). Input buffer IC4 is connected to DIP switch SW2 (addressed at 8000 hexadecimal). SW1 sets the serial-port protocol and baud rates; SW2 deals with the encryption/decryption functions. Table 1 gives a complete functional description of

(continued)

SW1. Table 2 gives a functional description of SW2.

BIT BANGING

Probably the most unique feature of this microcomputer is that while it incorporates two serial ports, it has no serial-port hardware! Since the effort was to synthesize as many hardware functions as possible, the baud-rate generator and UART were discarded along with the encryption logic. Instead, my data encryptor utilizes a technique often referred to as bit banging to simulate the missing hardware.

The 8031 includes predecoded parallel output ports among its pinout connections. Utilizing its crystal-controlled clock to precisely time the execution of certain routines, it is possible to take a single parallel output pin and directly change its logic level to be that that would have occurred through the parallel-to-serial conversion in a hardware UART. This software serial-port technique is frequently used where there is no need for high-speed interrupt processing (anything with a higher priority than the serial port, that is) or high data rates. Considering that the encryptor has to handle two full-duplex ports as well as handshaking, 1200 baud is about the top data rate without increasing the crystal frequency. (The routines for these tasks are not trivial. When it was finished, this bit-banger code turned out to be larger than the encryption software!)

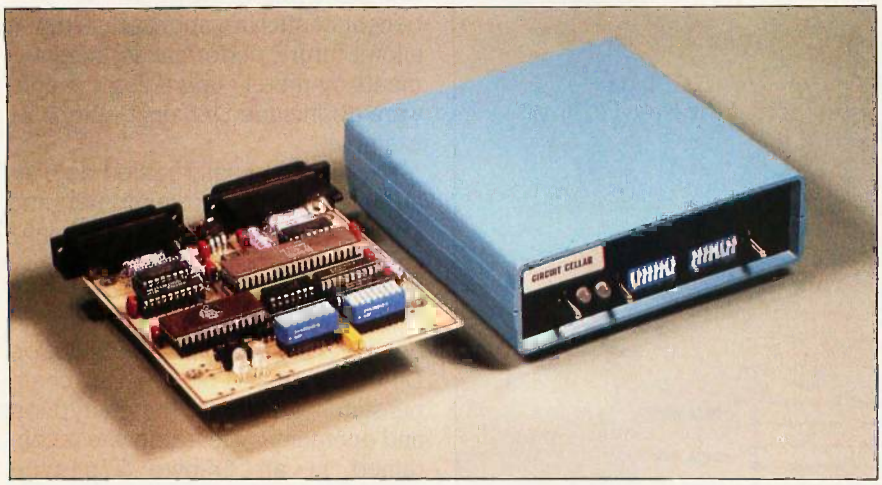


Photo 1: *The prototype Circuit Cellar data-encryptor board shown beside the fully enclosed unit.*

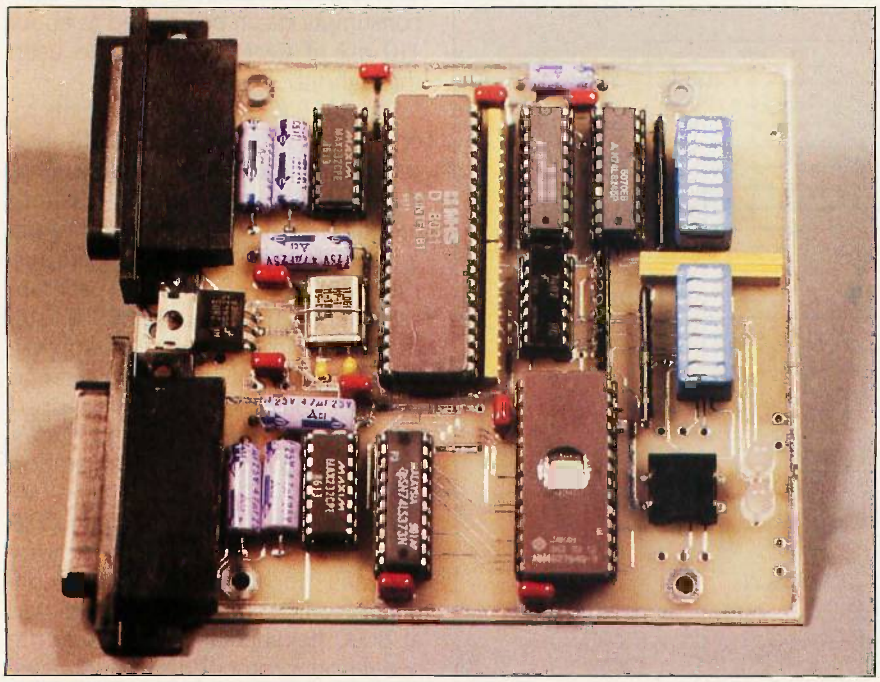


Photo 2: *A close-up of the Circuit Cellar data-encryptor board showing the rear-mounted RS-232C connectors (left side) and the manual start/stop and option switches on the front panel (right side).*

LEVEL-SHIFTER DESIGN

One other novel design addition in this circuit is found in the RS-232C level shifters themselves. Typically, designers use 1488/1489 level shifters for RS-232C connections. The 1488s are dual-supply devices that are relatively power-hungry. To have used them, the power-supply requirements for the encryptor would have been +12 V, −12 V, and +5 V. As an alternative, an ICL7660 voltage inverter could have been used to create a negative supply from the +12 V, but the power consumption would not have been improved.

Instead, I decided to use a new device called a MAX232 from Maxim. Shown in figure 5 and photo 4, the MAX232 is a dual CMOS RS-232C level shifter that operates on a single +5-V supply. It creates its own +/−10-V sources for use in the RS-232C transmission. While more expensive than the alternatives it replaces, it consumes less board real estate and power. As a result, the encryptor runs on a single 7.5–9-V 0.5-A power source. When populated with CMOS and high-speed CMOS logic, power consumption falls to about 200 mA. (See photo 5.)

One final circuit detail is the inclusion of a pair of bicolor LEDs to provide a visual status indicator to the user. The bicolor LEDs are equivalent to a regular pair of red-and-green LEDs encapsulated in the same two-wire package (three-wire bicolor LEDs are not the same). The bicolor LED glows either red or green, depending upon the polarity applied to it. Attaching a bicolor LED between the outputs of a pair of inverters produces a bicolor, bistable status indicator (actually, you get red, green, and off). The inverters are connected to additional parallel output pins on the 8031 and are controlled by the application program. When the LED shows red, the specific encryptor channel is passing plaintext. When it shows green, it is passing encrypted data.

DATA ENCRYPTOR SOFTWARE

The data encryptor is a perfect example of what not to build in hardware. Many of its functions can be simulated completely in software, as well as enhancements that would otherwise not be incorporated (like all the ATN= commands). Using just eight chips, a hardware and software system is configured that duplicates the hardware exactly in the method of encryption as well as the user interface. A complete description of the software will not be given here because it is beyond the scope of this article.

[Editor's note: *Should you care to build the encryptor from scratch, the 8K-byte executable-code contents of the encryptor's* EPROM *is available as a downloadable file from the* Circuit Cellar BBS *at* (203) 871-1988 *or preprogrammed from the source* (CCI, Tolland, CT) *listed at the end of the article.*]

At reset, the 8031 automatically jumps to location 0000 hexadecimal (where the Reset/Power-up Vector resides) and starts initializing the data encryptor. During initialization, the program makes use of three utility subroutines that function as a software UART. (See listing 1.)

GETCHAR waits for a character to appear in the terminal UART, transfers it to the processor's accumulator, and returns to the calling program. PUTCHAR transfers the character in the accumulator to the terminal UART for transmission to the terminal screen.

If hardware UARTs were being used, they would normally be memory-mapped, and their status and data registers would each occupy two locations in memory. In the software implementation, the status register and data register are both at one address, PARM2. The distinction as to whether PARM2 contains status or data is made by which subroutine is called to reference it.

In GETCHAR, JU2STATR is called to put the receive status into PARM2. GETCHAR will loop until bit 6 of the status byte, DAV, is high, indicating a character has been received by the UART, then JU2RECV is called, which puts the character into PARM2.

PUTCHAR works similarly, but it must loop until bit 7 of the status byte, TBMT, goes high, indicating that the transmit buffer is empty, then the character to be transmitted is put into PARM2, and JU2TRANS is called to have the UART transmit the character. PUTSTRG is called to print a string of characters from program memory to the screen. The data pointer, DPTR, is

(continued)

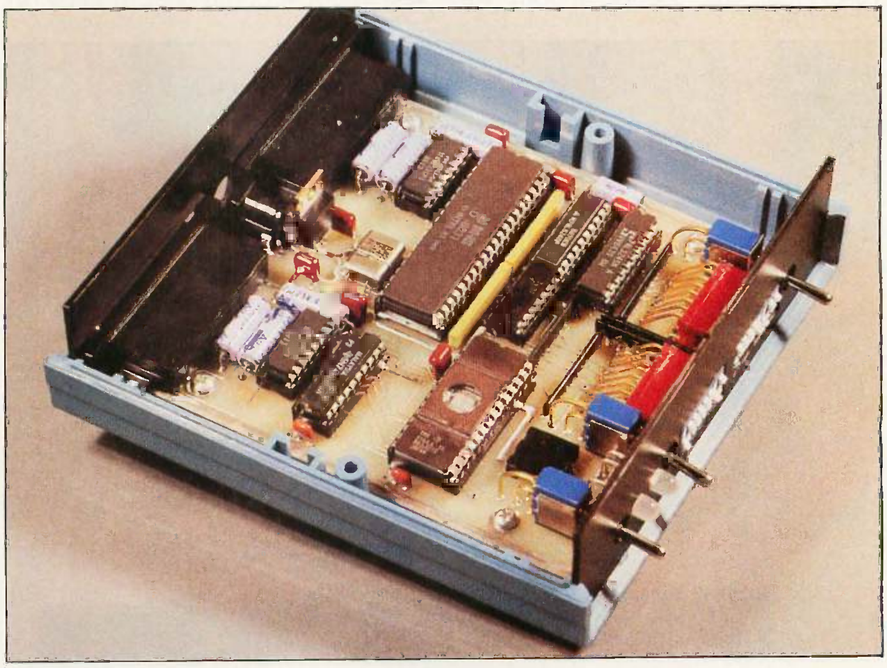


Photo 3: *If right-angle* DIP *sockets and toggle switches are used, the data encryptor can be attractively packaged in a 5- by 5¼-inch enclosure.*

Table 1: *Switch functions for* UART DIP *switch* SW1.

UART Control DIP Switch SW1

Switch	Function	Value	Result
8 & 7	data rate	OFF OFF	150 baud
		OFF ON	300 baud
		ON OFF	600 baud
		ON ON	1200 baud
6 & 5	data bits	OFF OFF	not used
		OFF ON	not used
		ON OFF	7 bits
		ON ON	8 bits
4	stop bits	ON	1 stop bit
		OFF	2 stop bits
3	parity enable	ON	parity disabled
		OFF	parity enabled
2 & 1	parity	OFF OFF	space
		OFF ON	mark
		ON OFF	odd
		ON ON	even

a 16-bit address pointer, set to the start of the string by the calling routine. The last byte is 00 hexadecimal, signaling the end-of-string to PUTCHAR. (The code for these routines is also available from the Circuit Cellar BBS.)

PSEUDORANDOM SEQUENCER

CHAIN1X and CHAIN2X are called by KEYGENE to create the feedback necessary for the pseudorandom sequencer. The exclusive-OR function is accomplished by putting one of the bits (bit 28 or bit 18) into the carry and then inverting the carry if the other bit (bit 31 or bit 23) is a 1. SHFCHAIN is called with a value either 2 or 3 hexadecimal in R2 to indicate how many bytes are being shifted. SHFCHAIN shifts the whole chain 1 bit to the left and returns to KEYGENE, which loops eight times to generate 8 bits of the key. The rest of the code is fairly ordinary, and you know how I feel about software.

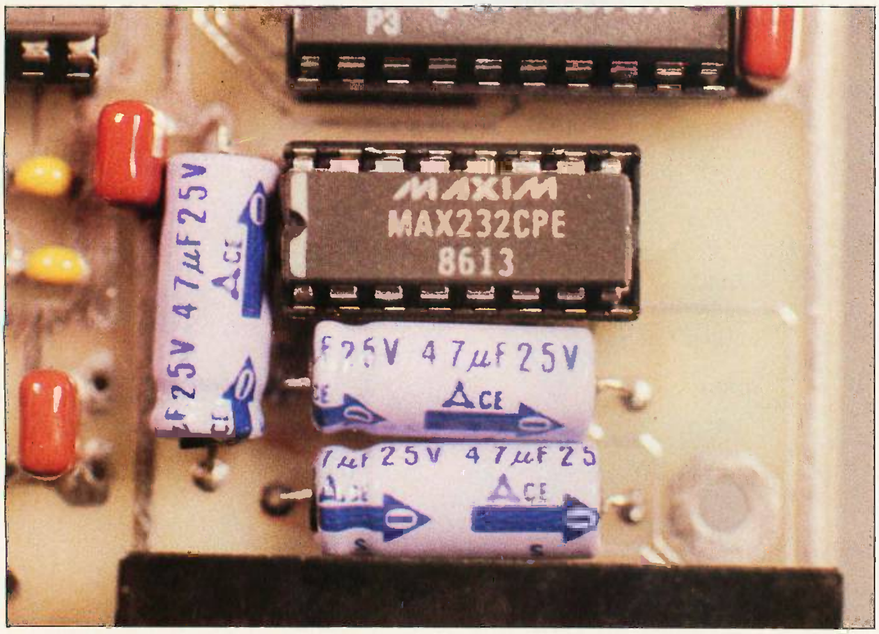


Photo 4: *The Maxim* MAX232 RS-232 *transceiver installed in the data encryptor. The* MAX232 *runs on* +5 V *and produces its own* +10 *and* −10 V *for* RS-232 *level output.*

Photo 5: *Power is supplied to the data encryptor by the wall-module power supply shown. The power supply plugs into the data encryptor between the two* RS-232C *connectors on the rear panel.*

HOW TO USE THE DATA ENCRYPTOR

Figure 6 is a block diagram showing the overall program flow of the data encryptor. After reset, initialization of the software UARTs is performed by reading the eight segments of SW1. The encryptor configuration and function are determined by reading the segments of SW2. (See table 1 and table 2 for a complete description of these switch functions.)

After initialization, a copyright notice and a listing of the preset selections defined by SW2 are displayed. If the key is selected to come from manual entry rather than the preset key provided in EPROM, the user is prompted to enter the transmit key and the receive key (the keys stored in EPROM are randomly selected during the manufacturing process and are unique to each encryptor). To aid the user in getting the keys entered correctly, a checksum is calculated and printed. The checksum should be delivered with the key so that users at both ends can check each key after it is entered.

After each key is entered, the user is asked to accept it. If it is rejected, the user is prompted to enter it again. After the transmit key is accepted, the user is prompted in the same manner for the receive key. After the receive key is accepted, the data encryptor goes into an infinite loop, encrypting and transmitting any characters entered from the local terminal/computer connected to it. Conversely, it decrypts and displays (via the local terminal/computer) any encrypted characters it receives from the remotely located modem, computer, or terminal. During the infinite loop, if the data encryptor is in the manual start/stop mode, SW2 is scanned to determine when encryption and decryption should start and stop.

In the manual start/stop mode, the user would start communication in plaintext mode, and the LEDs would glow red (unsafe communication) to indicate this. The users at each end would flip the transmit and/or receive

Table 2: *Functions of encrypt/decrypt mode control* DIP *switch* SW2.

Encrypt/Decrypt Mode Control DIP Switch SW2

Switch	Function	Value	Result
8	DSR reset	ON	disabled
		OFF	enabled
7	encryption key	ON	user-supplied
		OFF	EPROM-supplied
6	auto start/stop	ON	disabled
		OFF	enabled
5	data type	ON	8-bit binary
		OFF	7-bit ASCII
4	receive decrypt	ON	disabled
		OFF	enabled
3	transmit encrypt	ON	disabled
		OFF	enabled
2	# of encrypted data bits	ON	7 bits
		OFF	8 bits
1	loopback	ON	disabled
		OFF	enabled

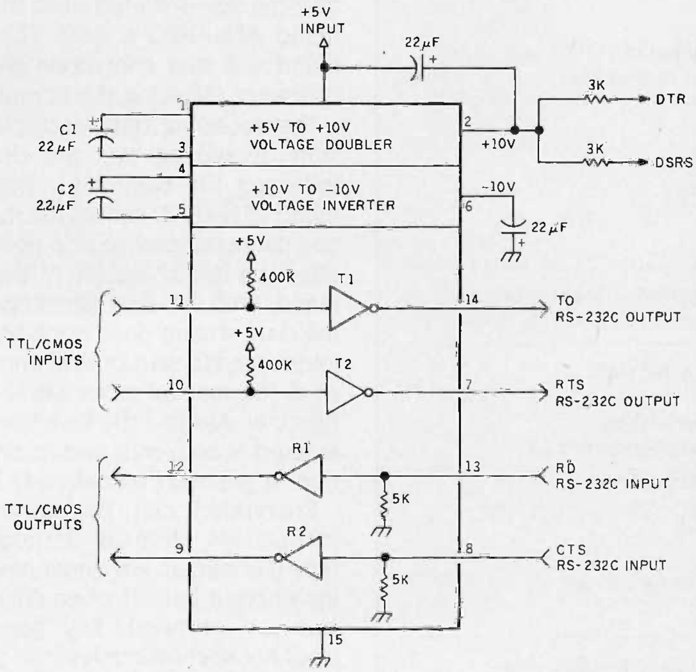


Figure 5: *A functional block diagram of the Maxim* MAX232 *level-converter chip.*

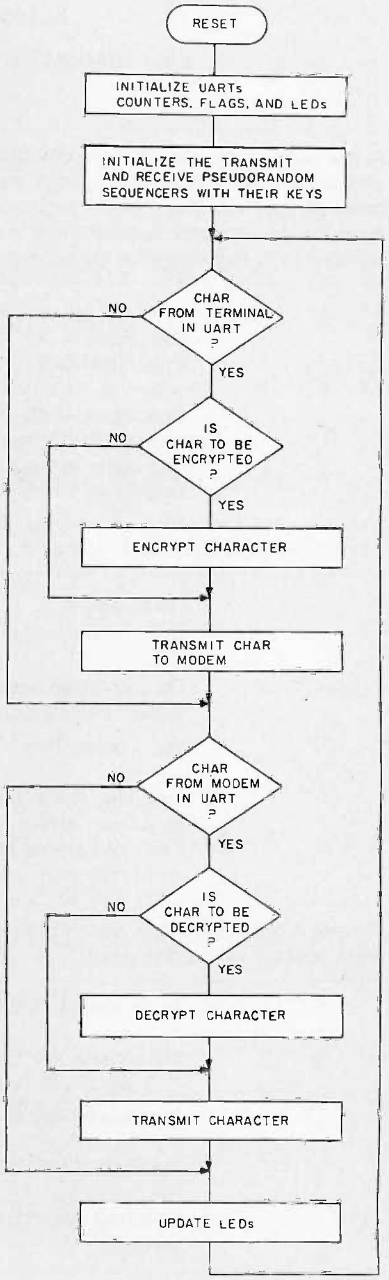


Figure 6: *The software flowchart of the Circuit Cellar data encryptor.*

```
Settings for Encryption Mode Switch SW2

Switch
Segment        Function         Setting
--------------------------------------------
8              DSR Reset:       disabled
7              Key Source:      user
6              Start/Stop:      manual
5              Data Type:       ASCII 7
4              Receive:         plain
3              Transmit:        plain
2              Encrypt:         7 bits
1              Loopback:        off

Enter TRANSMIT key:

>
```

At this point, if the user wants to change the switch settings, they can be changed and the encryptor reset. The settings shown on the screen after reset will reflect the new settings. Note that if switch segment 7 is OFF, nothing will be displayed because the encryptor is assuming it is at a remote site and there is no one to respond to it. Assuming that the settings are what is desired:

```
>How is the time for all good men
Checksum = A6. Accept key? (Y/N) n
Enter TRANSMIT key:
>Now is the time for all good men
Checksum = A0. Accept key? (Y/N) y
Enter RECEIVE key:
>to come to the aid of their party.
Checksum = 1D. Accept key? (Y/N) y
```

User A can now call user B, just as during any regular communication.

Hello, user B.
Hello, user A.

Do you remember the keys we agreed on?
Remember, my transmit key is your receive key.
Yes, I remember.

I will now switch over to ciphertext
so we can exchange sensitive data.
I will not transmit anything more
until I hear from you.

* User A and user B now switch both switches to ciphertext. Any transmissions from now on will be encrypted.

Hello, user A. What did you want to tell me?

My transmit key for our next session will be:
"J. S. Bach was born in 1685." The checksum is 22.
My transmit key for our next session will be:

"1.6180339887." The checksum is 71.

I will now switch over to plaintext so we can talk plainly.

* User A and user B both change the DIP-switch settings to plaintext. Any transmissions from now on will not be encrypted.

C U later, user A.

See you next time. Bye.

Figure 7: A *sample communication session between user* A *and user* B, *using both plaintext and encrypted transmission.*

encrypt switches during a pause in transmissions. For example, user A might transmit in plaintext, "I will flip both my switches after the next sentence is transmitted. I will not transmit any more until I receive the go-ahead from you." Then user A flips both switches. User B at the other end reads both sentences, flips both switches, and transmits back "go-ahead." They are now both transmitting encrypted messages. Both LEDs will indicate that transmission is being encrypted by glowing green (safe communication). Figure 7 is a sample communication session between user A and user B. User B's responses are in italic.

INTELLIGENT COMMAND SET

The Circuit Cellar data encryptor also incorporates an intelligent command structure (somewhat like smart modems) and can change functions without physically manipulating the DIP-switch settings. If the auto start/stop mode is selected instead of manual mode, encryption on the transmit side is started when the command ATN=BEG is sent. This command will start encryption with the character following the command.

The receiving data encryptor will start decrypting with the character following the command. The command ATN=END causes the transmitting data encryptor to stop decrypting after the last character of the command. With the auto start/stop mode, the data stream does not have to be interrupted to start or stop encryption as in the manual mode (as shown in figure 8). Assume the keys have been entered at both ends and communication in plaintext has already begun.

Encryption can be started and stopped as often as desired. Each time it is started, key generation picks up where it left off when encryption was last stopped. Key generation does not start over unless the data encryptor is reset.

LOOPBACK MODE

Another mode, illustrated in figure 1a, is transmitting to yourself by having the encryptor loop back. Loopback is one of the options selected on SW2. In loopback mode, you can encrypt a file, store it on disk to protect sensitive data, or transmit it to another computer with standard communication software like XMODEM (the encryptor can encrypt a file without changing control characters or creating them in the encrypted results). A sample loopback encrypting program written in BASIC for an IBM PC is available via the Circuit Cellar BBS.

```
>Now is the time for all good men
Checksum = A0. Accept key? (Y/N) y
```

Consider the example shown above. Since loopback requires the same transmit and receive keys, it asks for only one. As soon as the user concludes that entry by answering yes, any communication will be echoed back to the terminal.

```
This sentence is not encrypted.
  ATN=BEG
vD)tbbV7%6}=dXf6YpOnjfJh8
This sentence is also not encrypted.
```

If this were stored somewhere and at another time retransmitted to yourself, it will be decrypted, providing the same key is used that you used to encrypt it. The three lines above will then look like this:

```
This sentence is not encrypted.
  ATN=BEG
This sentence is. ATN=END
This sentence is also not encrypted.
```

(continued)

```
Hello, user B.
My transmit key for our next session
will be: ATN=BEG
"J. S. Bach was born in 1685." ATN=END
Talk to you next time. Bye.
```

Figure 8: *An example of the use of auto start/stop mode during transmission.*

Listing 1: *Input/output section of the data encryptor's assembly code.*

```
                 ;      UTILITIES FOR INPUT/OUTPUT
                 ;
                 ;
                 ; GET A CHARACTER FROM THE KEYBOARD
                 ;
03AF 9176        GETCHAR:  ACALL  JU2STATR
03B1 E559                  MOV    A,PARM2           ; GET RECEIVE STATUS
03B3 5440                  ANL    A,#DAV            ; AND LOOP UNTIL
03B5 B440F7                CJNE   A,#DAV,GETCHAR    ; DATA AVAILABLE.
03B8 917F                  ACALL  JU2RECV           ; GET CHARACTER AND
03BA E559                  MOV    A,PARM2           ; PUT INTO ACCUMULATOR.
03BC 22                    RET
                 ;
                 ; WRITE A CHARACTER ON THE SCREEN
                 ;
03BD C082        PUTCHAR:  PUSH   DPL               ; SAVE
03BF C083                  PUSH   DPH               ; DATA POINTER.
03C1 C0E0                  PUSH   ACC               ; SAVE CHAR FOR LATER.
03C3 9176        XMSTAT:   ACALL  JU2STATR
03C5 E559                  MOV    A,PARM2           ; GET TRANSMIT STATUS
03C7 5480                  ANL    A,#TBMT           ; AND LOOP UNTIL
03C9 B480F7                CJNE   A,#TBMT,XMTSTAT   ; TRANSMIT BUFFER EMPTY.
03CC D0E0                  POP    ACC               ; RETREIVE CHARACTER
03CE F559                  MOV    PARM2,A           ; AND TRANSMIT IT.
03D0 C0E0                  PUSH   ACC               ; SAVE FOR AFTER JU2TRANS
03D2 917C                  ACALL  JU2TRANS
03D4 D0E0                  POP    ACC               ; RETREIVE CHARACTER AND
03D6 D083                  POP    DPH               ; DATA POINTER FOR CALLING
03D8 D082                  POP    DPL               ; ROUTINE.
03DA 22                    RET
                 ;
                 ; WRITE A STRING TO THE SCREEN
                 ;
03DB C0E0        PUTSTRG:  PUSH   ACC               ; SAVE ACCUMULATOR.
03DD 7400        PNTCHAR:  MOV    A,#00H
03DF 93                    MOVC   A,@A+DPTR         ; POINT TO CHAR IN STRING
03E0 6005                  JZ     DONSTRG           ; DONE IF IT IS 0.
03E2 71BD                  ACALL  PUTCHAR           ; OTHERWISE WRITE IT
03E4 A3                    INC    DPTR              ; AND POINT TO NEXT CHAR.
03E5 80F6                  SJMP   PNTCHAR
03E7 D0E0        DONSTRG:  POP    ACC               ; RESTORE ACCUMULATOR.
03E9 22                    RET
```

Because it is a bad practice to use the same key over and over, five additional plaintext characters are sent to scramble the fixed key.

Two other commands are included to enable one encryptor to be located at a remote site. You may want to be able to communicate with your computer at home or at your office, but no one is at the remote computer to initialize the encryptor. With these commands, you can call the computer and initialize the encryptor by phone before sensitive information is transmitted either way (leaving the encryptor attached protects you from the malicious crackers who auto-dial search for unattended auto-answer computers). This procedure is also applicable for use on LANs or multiterminal systems.

The two commands are ATN=PROM+xxxxx and ATN=USER+xxxxx, where xxxxx are any five characters used to offset the key already loaded in the remote data encryptor. (The reason for the offset will be explained later.) Both commands reset the key to a known point in case the key generators in the transmitting and receiving encryptors have gotten out of sync. ATN=USER+xxxxx will reset to the manual key that was previously entered through the normal prompting after a power-on reset.

Unfortunately, if a power failure had occurred (without some sort of uninterruptible power source), the key would be lost, and the remote encryptor would have no way of reinitializing without a manually entered key. ATN=PROM+xxxxx takes care of this situation by using a key stored in the encryptor's EPROM to reinitialize with.

Because it is a bad practice to use the same key over and over, however, the five extra characters are sent to scramble the fixed key. This defeats any attempts of an attacker using the most-probable-word method to discover the key. Even though these five characters are sent in plaintext, their effect on the unknown key cannot be predicted. The most-probable-word method can be used only if the attacker knows what part of the key was used to encrypt a given part of a message, and that part of the key must be used often. Both of these commands initialize the transmit and receive side of both encryptors, and encryption or decryption is started immediately after the fifth scrambling character is processed.

In Conclusion

I'll have to admit that I didn't know much about data encryption before attempting this project. Since most of you probably share this lack of knowledge, I included more background materials than I might ordinarily present with a project. I trust that I neither bored you nor made you into a paranoid computer user. It's just that forewarned is forearmed.

One additional observation about using the encryptor. While it was designed to facilitate direct use through a modem, the telephone lines are sometimes not up to the task. Dropping or adding a character destroys the synchronization necessary between the encryptor and decryptor, and most modems do not include error checking. Rather than restarting after sending fixed character blocks using the intelligent (ATN=) command set, it is much easier to preencrypt the entire file using the loopback mode.

Then, using XMODEM or any good error-checking communication program, send the whole file to the receiving system. This situation does not occur in directly connected computers, LANs, or any communication system with block transmission and error checking.

Finally, after describing the encryptor to a longtime engineering friend, I was informed of an unconsidered application. His job was to design animated graphics simulations of various research projects so that management has some clue as to what their big-bucks scientists are up to. Unfortunately, to most people these simulations looked and ran like the greatest video games, and he was always trying to track down who had swiped his software for a demo.

The solution was to create a hardware key to his software. He did this by connecting a data-encryptor set in the loopback mode to the serial port on his computer and partially encrypting the graphics software to the cipher key stored in EPROM. As his program initialized, it had to send the encrypted block out to be deciphered correctly before there were any graphics routines to execute. This didn't inhibit the demonstrations but required that they be only at his computer, where he could keep track of his software, or wherever he carried his little black encryptor. Too bad. I used to have such a good time running around demonstrating his stuff!

Circuit Cellar Feedback

This month's feedback begins on page 58.

Next Month

Steve presents his new and improved serial EPROM programmer.

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Special thanks to Roger James and Bill Curlew for their software expertise.

GLOSSARY

Caesar Cipher: The simplest encryption scheme, where the encrypted character is displaced from the plaintext character by a fixed amount:

Plaintext:
ABCDEFGHIJKLMNOPQRSTUVWXYZ
Ciphertext:
DEFGHIJKLMNOPQRSTUVWXYZABC

Plaintext: THE QUICK BROWN FOX
Ciphertext: WKH TXLFN EURZK IRA

This cipher is easily broken using frequency analysis.

DES: This stands for data-encryption standard, a system in which a 64-bit block of data (eight characters) is transformed into an encrypted block of 64 bits using a standard algorithm controlled by a 56-bit key. Because the value of each bit in the output block is dependent on every bit in the input block, it is called a block cipher.

Frequency Analysis: Tabulating the occurrences of each letter in the ciphertext. It is assumed that the most frequently occurring letter is a plaintext "e," the next most frequently occurring letter is a "t," etc. Cryptograms in the Sunday paper are easily broken using frequency analysis.

Kasinsky Solution: A method of determining the number of alphabets used in a polyalphabetic cipher.

Monoalphabetic Cipher: A simple substitution in which each letter of plaintext has a unique letter in the ciphertext.

Plaintext:
ABCDEFGHIJKLMNOPQRSTUVWXYZ
Ciphertext:
EXUGRQFBPJAKCZHINODLMSVWYT

Plaintext: THE QUICK BROWN FOX
Ciphertext: LBR NMPUA XOHVZ QHW

This cipher is easily broken using frequency analysis.

Polyalphabetic Cipher: A system in which several monoalphabetic ciphers are used together in a cycle. This example has a short cycle of 3:

Plaintext:
ABCDEFGHIJKLMNOPQRSTUVWXYZ
Ciphertext 1:
EXUGRQFBPJAKCZHINODLMSVWYT
Ciphertext 2:
LWKCVJAXMBNFEUDSTGOPRYIQZH
Ciphertext 3:
JPIOAKHQBLGNMRCFEWSYVUTZXD

Plaintext: THE QUICK BROWN FOX
Ciphertext: LXA NRBUN PODTZ JCW

Frequency analysis can be used to decipher this, but a separate tabulation must be kept for each alphabet. In this example, three tables would have to be kept. With even a few lines of text, it could be broken. Before tabulation can begin, the attacker must know how many alphabets are being used. If a message is encrypted with as many alphabets as there are characters in the message, and the arrangements of the letters in each is truly random, the message will prove to be impossible to break.

Pseudorandom Sequence Generator: Any hardware or software that generates a very long sequence of bits. The sequence will eventually start over and repeat. This is why it is a pseudorandom sequencer and not a random sequencer. In addition, while the sequence appears to be random, it will always be the same if it is started with the same seed.

Vernam Cipher: A method where a continuous stream of key bits is combined, using an exclusive-OR function, with the message bits for encryption. Each bit in the output stream is dependent on only 1 bit in the input stream and 1 bit in the key.

The following items are available from

CCI
P.O. Box 428
Tolland, CT 06084

1. Data encryptor/decryptor blank PC board and programmed 2764 EPROM containing encryption algorithm and serial I/O software. .... $79, two for $150
2. Data encryptor/decryptor PC board kit. Includes all board-mounted components, programmed EPROM, and microprocessor, less power-supply module and case . . $99, two for $195
3. 115-V AC/60-Hz power-supply module for above $9
4. 5- by 5¼- by 1½-inch enclosure with blank end plates $9.75

The data encryptor is available in low quantities only in kit form. It is available assembled and tested with right-angle toggle and DIP switches only in volume OEM quantities (telex: 643331). Price and delivery information available on request.

All payments should be made in U.S. dollars by check, money order, MasterCard, or Visa. Surface delivery (U.S. and Canada only): add $5 for U.S., $10 for Canada. For delivery to Europe via U.S. air mail, add $20. Three-day air freight delivery: add $8 for U.S. (UPS Blue), $25 for Canada (Purolator overnight), $45 for Europe (Federal Express), or $60 (Federal Express) for Asia and elsewhere in the world. Shipping costs are the same for one or two units. Connecticut residents add 7.5 percent sales tax.

Most of the individual encryptor components, including the 8031, are available from JDR Microdevices, 1224 South Bascom Ave., San Jose, CA 95128, (800) 538-5000.

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.

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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ILLUSTRATED BY CARY HENRIE

CALCULATING CRCs BY BITS AND BYTES

BY GREG MORSE

Use the XOR function to implement modulo 2 division when calculating cyclic redundancy checks

Recently I needed to implement the XMODEM cyclic redundancy check (CRC) option on my XCom9 modem program. Despite the many programs available for calculating CRCs, I had some difficulty understanding the math behind the calculations. The details became clear after much research and experimentation.

The starting point for all CRCs is fancy linear algebra. The CRC is defined in terms of message polynomials, generator polynomials, and so on. As Perez, Wismer, and Becker state in "Byte-wise CRC Calculations" (*IEEE Micro*, June 1983),

> In a system employing CRC the message being transmitted is considered to be a binary polynomial $M(X)$. It is first multiplied by X^k and then divided (modulo 2) by an arbitrary generator polynomial $G(X)$ of degree k which results in a quotient $Q(X)$ and a remainder. . .

It sounds confusing, but if you can understand how to apply the math, you can design more efficient programs and spot many erroneous ones.

THE "MATH-NESS" TO THE METHOD

The design of the polynomial $G(X)$ is extremely complex. You need to pick one that produces CRCs that are good at detecting errors. Fortunately, many $G(X)$s exist already. Table 1 contains the two most common $G(X)$s in an 8-bit-byte environment.

Let's calculate the CRC for the letter *T*, 0101 0100 in binary. $M(X)$ is the message as it is transmitted. You transmit a character's least significant bit (LSB) first, so $M(X)$ becomes 00101010. Then you divide modulo 2 as shown in figure 1. (Modulo 2 means you use the XOR instruction instead of the normal add and subtract.) Work it through according to the process shown in figure 2. Note that the CRC result is given in reverse order, that is, most significant bit (MSB) on the right, LSB on the left.

BIT-ORIENTED ALGORITHMS

Using the long-division approach, if you had only a single zero bit to send, you would get the result shown in figure 3. If you had two bits to send, a zero and then a one, long division would produce the result shown in figure 4. The first remainder in figure 4 is the same as the first remainder in figure 3 except that its LSB has been XORed with

(continued)

Greg Morse (10871 Roseland Gate, Richmond, B.C., Canada V7A 2R1) is an engineer with the British Columbia Telephone Company. He has 20 years' experience with computers and 10 with data communications. Greg has B.A.Sc. and M.A.Sc. degrees in electrical engineering.

Table 1: *The two most common G(X)s (generator polynomials) in an 8-bit-byte environment. You can code the G(X) as a 17-bit binary, or hexadecimal, number. The ones and zeros represent the coefficients of the different powers of X in the polynomial.*

CRC-16 (Bisynchronous)

$X^{16} + X^{15} + X^2 + 1 = 1\ 1000\ 0000\ 0000\ 0101$

CRC-CCITT (SDLC, X.25, XMODEM)

$X^{16} + X^{12} + X^5 + 1 = 1\ 0001\ 0000\ 0010\ 0001$

```
                          ______________________________________
 1  0001  0000  0010  0001 | 0010  1010  0000  0000  0000  0000
 └───────────┬───────────┘   └─────┬────┘ └──────────┬─────────┘
      CCITT polynomial          letter T        16 extra zeros
                               LSB    MSB
```

Figure 1: *The initial modulo 2 division used to calculate the CRC for the letter T. Note that the letter is given LSB first; in other words, it is reversed.*

```
                          (quotient, ignored)        0010  1000
                            ______________________________________
 1  0001  0000  0010  0001 | 0010  1010  0000  0000  0000  0000
                             0
                            ___________________________
 1st remainder →             .010  1010  0000  0000  0O
                              0
                             __________________________
                              . 10  1010  0000  0000  00O
                                10  0010  0000  0100  001
                               __________________________
                                . 0  1000  0000  0100  001O
                                  0
                                 ___________________________
 remainder after 4 bits              1000  0000  0100  0010  O
                                     1000  1000  0001  0000  1
                                  ___________________________
                                    . 000  1000  0101  0010  1O
                                      0
                                     ________________________
                                      . 00  1000  0101  0010  10O
                                        0
                                       _______________________
                                        . 0  1000  0101  0010  100O
                                          0
                                         ______________________
 CRC for the letter T                     .  1000  0101  0010  1000
                                       LSB ─┘                    └─MSB
```

Figure 2: *The entire long-division calculation process used to derive the CRC for the letter T. The apparent subtractions in this process are* XORs; *therefore, there are no "borrows." A "." represents a zero that has no further part in the calculation, and "O" represents a zero that was "brought down" from the dividend line. Therefore, the line* .00 1000 0101 0010 10O *represents a remainder of* 00 1000 0101 0010 10. *Note that the CRC is given with the* LSB *on the left. Thus, the* CRC *for the letter T* = 0 54 *is* (MSB *first*) 0001 0100 1010 0001, *or* 14A1 *hexadecimal.*

the second data bit. This similarity will always be true because of the way the *M(X)* polynomial is built.

This observation leads to the following bit-by-bit algorithm for calculating the CRC:

1. Write down the first data bit (zero or one) to be transmitted.
2. Write down 16 zeros to its right.
3. Divide the 17-bit number by the 17-bit CRC polynomial using XOR instead of subtraction. Make a note of the remainder, which is the CRC.
4. Get the next data bit.
5. XOR this bit with the LSB (leftmost bit) of the CRC in step 3.
6. Append a zero to the right-hand end of the result in step 5.
7. Divide the 17-bit number from step 6 by the 17-bit CRC polynomial. Use XOR instead of subtraction. The remainder is the CRC.
8. Repeat steps 4 through 7 until there are no more data bits. (You can replace steps 1 through 3 with a single step to initialize the CRC to zeros.)

Thus, you can calculate the CRC a bit at a time, for any number of bits, with almost no extra calculation overhead. In summary, the steps involved in the long-division method are

1. The message bits are written down in the order in which they are transmitted, from left to right, that is, LSB on the left.
2. Sixteen zeros are appended to the right-hand end of the binary number formed in step 1.
3. The generating polynomial is written down MSB first, that is, on the left.
4. The division is done modulo 2, that is, using XOR instead of normal subtraction.
5. The CRC is the remainder after all data bits have been processed. The LSB is on the left.

Figure 5 translates these steps into a flowchart.

HARDWARE IMPLEMENTATIONS

One disadvantage of the flowchart in figure 5 is that it requires a 17-bit reg-

(continued)

```
                                              0
1 0001 0000 0010 0001 | 0 0000 0000 0000 0000
                        0
                        ---------------------
      1st remainder →     0000 0000 0000 0000
                   LSB ┘                    └ MSB
```

Figure 3: *The long-division CRC calculation for a single zero bit.*

```
                                                  01
1 0001 0000 0010 0001 | 01 0000 0000 0000 0000
                        0
                        ------------------------
1st remainder →           1 0000 0000 0000 0000
                          1 0001 0000 0010 0001
                          ----------------------
2nd remainder →             0001 0000 0010 0001
```

Figure 4: *The long-division CRC calculation for the two bits 01.*

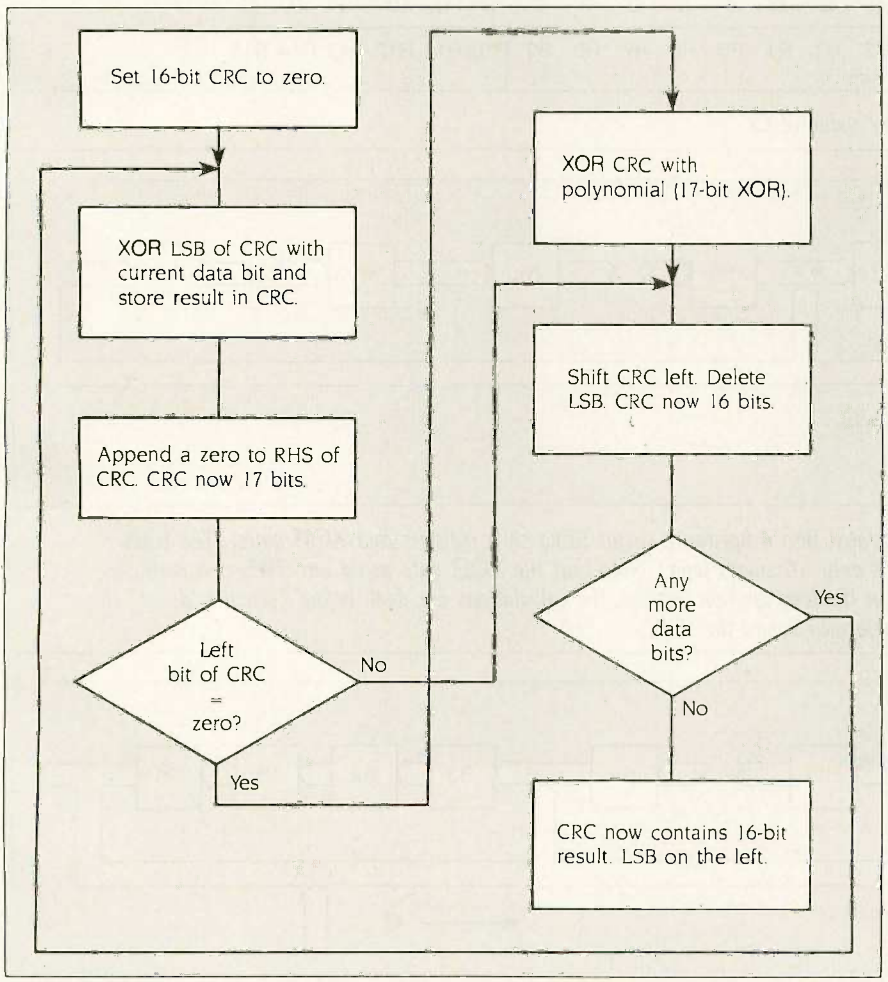
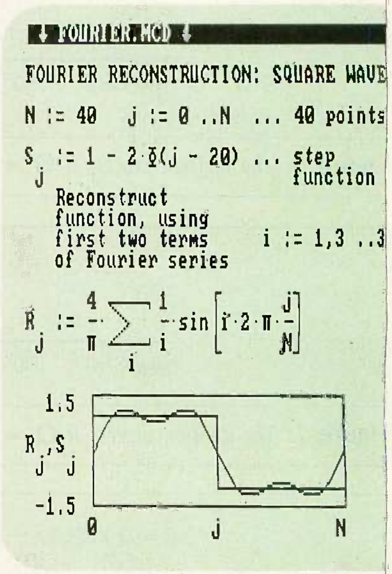


Figure 5: *A flowchart representing the steps involved in the long-division method of calculating a CRC.*



Q = 1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	0
XOR X16 = 1	0	0	0	X12	0	0	0	0	0	0	X5	0	0	0	0	1
New CRC	R0	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15

Figure 6: *The division process if* Q = 1.

Q = 0	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	0
XOR 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New CRC	R0	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15

Figure 7: *The division process if* Q = 0.

Q = (D XOR R0)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	0
XOR X16	0	0	0	Q	0	0	0	0	0	0	Q	0	0	0	0	Q
New CRC	R0	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15

Figure 8: *The division process regardless of the value of* Q.

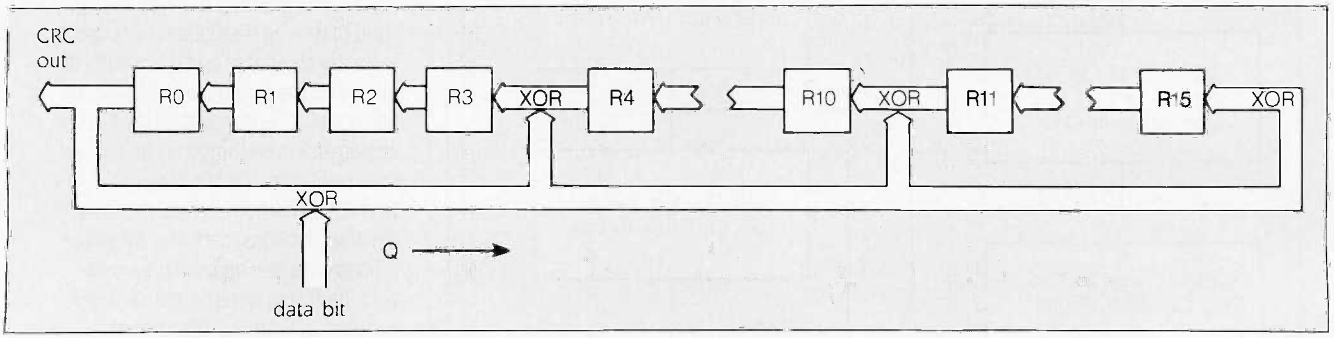


Figure 9: *The process shown in figure 8 translated into a hardware circuit using shift registers and* XOR *gates. (The boxes are stages to a shift register; the shift register is only* 16 *stages long.)* Note *that the* XOR *gate going into* R15 *is superfluous, since* Q XOR 0 *is always* Q. Note *also that in the long-division method, the calculations are done before "bringing down" the next zero bit. Similarly here, the* XORs *are performed before the shift.*

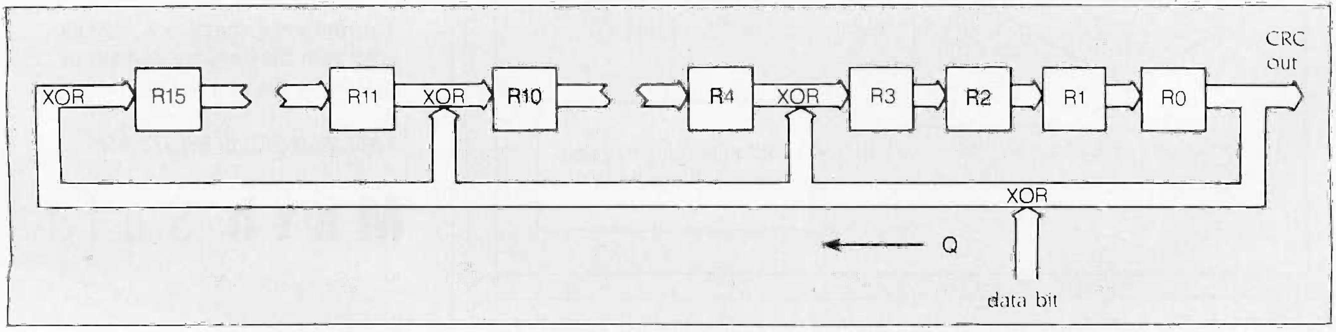


Figure 10: *The reverse drawing of figure 9: the* LSB *is on the right instead of on the left.*

ister. However, after the division is complete, the left bit will always be a zero. Either it was a zero to begin with, or if it was a one, it was XORed with the X^{16} bit of the polynomial, which is also a one, producing a zero. Thus, you can XOR with only the 16 LSBs of the polynomial. In the case of the CRC-CCITT polynomial, $X^{16} + X^{12} + X^5 + 1$ (1 0001 0000 0010 0001 in binary or 1 1021 in hexadecimal), you can XOR with 0 1021.

Let the bits of the CRC register be R0, R1, up to R15; let the data bits be D0 up to D7; let the polynomial bits be X0 up to X15; and define Q = D XOR R0, that is, set Q equal to the current data bit, D, XORed with R0. In every case, the LSB is bit 0.

Then, if Q = 1, the division process looks like that in figure 6. If Q = D XOR R0 is zero, then the division reduces to that in figure 7. But when Q = 1, the new R15 is always 1, and you XOR R4 and R11 with X12 and X5, which are 1. If Q = 0, then the new R15 is zero and you XOR R4 and R11 (and all other R*n*s) with zero.

You can combine the two cases as shown in figure 8. Turning that process into a circuit using shift registers and XOR gates (see figure 9) is straightforward. You can also draw the circuit so that the LSB (R0) is on the right (see figure 10). Both diagrams are convenient depending on the kind of software algorithm to be derived. Note that in hardware the XOR is done before the shift because of the way flip-flops work. The important point is that the new R10 = (old R11) XOR (old R0) XOR (new data bit).

BIT-BY-BIT SOFTWARE ALGORITHMS

When you do the calculations in software, you don't have to do the XOR before the shift. The important thing in software is to avoid having to deal with 17-bit values that don't fit into a variable. A software routine also doesn't need to use the Q = D XOR R0 result to drive a gate. You can program the polynomial directly into the code as a constant.

You can now derive a software routine based on figure 10 (or figure 9, in which the order of storing the bits of the CRC is reversed). If you assume that the CRC result is kept in a 16-bit integer with R15 (the MSB of the CRC) in the high (leftmost) bit position, then if Q = 1, you first shift the previous CRC to the right as in figure 11. In terms of a high-level language, you shift the CRC right by one, discarding the LSB, and XOR with 0 8408. By testing Q first and then doing the shift before the XOR, you avoid the need for a 17-bit register. Because of the way in which the CRC is stored in the variable, the XOR is done with 0 8408 rather than 0 1021, as you might expect. This follows directly from the

(continued)

```
       0  R15 R14 R13 R12 R11 R10  R9  R8  R7  R6  R5  R4  R3  R2  R1
  and then XOR with:
       1   0   0   0   0   1   0   0   0   0   0   0   1   0   0   0

  to get the new CRC:
     R15 R14 R13 R12 R11 R10  R9  R8  R7  R6  R5  R4  R3  R2  R1  R0
                           ↑_ Note new R10 = old R11 XOR 1
```

Figure 11: *The diagram for a software routine based on the hardware circuit in figure* 10. *When* Q = 1 *the new* CRC *becomes the previous* CRC *shifted right by one bit position and* XOR*ed with G(X).*

Listing 1: CCITT.C, *the* CCITT *routine for calculating* CRCs *in* C *source code.*

```
/* Straightforward, non-optimized CRC-CCITT routine    */
/* Assumes 16-bit integer variables                    */
/* MSB of integer is MSB of CRC result                 */
#define POLY 0x8408
/*                            POLY = 1021 in bit rev order*/
BLKCRC(bufptr, crcres, count)
   unsigned char *bufptr;
   unsigned int  *crcres, count;
  {
    int i;
    *crcres = 0;                           /* for SDLC use 0xFFFF */
    for (i=1; i<=count; ++i, bufptr++) /* do for whole BLK*/
       bytecrc(bufptr, crcres)             /* do CRC for 1 char   */
    return (*crcres);
  }   /* end BLKCRC */

bytecrc(bufptr, crcres)
   unsigned char *bufptr;
   unsigned int  *crcres;
  {
    unsigned int j,ch,Q;
    ch = (unsigned int) *bufptr;         /* get char, to int fmt*/
    for (j=1; j<=8; j++) {               /* do each bit LSB 1st */
     Q=(*crcres&0x0001)^(ch&0x0001)   /* Q=R0 XOR D          */
     if ( Q == 0x0001) {                 /* Q is one            */
        *crcres= *crcres>>1;             /* shift right one     */
        *crcres= *crcres^POLY;           /* XOR with number     */
       }
     else                                /* Q is zero           */
        *crcres= *crcres>>1;             /* just shift no XOR   */
     ch = ch >>1;                        /* move next data bit  */
                                         /*  into position      */
    }   /* end FOR - data bits all done */
    return (*crcres);
  } /* end bytecrc */
```

diagram shown in figure 10. Generally speaking, if you process data LSB first, you can store the CRC with its MSB in the MSB position of the integer variable.

Listing 1 contains the implementation of a CRC calculation based on the CCITT polynomial. CCITT.C provides lots of intermediate results, for clarity rather than performance. This program implements the CCITT/IBM FCS calculation in a standard way with one exception: initializing the CRC. [*Editor's note*: CCITT.C, XMODEM.C, SDLC.ASM, *and* XMODEM.ASM *for* OS9 *are available in several formats; see the insert card after page* 368.]

The purpose, however, is to implement the de facto XMODEM standard. I found no published XMODEM CRC specification as such. What has been published is a C program, XMODEM.C, that does the calculations (see listing 2). Apart from using the CCITT polynomial, this program is not CCITT standard in that data is processed MSB first, rather than LSB first, and the CRC is initialized to zeros rather than to ones.

CHOICES IN CRC CALCULATION AND TRANSMISSION

A CRC calculated by these methods has some very desirable error-detection properties, but it is not perfect. For example, you can add or delete any number of zero bits to or from the beginning of the block without affecting the CRC. (The remainder stays zero no matter how many zero bits start the block.) Furthermore, since the CRC is a cyclic code, any error, such as a clock slippage, that deletes a bit at the beginning of the block and inserts the same bit at the end of the block (the last bit of the CRC) will not affect the CRC. For these reasons the CRCs used by IBM in the SDLC protocol and CCITT in the X.25 and HDLC protocols specify the following:

1. All bits of a block are protected by the CRC.
2. The data is sent LSB first. The CRC is calculated on bits as they are sent.
3. The CRC is initialized to all ones. This allows detection of any missed or inserted zero bits at the beginning of a block. (Missed or inserted ones are still detected.)
4. The one's complement of the

(continued)

Listing 2: XMODEM.C, *the* XMODEM *routine for calculating* CRCs *in* C *source code.*

```
      /*        Sample bit-oriented CRC routine          */
      /*        Adapted from YMODEM protocol reference    */

/* Calculate CRC on a block of data.                                    */
/* Ptr points to block of characters, count gives size of buffer.      */
/* This program returns the CRC with the LSB of the CRC in the         */
/* high bit of the result integer.                                     */
/* XMODEM deviates from the CCITT standard in that it does not use    */
/* the LSB of the data 1st, nor does it initialize the CRC to all     */
/* ones as specified by the standard.                                  */

int calcrc(ptr, count)
  char *ptr;
  int  count;
  {
    unsigned int crc;
    int      i;
    crc = 0;                          /* note not 0xFFFF            */
    while (--count >= 0) {
      i = (int) *ptr++;               /* convert data char to int   */
      i = i << 8;                     /* shift char to high byte    */
      crc = crc ^ i;                  /* add current data to current  */
                                      /* remainder modifies only least */
                                      /* sig 8 bits (high byte) of CRC */
      for (i=0; i<8; ++i)             /* loop for each bit          */
        if (crc & 0x8000) {           /* test D XOR R0              */
          crc = (crc << 1);           /* discard LSB of CRC  and    */
                                      /* append zero                */
          crc = crc ^ 0x1021;         /* XOR with low 16 bits       */
                                      /* of CCITT polynomial        */
                                      /* because CRC is stored LSB 1st */
                                      /* polynomial written MSB 1st   */
        }    /* endif */
        else
          crc = crc << 1;             /* discard LSB & append 0 */

     }  /* end while */
     return (crc & 0xFFFF);           /* 16-bit result for whole block */
  }  /* end calcrc */
```

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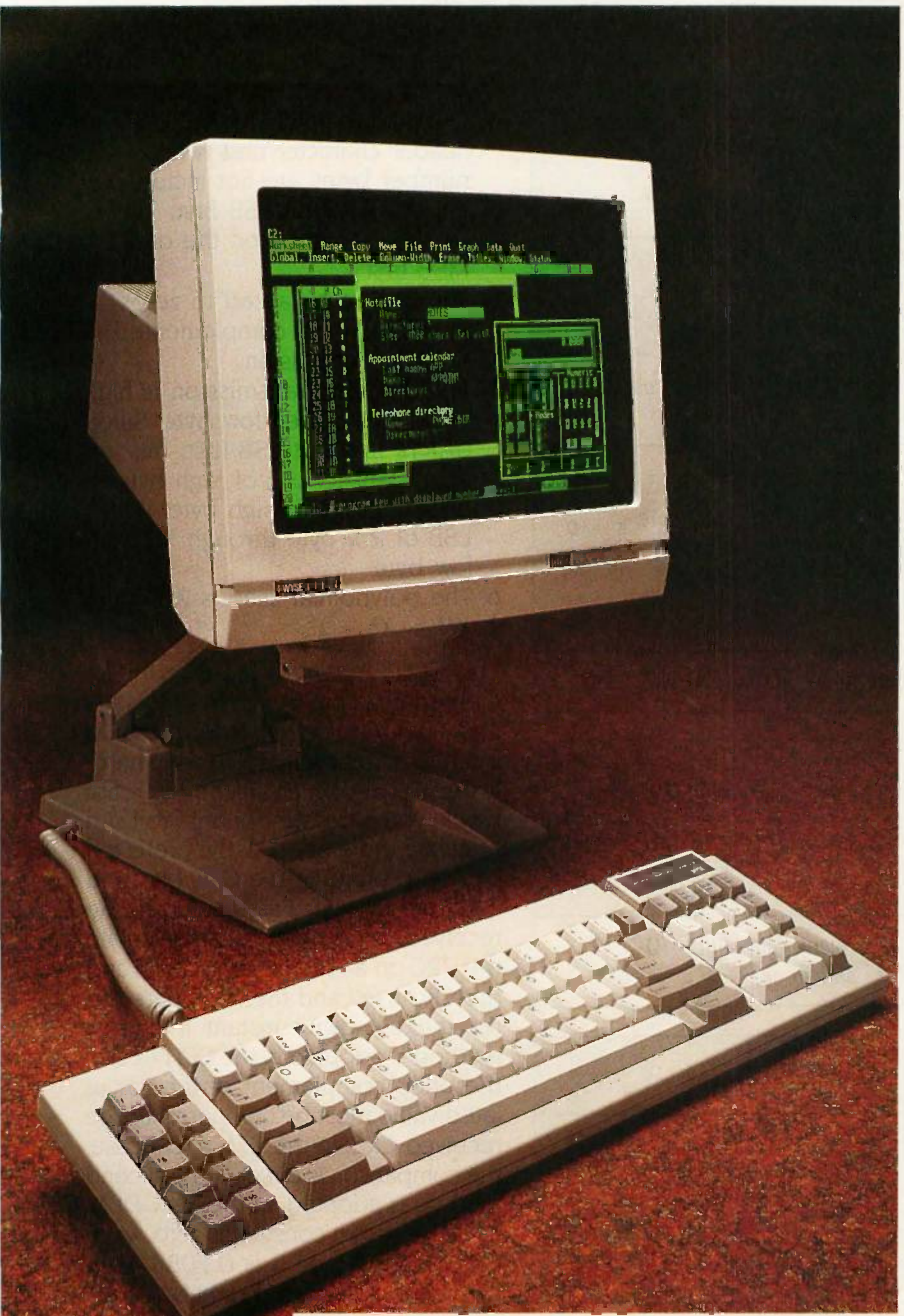

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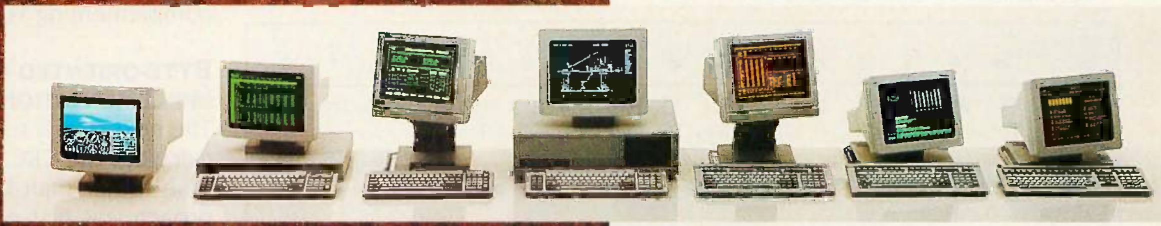

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Inquiry 383

Bit	*15	14	13	12	11	*10	9	8	7	6	5	4	*3	2	1	0
	R15	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5	R4	R3	R2	R1	R0

Figure 12: *The contents of the shift register at the beginning of bytewise* SDLC *calculations.*

Bit	*15	14	13	12	11	*10	9	8	7	6	5	4	*3	2	1	0
Shift 1	D0	R15	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5	R4	R3	R2	R1
	R0					D0							D0			
						R0							R0			

Figure 13: *The contents of the shift register after the first shift. Note that all entries in a column are* XOR*ed together.*

Bit	*15	14	13	12	11	*10	9	8	7	6	5	4	*3	2	1	0
Shift 1	T0	R15	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5	R4	R3	R2	R1
						T0							T0			

Figure 14: *The same as figure 13 but with the abbreviation* T0 *for* D0 XOR R0.

Bit	*15	14	13	12	11	*10	9	8	7	6	5	4	*3	2	1	0
Shift 4	T3	T2	T1	T0	R15	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5	R4
						T3	T2	T1	T0				T3	T2	T1	T0

Figure 15: *The contents of the shift register after three more right shifts.* T0 *represents* D0 XOR R0, T1 *represents* D1 XOR R1, *and so on.*

Bit	*15	14	13	12	11	*10	9	8	7	6	5	4	*3	2	1	0
Shift 5	T4	T3	T2	T1	T0	R15	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5
	T0					T4	T3	T2	T1	T0			T4	T3	T2	T1
						T0							T0			

Figure 16: *The contents of the shift register after the fifth shift.*

Bit	*15	14	13	12	11	*10	9	8	7	6	5	4	*3	2	1	0
Shift 8	T7	T6	T5	T4	T3	T2	T1	T0	R15	R14	R13	R12	R11	R10	R9	R8
	T3	T2	T1	T0		T7	T6	T5	T4	T3	T2	T1	T0			
						T3	T2	T1	T0				T7	T6	T5	T4
													T3	T2	T1	T0

Figure 17: *The contents of the shift register after the eighth shift.*

CRC is transmitted rather than the CRC itself. This allows detection of slippage-type errors.

5. The CRC is sent LSB first.
6. The polynomial used is $X^{16} + X^{12} + X^5 + 1$.

XMODEM.C implements the CRC as follows:

1. Only data bits are included. The header character and two block-number bytes are not included.
2. The data is sent LSB first. The CRC is calculated on the data MSB first.
3. The CRC is initialized to zeros.
4. The CRC is not complemented before transmission.
5. The order of transmission is high byte of CRC then low byte. Since UARTs transmit LSB first, this is equivalent to LSB of high byte through MSB of high byte, then LSB of low byte through MSB of low byte.
6. The polynomial used is $X^{16} + X^{12} + X^5 + 1$.

The CCITT method is easily implemented in a chip using shift registers and XOR gates, while the XMODEM method is not easily realized in hardware. To check an incoming data block, you have two options. You can calculate the CRC on all the protected bits only, omitting the CRC bits, and compare the calculated value to the received value. Or you can calculate the CRC on all the protected bits and the CRC itself and then compare the result to a known constant. If the first method is adopted in the CCITT case, the one's complement of the calculated value must be compared to the received CRC. In the XMODEM case, the comparison is direct. If the second method is adopted, in the XMODEM case the known constant is zero, while in the CCITT case it is 0 F0B8. (The high bit is on the left, i.e., 1.) No one's-complementing is required.

BYTE-ORIENTED SOFTWARE IMPLEMENTATIONS

The next step is to derive routines to calculate the CRC a whole byte at a time rather than bit by bit. This approach was first proposed by Perez, Wismer, and Becker. The motivation is that an 8-bit microprocessor is not limited to single-bit XORs but can do them 8 bits at a time. The basic approach is to work from the hardware diagram (figure 9 or 10) and see what the CRC register would look like after 8 bits have been calculated.

Bytewise SDLC calculations. In figure 10 you can see that you have the contents of figure 12 in the shift register at the beginning of calculations. Then you take the LSB of data, D0, and XOR it with R0 (D0 XOR R0). After the right shift, the new R15 is D0 XOR R0, the new R10 is R11 XOR D0 XOR R0, and the new R3 is R4 XOR D0 XOR R0. (See figure 13).

The combinations D0 XOR R0, D1 XOR R1, D2 XOR R2, and so on, occur frequently, so let's abbreviate them as T0 = D0 XOR R0, T1 = D1 XOR R1, and so on. Figure 13 can now be rewritten as in figure 14. If you proceed in this fashion for three more shifts, you get figure 15.

To do the XOR on D4, you must use the content of the LSB of the shift register, which is now R4 XOR D0 XOR R0. The result is D4 XOR R4 XOR D0 XOR R0, or in shorter form, T4 XOR T0. The result after the fifth shift is shown in figure 16; after the eighth shift, in figure 17.

The tedious part is done. Now you want to write a program that will produce the same result when you're working with a byte of data as you would get from the shift register after eight shifts. The emphasis in this routine will be on speed. If you make it too general-purpose, a different choice of polynomial will lead to a completely different program. Also, for speed, it makes sense to code the routine in assembly language.

When working with 8-bit microcomputers, it is convenient to define the 8-bit quantities found in table 2. If you study figure 17, you will see that the combination

T7 T6 T5 T4
XOR T3 T2 T1 T0

occurs several times. Let's call this term U = U7 U6 U5 U4. If you rewrite figure 17 with these substitutions, you get figure 18.

Bit	*15	14	13	12	11	*10	9	8	7	6	5	4	*3	2	1	0
Line #																
1									R15	R14	R13	R12	R11	R10	R9	R8
2	U7	U6	U5	U4	T3	T2	T1	T0								
3						U7	U6	U5	U4	T3	T2	T1	T0			
4													U7	U6	U5	U4

Figure 18: *The same as figure 17 but using the abbreviations given in table 2. Line 1 is* CRCHi *moved into* CRCLo; *line 2 is the high nybble of* U *and the low nybble of* T; *line 3 is the line 2 byte shifted left by 3 bits; and line 4 is* U *shifted right by 4 bits.*

Table 2: *Some convenient abbreviations for various 8-bit quantities used in CRC calculations in an 8-bit microcomputer environment.*

CRCHi	=	R15	R14	R13	R12	R11	R10	R9	R8
CRCLo	=	R7	R6	R5	R4	R3	R2	R1	R0
Data	=	D7	D6	D5	D4	D3	D2	D1	D0
T	=	T7	T6	T5	T4	T3	T2	T1	T0
U	=	U7	U6	U5	U4	0	0	0	0

Table 3: *Some test cases provided for comparison if you want to write your own routine.*

Text	SDLC	CRC
T	1B26	14A1
THE	44BE	7D8D
THE,QUICK,BROWN,FOX,0123456789	DF91	7DC5

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R15	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5	R4	R3	R2	R1	R0

Figure 19: *The contents of the shift register at the beginning of bytewise* XMODEM *calculations.*

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R15	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5	R4	R3	R2	R1	R0
D7	D6	D5	D4	D3	D2	D1	D0								

Figure 20: *The contents of the shift register after the* XOR *with the data byte.*

Further optimizations become apparent as you write the code. It is convenient to implement the SDLC algorithm (as in the program SDLC.ASM) because of the built-in check that calculating a CRC on a "received" block provides; that is, the result should always be 0 F0B8.

The innermost loop of SDLC.ASM takes only 86 cycles per byte including seven overhead cycles to check for end of buffer. If a 2-MHz 6809 were dedicated to CRC calculations, this would result in a through-

(continued)

put of about 200,000 bps. A bitwise algorithm to do the same job takes on average 353 cycles per byte and could take as many as 385. So the bytewise algorithm is about four times faster.

The test cases in table 3 are provided in case you want to write your own routine. The column labeled SDLC results when you initialize the CRC with ones (this is the result before the one's-complementing), and the column labeled CRC results when you initialize with zeros.

XMODEM byte-oriented algorithms. The XMODEM CRC "spec," such as it is, is shown in listing 2. If you repeat the work done for SDLC calculations (in figures 12 through 18) using listing 2 as a base, you will obtain the contents of the diagrams in figures 19 through 25. The contents of the starting CRC are shown in figure 19. After the XOR with the data byte, you get the result shown in figure 20. When you abbreviate R15 XOR D7 as T7, R14 XOR D6 as T6, and so on, figure 20 becomes figure 21. After processing the first data bit and the left shift, you get the result shown in figure 22; after four shifts, figure 23; after five shifts, figure 24; and after eight shifts (the final result), figure 25. Next, you define the appropriate variables such as CRCHi, CRCLo, T, and U, and you look for factors.

An implementation of the XMODEM CRC calculations for the 6809 is given in the program XMODEM.ASM. The test case results using the XMODEM algorithm are shown in table 4.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
T7	T6	T5	T4	T3	T2	T1	T0	R7	R6	R5	R4	R3	R2	R1	R0

Figure 21: *The same as figure 20 but with the abbreviations* T7 *for* R15 XOR D7, T6 *for* R14 XOR D6, *and so on.*

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
T6	T5	T4	T3	T2	T1	T0	R7	R6	R5	R4	R3	R2	R1	R0	T7
			T7							T7					

Figure 22: *The contents of the shift register after processing the first data bit and performing the left shift.*

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
T3	T2	T1	T0	R7	R6	R5	R4	R3	R2	R1	R0	T7	T6	T5	T4
T7	T6	T5	T4				T7	T6	T5	T4					

Figure 23: *The contents of the shift register after four shifts.*

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
T2	T1	T0	R7	R6	R5	R4	R3	R2	R1	R0	T7	T6	T5	T4	T3
T6	T5	T4	T3			T7	T6	T5	T4	T3					T7
			T7							T7					

Figure 24: *The contents of the shift register after five shifts.*

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R7	R6	R5	R4	R3	R2	R1	R0	T7	T6	T5	T4	T3	T2	T1	T0
T3	T2	T1	T0				T7	T6	T5	T4		T7	T6	T5	T4
T7	T6	T5	T4												
			T7	T6	T5	T4	T3	T2	T1	T0					

Figure 25: *The contents of the shift register after eight shifts.*

Table 4: *The same test cases as in table 3 but for* XMODEM.

Text	XMODEM CRC
T	1A71
THE	1E0A
THE,QUICK,BROWN,FOX,0123456789	0498

CONCLUSION

Once you arrive at the basic idea of using the XOR function to implement modulo 2 division, it is not difficult to apply the CRC algorithms, only tedious. As with so many other communications standards, the options and the details provide most of the difficulties and confusion. ■

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McNamara, J. E. *Technical Aspects of Data Communications.* Bedford, MA: Digital Equipment Press, 1982.

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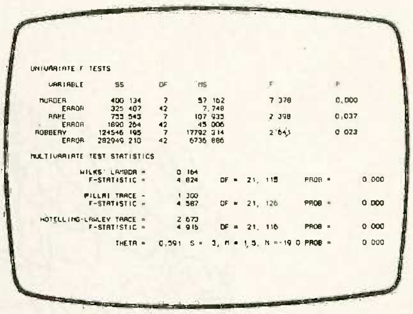
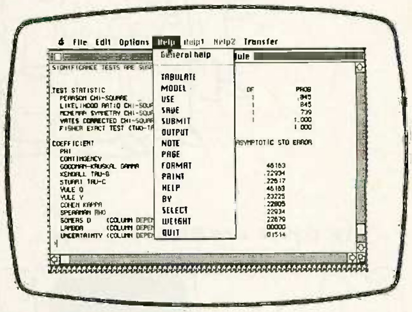


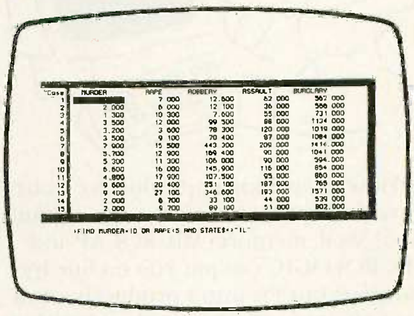
```
UNIVARIATE F TESTS

   VARIABLE       SS          DF        MS                F           P

  MURDER       400 134        7       57 162           7 378        0,000
       ERROR   325 407       42        7,748
   RAPE        755 543        7      107 935           2 398        0,037
       ERROR  1890 264       42       45 006
 ROBBERY     124546 195       7     17792 314          2 641        0 023
       ERROR 282949 210      42      6736 886

MULTIVARIATE TEST STATISTICS

            WILKS' LAMBDA =         0 164
              F-STATISTIC =         4 824    DF =  21,  115     PROB =        0 000

             PILLAI TRACE -         1 300
              F-STATISTIC =         4 587    DF =  21,  126     PROB =        0 000

   HOTELLING-LAWLEY TRACE =         2 673
              F-STATISTIC =         4 915    DF =  21,  116     PROB =        0 000

                  THETA =   0,591  S =  3, M = 1,5, N =-19 0 PROB =        0 000
```

CP/M



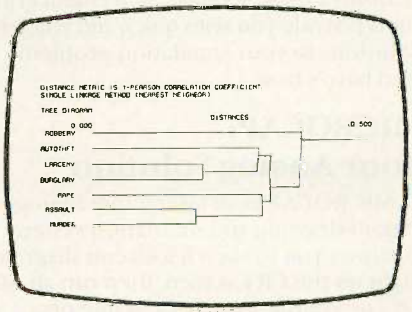
```
SIGNIFICANCE TESTS ARE SQUA                                ule

TEST STATISTIC                                             DF         PROB
  PEARSON CHI-SQUARE                                        1         .845
  LIKELIHOOD RATIO CHI-SQUA                                 1         .845
  MCNEMAR SYMMETRY CHI-SQUA                                 1         .739
  YATES CORRECTED CHI-SQUAR                                 1        1.000
  FISHER EXACT TEST (TWO-TA                                          1 000

COEFFICIENT                                               ASYMPTOTIC STD ERROR
  PHI
  CONTINGENCY
  GOODMAN-KRUSKAL GAMMA                                        46163
  KENDALL TAU-B                                               .22934
  STUART TAU-C                                                .22617
  YULE Q                                                       46163
  YULE Y                                                      .23225
  COHEN KAPPA                                                 .22805
  SPEARMAN RHO                                                 22934
  SOMERS D     (COLUMN DEPEN                                   22679
  LAMBDA       (COLUMN DEPEN                                   00000
  UNCERTAINTY  (COLUMN DEPEN                                   01514
```

Apple Macintosh



```
 Case  MURDER        RAPE      ROBBERY     ASSAULT     BURGLARY
    1                  7 000     12.600      62 000     567 000
    2      2 000       6 000     12 100      36 000     566 000
    3      1 300      10 300      7.600      55 000     731 000
    4      3 500      12 000     99 500      88 000    1134 000
    5      3.200       3 600     78 300     120 000    1019 000
    6      3 500       9 100     70 400      87 000    1084 000
    7      7 900      15 500    443 300     209 000    1416.000
    8      5.700      12 900    169 400      90 000    1041 000
    9      5 300      11 300    106 000      90 000     594.000
   10      6.600      16 000    145,900     116 000     854 000
   11      4.800      17 900    107.500      95 000     860 000
   12      9 600      20 400    251 100     187 000     765 000
   13      9 400      27 100    346 600     193 000    1571 000
   14      2 000       8 700     33 100      44 000     539 000
   15      2 000       9 700     89 100      51 000     802.000

>FIND MURDER>10 OR RAPE<5 AND STATE$<>"IL"
```

VAX



```
DISTANCE METRIC IS 1-PEARSON CORRELATION COEFFICIENT
SINGLE LINKAGE METHOD (NEAREST NEIGHBOR)

TREE DIAGRAM
```

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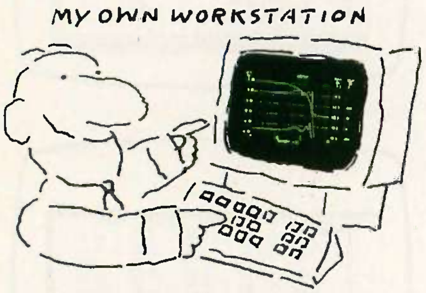

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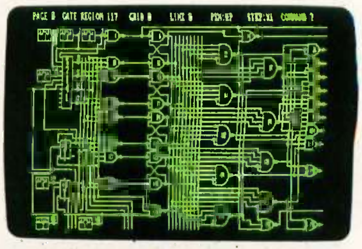

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Inquiry 325

BREAKING OUT

BY EDWARD BATUTIS

This routine enables a breakpoint in the PC-DOS DEBUG *program*

MOST DEBUGGERS have a "breakout" switch that allows you to jump into the debugger regardless of what your computer is doing. Unfortunately, the DEBUG program provided with IBM PC-DOS does not have this feature. I have designed a program called BREAKPT (short for breakpoint) that gives PC-DOS DEBUG this capability (see listings 1 and 2). [*Editor's note:* BREAKPT.ASM *and* BRKPTCOM.BAS *are available in a variety of formats; see the insert card following page* 368.]

HOW BREAKPT WORKS

BREAKPT is a memory-resident program that you need to run just once after booting your computer. It searches for a specific set of keystrokes. When it finds them, the program executes the breakpoint interrupt (interrupt 3). If DEBUG is running, BREAKPT prints out the registers, shows the next instruction, and waits for a command.

BREAKPT intercepts the keyboard interrupt (interrupt 9), which is invoked every time you strike a key. The program examines the keyboard flags in the ROM BIOS data area. The first flag, at segment 40H (hexadecimal), byte 17H, shows what Shift and Control keys are currently depressed. If the flags indicate that the Control key and both Shift keys are depressed simultaneously, BREAKPT sets the microprocessor's trap flag (bit 8) to 1. This initiates the execution of interrupt 3 (the breakpoint interrupt) via interrupt 1 (single step).

For example, you install BREAKPT by entering the command BREAKPT at the DOS prompt. If you want to explore the inner workings of BASICA.COM, you load DEBUG and BASICA.COM with the command DEBUG BASICA.COM. Then you start BASICA with the go, or g, command. At this point, BASICA is in a loop waiting for a keyboard entry. If you hold down the Control, left Shift, and right Shift keys and then release them,

(continued)

Edward Batutis is a systems analyst for LFP *Systems Inc.* (4600 *Marriott* Dr., *Suite* 400, *Raleigh*, NC 27612).

Listing 1: *Assembly language source code for* BREAKPT.

```
; BREAKPT
; Copyright 1985, Edward Batutis
;
; Invokes the breakpoint interrupt when Ctrl-Shift-Shift
; combination is pressed.

; Assembled with the IBM Macro Assembler Version 1.00

cseg    segment para    public 'code'
        assume cs:cseg,ds:cseg
        org     100h

breakpt proc

        jmp     install

copyright       db      'BREAKPT (c) Copyright 1985,'
                db      ' Edward J. Batutis',01ah

old_int9_vector label   dword
old_int9_offs   dw      ?
old_int9_seg    dw      ?
```

(continued)

```
new_int9:

        ; call old keyboard routine by simulating an int

        pushf
        call    cs:old_int9_vector

        push    es              ; save registers
        push    ax
        push    bx

        mov     ax,40h          ; look at keyboard flag1 in
        mov     es,ax           ;  ROM BIOS data area
        mov     bx,17h
        mov     al,es:[bx]
        and     al,07h          ; mask off everything but lowest
                                ;  three bits
        cmp     al,7            ; are Ctrl-Shift-Shift depressed?
        jne     quit            ; no, quit

        ; turn on the trap flag

        pop     bx              ; restore registers
        pop     ax
        pop     es

        push    ax              ; save register
        pushf                   ; get flags into ax
        pop     ax

        or      ax,0100h        ; set trap flag on
        push    ax              ; put new flags back
        popf
        pop     ax              ; restore ax
        nop                     ; wait one instruction
        iret                    ; debug is invoked at this instruction
quit:
        pop     bx              ; restore registers when
        pop     ax              ;  quitting
        pop     es
done:
        iret

END_OF_RESIDENT_CODE    LABEL   BYTE

banner  db      'BREAKPT installed.',10,13,'$'

install:
                                ; get interrupt vector for
                                ;  keyboard interrupt

        mov     ah,35h          ; get interrupt vector function
        mov     al,9            ; get interrupt 9
        int     21h

        cmp     bx,offset new_int9      ; are we already installed?
        je      no_install              ; yes, just exit

        mov     old_int9_offs,bx        ; save old keyboard interrupt
        mov     old_int9_seg,es         ;  address

        mov     dx,offset banner        ; print banner
        mov     ah,9                    ; print string function
        int     21h

                                        ; set keyboard interrupt
                                        ;  to point to new_int9
```

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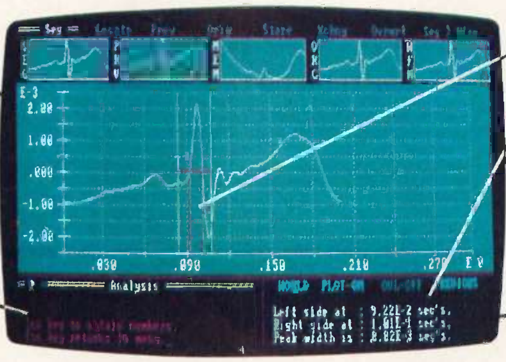

```
Left side at   : 9.22E-2 sec's.
Right side at  : 1.01E-1 sec's.
Peak width is  : 8.82E-3 sec's.
```

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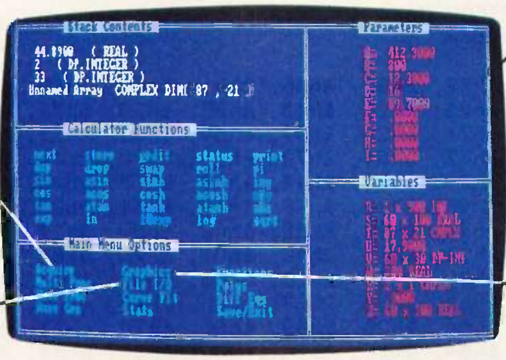

```
44.0900   ( REAL )
2   ( DP.INTEGER )
33   ( DP.INTEGER )
Unnamed Array  COMPLEX DIM[ 87 , 21 ]
```

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Inquiry 214

```
        mov     ah,25h                  ; set interrupt function
        mov     al,9                    ; set interrupt 9
        mov     dx,offset new_int9      ; point to new routine
        int     21h

                                        ; terminate, but stay
                                        ;  partially resident
                                        ; point to last byte of resident
                                        ;  routines+1

        mov     dx,offset END_OF_RESIDENT_CODE+1
        int     27h

no_install:
        int     20h             ; don't install, just exit

breakpt endp

cseg    ends
        end     breakpt
```

Listing 2: *The* BASIC *program that creates* BREAKPT.COM.

```
100  'RUN THIS PROGRAM (BRKPTCOM.BAS) TO CREATE breakpt.com
110  PRINT "Creating breakpt.com"
120  OUTFILE$="breakpt.com"
140  DATA &hEB, &h74, &h90, &h42, &h52, &h45, &h41, &h4B, &h50, &h54
150  DATA &h20, &h28, &h63, &h29, &h20, &h43, &h6F, &h70, &h79, &h72
160  DATA &h69, &h67, &h68, &h74, &h20, &h31, &h39, &h38, &h35, &h2C
170  DATA &h20, &h45, &h64, &h77, &h61, &h72, &h64, &h20, &h4A, &h2E
180  DATA &h20, &h42, &h61, &h74, &h75, &h74, &h69, &h73, &h1A, &h00
190  DATA &h00, &h00, &h00, &h9C, &h2E, &hFF, &h1E, &h31, &h01, &h06
200  DATA &h50, &h53, &hB8, &h40, &h00, &h8E, &hC0, &hBB, &h17, &h00
210  DATA &h26, &h8A, &h07, &h24, &h07, &h3C, &h07, &h75, &h0E, &h5B
220  DATA &h58, &h07, &h50, &h9C, &h58, &h0D, &h00, &h01, &h50, &h9D
230  DATA &h58, &h90, &hCF, &h5B, &h58, &h07, &hCF, &h42, &h52, &h45
240  DATA &h41, &h4B, &h50, &h54, &h20, &h69, &h6E, &h73, &h74, &h61
250  DATA &h6C, &h6C, &h65, &h64, &h2E, &h0A, &h0D, &h24, &hB4, &h35
260  DATA &hB0, &h09, &hCD, &h21, &h81, &hFB, &h35, &h01, &h74, &h1D
270  DATA &h89, &h1E, &h31, &h01, &h8C, &h06, &h33, &h01, &hBA, &h61
280  DATA &h01, &hB4, &h09, &hCD, &h21, &hB4, &h25, &hB0, &h09, &hBA
290  DATA &h35, &h01, &hCD, &h21, &hBA, &h62, &h01, &hCD, &h27, &hCD
300  DATA &h20
310  TOTAL= 161
320  OPEN OUTFILE$ AS #1 LEN=1
330  FIELD #1,1 AS A$
340  FOR I=1 TO TOTAL
350      READ A
360      LSET A$=CHR$(A)
370      PUT 1
380  NEXT
390  CLOSE
400  PRINT"Done."
410  END
```

Table 1: *An example of the register-content display produced by* BREAKPT.

```
AX=3920  BX=3160  CX=0324  DX=0078  SP=FFDA  BP=FFEE  SI=0000  DI=000F
DS=3160  ES=48CE  SS=48CE  CS=435E  IP=1D31   NV UP EI PL ZR AC PE NC
435E:1D31 CF                  IRET
```

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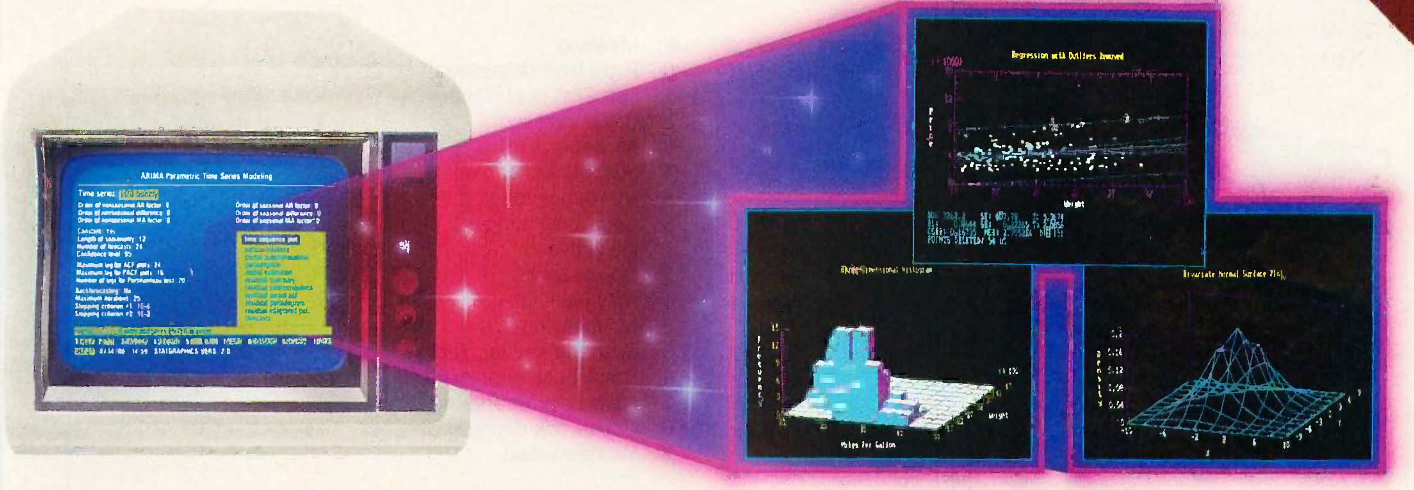

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Table 2: *The meanings of the various bits in the keyboard flags.*

Segment	Offset	Bit	Meaning
40H	17H	0	Right Shift depressed
		1	Left Shift depressed
		2	Ctrl depressed
		3	Alt depressed
		4	Scroll Lock toggled
		5	Num Lock toggled
		6	Caps Lock toggled
		7	Ins active
40H	18H	0	No meaning
		1	No meaning
		2	No meaning
		3	Suspend key toggled
		4	Scroll Lock depressed
		5	Num Lock depressed
		6	Caps Lock depressed
		7	Ins depressed

you will see a display that resembles the one in table 1.

The instruction displayed at the end of the table, IRET, is the last instruction in the BREAKPT routine itself. The contents of the registers will vary depending on exactly where the program is when you press Control-Shift-Shift and depending on where DEBUG is loaded in memory.

If you use the DEBUG trace command, t, you will see the instruction immediately following the one you interrupted. If you use the go command, g, you will return to BASICA.

To explore a particular feature of BASICA, you can write a program that puts the interpreter in a loop and then break out of it with Control-Shift-Shift. For example, breaking out during the program

```
10 a=1.0*1.0:goto 10
```

will probably put you somewhere in (or near) the floating-point multiplication routine.

You can also use BREAKPT if you are debugging a program and it gets away from you. For example, if you set a DEBUG breakpoint in the wrong place, or if the program does something unexpected and does not execute the breakpoint you've set, you can often save yourself by pressing Control-Shift-Shift.

You must be careful not to press Control-Shift-Shift when DEBUG is not loaded. Also, DEBUG is not very good at debugging programs that make a lot of calls to DOS because DEBUG itself uses DOS. If DEBUG is called during certain DOS interrupts, you normally won't be able to return to the original calling program. It's also important to keep in mind that the breakpoint interrupt won't execute if the interrupts within DEBUG are disabled. DEBUG will be invoked when they become enabled. For this reason, you don't always break out where you think you should.

MODIFICATIONS

The default condition when DEBUG starts up is for the interrupts to be turned off. If you want to turn them on before starting the program you want to debug, enter the following DEBUG commands: r f then ei. If you want to change the keystrokes that invoke BREAKPT, see table 2, which contains a list of the meanings of each bit in the keyboard flags.

You can alter BREAKPT quickly and easily by using the assemble command in DEBUG or by altering and assembling the source code using the IBM Macro Assembler. You mask the bits that you don't want to check using the and instruction, and then you test to see if the proper bits are turned on with the cmp (compare) instruction. (BREAKPT is compatible with SideKick if loaded after it.) ■

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Great Code: Manx Aztec C86 generates fast executing compact code. The benchmark results below are from a study conducted by Manx. The Dhrystone benchmark (CACM 10/84 27:10 p1018) measures performance for a systems software instruction mix. The results are without register variables. With register variables, Manx, Microsoft, and Mark Williams run proportionately faster, Lattice and Computer Innovations show no improvement.

	Execution Time	Code Size	Compile/ Link Time
Dhrystone Benchmark			
Manx Aztec C86 3.3	34 secs	5,760	93 secs
Microsoft C 3.0	34 secs	7,146	119 secs
Optimized C86 2.20J	53 secs	11,009	172 secs
Mark Williams 2.0	56 secs	12,980	113 secs
Lattice 2.14	89 secs	20,404	117 secs

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- Z (vi) Source Editor -c
- ROM Support Package -c
- Library Source Code -c
- MAKE, DIFF, and GREP -c
- One year of updates -c
- Symbolic Debugger
- LN86 Overlay Linker
- Librarian
- Profiler
- DOS, Screen, & Graphics Lib
- Intel Object Option
- CP/M-86 Library -c
- INTEL HEX Utility -c
- Mixed memory models -c
- Source Debugger -c
- CP/M-86 Library -c

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MACINTOSH, AMIGA, XENIX, CP/M-68K, 68k ROM

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- Terminal Emulator (Source)
- Clear Detailed Documentation
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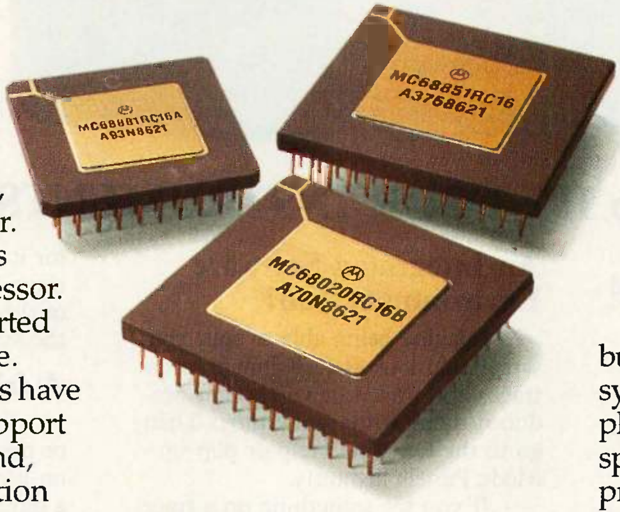

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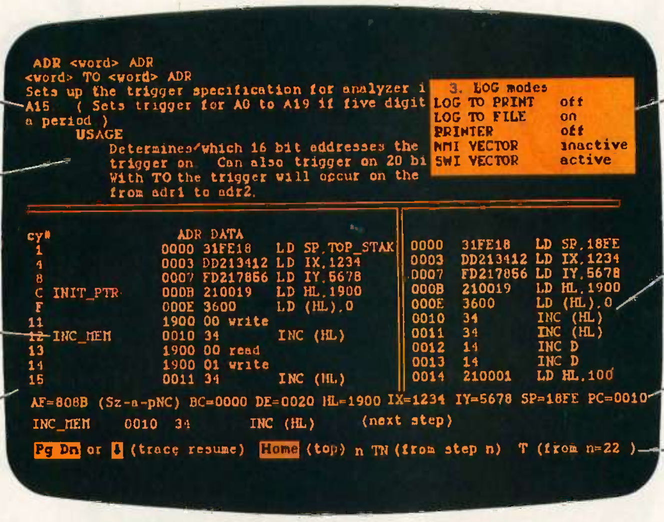

```
 ADR <word> ADR
<word> TO <word> ADR
Sets up the trigger specification for analyzer i   3. LOG modes
A15   ( Sets trigger for A0 to A19 if five digit LOG TO PRINT   off
a period )                                         LOG TO FILE    on
      USAGE                                        PRINTER        off
         Determines/which 16 bit addresses the     NMI VECTOR     inactive
         trigger on   Can also trigger on 20 bi    SWI VECTOR     active
         With TO the trigger will occur on the
         from adr1 to adr2.

cy#           ADR  DATA                            0000  31FE18   LD SP,18FE
 1            0000 31FE18   LD SP,TOP_STAK         0003  DD213412 LD IX,1234
 4            0003 DD213412 LD IX,1234             0007  FD217856 LD IY,5678
 8            0007 FD217856 LD IY,5678             000B  210019   LD HL,1900
 C INIT_PTR   000B 210019   LD HL,1900             000E  3600     LD (HL),0
 F            000E 3600     LD (HL),0              0010  34       INC (HL)
11            1900 00 write                        0011  34       INC (HL)
12 INC_MEM    0010 34       INC (HL)               0012  14       INC D
13            1900 00 read                         0013  14       INC D
14            1900 01 write                        0014  210001   LD HL,100
15            0011 34       INC (HL)
AF=808B (Sz-a-pNC) BC=0000 DE=0020 HL=1900 IX=1234 IY=5678 SP=18FE PC=0010
INC_MEM     0010  34        INC (HL)        (next step)
Pg Dn or ↓ (trace resume) Home (top) n TN (from step n)  T (from n=22 )
```

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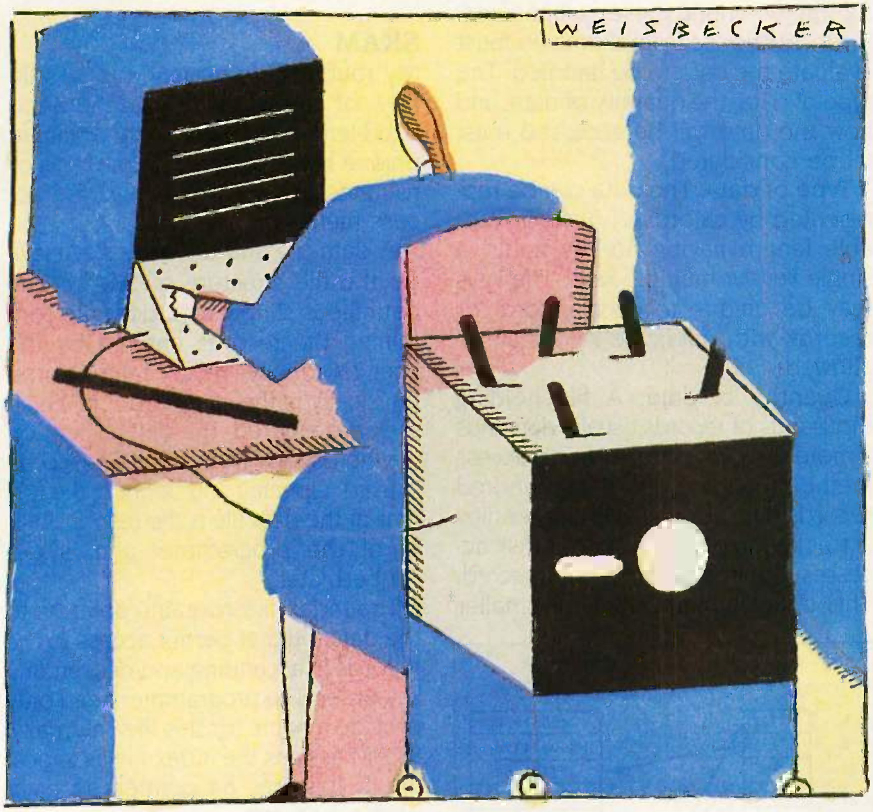
BY STEPHEN C. PERRY

KEYED FILE ACCESS IN BASIC



These routines provide efficient access to data files

For both beginning and experienced BASIC programmers, maintaining data on disk files can be a challenging aspect of programming. For beginners, it's often a question of how to do it; for the more experienced, it's a matter of how to do it most efficiently. Either way, programmers are limited by the file operations available in BASIC.

Most versions of BASIC provide two methods for accessing records on a disk file: sequential and random. With sequential access, you locate a record by reading from the beginning of the file until you retrieve the desired record; updating a record requires you to rewrite the entire file. Random access allows you to jump around in the file, directly reading or writing at any location. The record to be located is designated by its relative file position with a GET or PUT statement.

These access methods are adequate for the simple file-handling examples in most BASIC manuals but are of limited use in interactive programs that must respond promptly to user requests. For example, an accounting program that maintains customer records should respond quickly to a query for information about any customer. Typically, this requires searching the file for a record with the name or customer code supplied by the user. Clearly, searching sequentially takes too long for all but the shortest files, and random access often provides no way to locate a record by a field value. Thus the need for another access method—one that will find a record by its field value.

Accessing records by field values, called "keyed access," has long been available in high-level languages.

(continued)

Stephen C. Perry (3413 Malibu Dr., Raleigh, NC 27607) is a manager of information systems at Cotton Inc. He specializes in applying microcomputers to office and management use. His interests are database management systems and local-area networks.

ILLUSTRATED BY PHILIPPE WEISBECKER

Using such routines as ISAM (indexed sequential access method), programs can read, write, delete, or update records by one or more key values. The programmer is relieved of coding the underlying search routine and maintaining data and file structures.

This article describes a set of subroutines you can use in BASIC programs to provide keyed access. The routines enable you to randomly add, delete, update, and retrieve records based on a single, unique key value. The routines also provide sequential access to records based on ascending or descending key value.

Before examining the routines and how to use them, let's review the general concept and requirements of a file management system.

FILE MANAGEMENT SYSTEMS

The purpose of any file management system is to give you simple and fast access to records in a file. Ideally, the system should be set up as a "black box" that conceals from you the detailed steps needed to carry out file maintenance operations. Let's examine this box and see how file access is accomplished.

Logically, any file management system can be defined by its file structure, its data structure, and its method of searching. The file structure determines how records are actually stored on a disk, including the contents and format of data files, and any indexes required for keyed access. The data structure reflects how overhead information for accessing data is maintained in the program, that is, the arrays or list structures containing pointers and key values. The search method is based on the algorithm used to access the data structure. Usually, the method of searching determines the data structure.

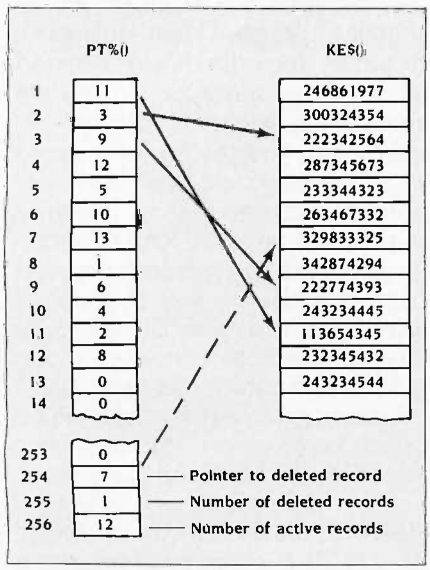


Figure 1: *The* SKAM *vectors before a new record is inserted.*

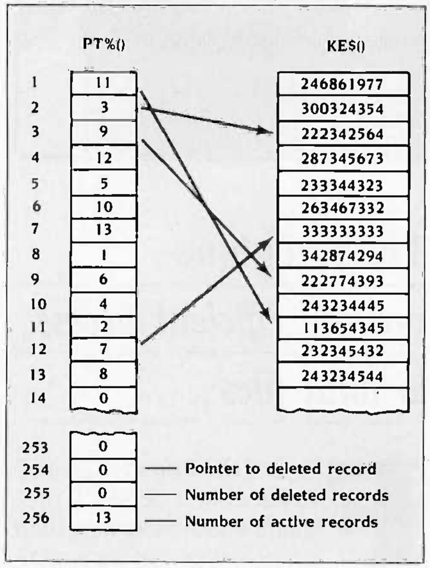


Figure 2: *The* SKAM *vectors after a new record has been added.* Note the *changes in the* PT% *vector.*

Numerous techniques are available for implementing these essential features. To choose from them you must evaluate the data to be handled. The type of data, the quantity of data, and how the data will be accessed must all be considered.

Type of data: The data can be represented by records of fixed or variable length having no key fields, a single key, or multiple keys. The keys may be unique to each record, or records with duplicate keys may be allowed.

Quantity of data: A file holding thousands of records usually demands a more elaborate structure and access method than one with a few hundred records. The concern with larger files is to minimize the number of disk accesses required to search for a record. This is not as important for smaller files, since it is possible to keep an index and set of keys in memory for the entire file.

Processing requirements: Four basic operations are required on most files—record addition, deletion, modification, and retrieval. What varies is how frequently, and on how much data, each operation must be performed.

Now, having examined the important features of file management in general, let's look at my file management routines.

SKAM

My routines are designed to handle files of approximately a thousand fixed-length records with a single unique key. I refer to this collection of routines as SKAM (single-keyed access method).

A data file and an index file make up the file structure of SKAM. The data file is simply a random file containing the records entered by the user. Normally, records are stored physically in the same order in which they are entered; the only exception is when space from deleted records is used. Opening and defining the format of the data file is the responsibility of the programmer and is described later.

The index file contains pointers to the data file that permit access to the records in ascending and descending key order. The programmer need only provide a name for this file. Internally, SKAM assigns the index file as logical file 1. It stores 64 pointers in each physical record.

Besides the pointers for ordering, three other types of information are kept in the index file: the last pointer in the last record contains the number of active records in the data file; the pointer preceding this one contains the number of deleted records in the data file; and a last-in/first-out stack of pointers to the deleted records precedes these last two values.

Corresponding to the data file and index file are two vectors (see figure 1) used by the BASIC routines to hold record keys and addresses. KE$ contains the key values ordered by actual physical location, and PT% contains a sorted list of pointers that address records by ascending key value. Vector PT% contains the exact contents of the index file, with the deleted and active record information stored in its last locations.

To understand the logic of this data structure, let's look at what happens when a record is added to a file. Figure 1 shows the original structure containing 12 records. Figure 2 shows it after a record with the key value 333333333 has been added. Note the changes:

- Location 7 in KE$, which held a deleted key value, now holds the new key. The physical record has been stored as the seventh record in the data file.
- The total number of deleted records, in PT%(255) has been decremented by 1.
- The total number of active records, in PT%(256) has been incremented by 1.
- A pointer addressing the new record (location 7) has been inserted in location 12 of PT%. This indicates that the new key is logically twelfth in key sequence.

To delete a record, this process is reversed. A pointer is deleted from PT%, and the totals of deleted and active records are appropriately updated. The physical space of the deleted record is made available for reuse by placing a pointer to it in PT%.

It is important to realize that these changes to PT% do not immediately affect the index file; all changes occur only in main memory. As a result, this vector must be written back to the index file after all operations have been completed.

To locate records by key value, a binary search is performed using the vector PT%. First, the pointer at the midpoint of the vector is selected. The key it points to in KE$ is then compared with a search key. If no match is found, the pointer search area is halved and the midpoint of the new range is selected. This process continues until a match or no match is confirmed.

By searching for keys in main memory, it is not necessary to access the disk for each comparison. Only when a match is found must the actual record be read or written to disk. This works because a matching key found in the *n*th location of KE$ has its corresponding record at the *n*th record position in the data file.

Table 1: *The SKAM routines arranged by function. To invoke an operation, set II% to the required value. Depending upon the operation, other variables will also have to be set. The return code, RC%, indicates the result of the operation.*

II%	Operation	F1$	A$	NX%	RC%
1	Set Up Data Structure	Name of index file			0 – Successful 1 – Index name or MX% not defined
2	Add Record		Key value		0 – Successful 1 – Key exists 2 – File is full
3	Rewrite Record		Key of record to rewrite		0 – Successful 1 – Key does not exist
4	Delete Record		Key of record to delete		0 – Successful 1 – Key does not exist
5	Read Record by Key		Key value	Relative position of record	0 – Successful 1 – Key does not exist
6	Read Relative Record			Relative location	0 – Successful 1 – Invalid location
7	Store Index				0 – Successful
8	Display File Statistics				0 – Successful

USING THE SKAM ROUTINES

The eight operations shown in table 1 are available for your BASIC programs. To use them, set variable II% to the value of a desired operation, set any required parameters, and issue a GOSUB command to pass program control to the entry point of the SKAM subroutines. The desired operation, determined by II%, will be performed and a return code sent back in variable RC%. If this value is 0, the operation was successful; other values identify specific errors.

Let's look at the details of these eight operations.

1. Set Up Data Structure reads the pointers from the index file into the vector PT% and reads the keys from the data file into KE$. This routine must be called before the other operations can be used. If F1$ or MX% is not defined, a code of 1 is returned.

Parameters: II%=1, F1$=name of index file, MX%=maximum number of records.

2. Add Record stores a new record in the data file. The index is automatically updated to locate the record in proper key sequence. If a record with the key already exists, the operation will fail.

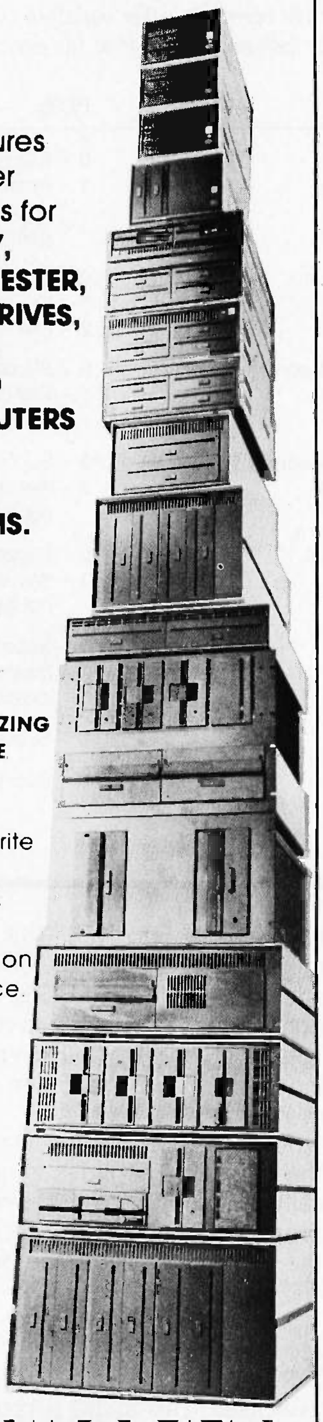
Parameters: II%=2, A$=key of record to be stored.

3. Rewrite Record writes a record back over itself. This allows a program to update a record by reading it, changing a field, and then rewriting the altered record in its old location.

Parameters: II%=3, A$=key of record to be rewritten.

4. Delete Record deletes a record having the specified key. Internally, the record is logically—not physically—

(continued)



Listing 1: A *simple* BASIC *program for maintaining employee records illustrates the use of* SKAM *routines.*

```
1  '-------------------------------------------------------
2  '         SAMPLE PROGRAM USING KEYED ACCESS ROUTINES     -
3  ' ------------------------------------------------------
5  UA$="A"    ' .. DRIVE CONTAINING DATA
16 OPEN "R",#2,UA$+":DATA.EMP",84   ' .. OPEN DATA FILE
17 FIELD #2, 9 AS KY$, 20 AS NM$, 6 AS BD$, 1 AS SX$, 3 AS JC$, 20 AS A1$, 20 AS
 A2$, 5 AS ZP$
18 '
19 '     KY$ - ZIP CODE (KEY) JC$ - JOB CODE
20 '     NM$ - NAME           A1$ - STREET ADDR.
21 '     BD$ - BIRTH DATE     A2$ - CITY-STATE
22 '     SX$ - SEX            ZP$ - ZIP CODE
23 '
25 MX%=150: F1$="PTR.EMP"          ' ..INDEX FILE NAME
30 II%=1: GOSUB 2000               ' ..INITIALIZE DATA STRUCTURE
31 '
32 INPUT "OPERATION (D,A,L,S,LA,U,Q)";Q$
33 IF Q$="D" THEN GOSUB 150: GOTO 32             ' DELETE
34 IF Q$="L" THEN GOSUB 180: GOTO 32             ' LIST INDIVIDUAL DATA
35 IF Q$="A" THEN GOSUB 100: GOTO 32             ' ADD
36 IF Q$="S" THEN II%=8: GOSUB 2000: GOTO 32 ' DISPLAY STATISTICS
37 IF Q$="LA"THEN GOSUB 200: GOTO 32             ' LIST ALL RECORDS
38 IF Q$="U" THEN GOSUB 250: GOTO 32             ' UPDATE RECORD
40 IF Q$<>"Q" THEN 32
50 CLOSE: END
97  '
98  ' ***** ADD RECORD
99  '
100  INPUT "SS#";A$ : IF A$="END" THEN 120 ELSE IF LEN(A$)<>9 THEN 100
101  II%=5:GOSUB 2000: IF RC%<>0 THEN LSET KY$=A$: GOTO 102 ELSE PRINT"** ERROR
 - KEY ALREADY EXISTS": GOTO 100
102  INPUT "NAME";F$: LSET NM$=F$
105  INPUT "BIRTH DATE";F$: LSET BD$=F$
107  INPUT "SEX";F$: LSET SX$=F$
109  INPUT "JOB CODE";F$: LSET JC$=F$
110  INPUT "STREET";F$: LSET A1$=F$
111  INPUT "CITY-STATE";F$: LSET A2$=F$
112  INPUT "ZIP CODE";F$: LSET ZP$=F$
115  II%=2: GOSUB 2000        '.. ADD RECORD
116  IF RC%=0 THEN 100 ELSE PRINT"** ERROR - RECORD CANNOT BE STORED": GOTO 100
120  II%=7: GOSUB 2000        '.. STORE POINTERS
122  RETURN
147 '
148 ' ***** DELETE RECORD
149 '
150 ST%=0
151 INPUT "CODE TO DELETE";A$: IF A$="END" THEN 156
152 II%=4: GOSUB 2000
154 IF RC%=0 THEN ST%=1 ELSE  PRINT "** ERROR - KEY DOES NOT EXIST"
155 GOTO 151
156 IF ST%=1 THEN II%=7: GOSUB 2000   ' RESTORE POINTERS IF RECORD DELETED
158 RETURN
177 '
178 ' ***** LIST INDIVIDUAL RECORD
179 '
180 INPUT "SOCIAL SECURITY NUMBER";A$: IF A$="END" THEN 190
182 II%=5: GOSUB 2000: IF RC%<>0 THEN PRINT"**ERROR - KEY DOES NOT EXIST": GOTO
 180
183 PRINT " "
184 PRINT "      NAME: ";NM$
185 PRINT "  JOB CODE: ";JC$
186 PRINT "BIRTH DATE: ";LEFT$(BD$,2);"/";MID$(BD$,3,2);"/";RIGHT$(BD$,2)
187 PRINT "   ADDRESS: ";A1$
188 PRINT TAB(13);A2$:PRINT ""
189 GOTO 180
190 RETURN
197 '
198 ' ***** LIST RANGE OF RECORDS
199 '
200 NX%=0: II%=6: K%=0
202 NX%=NX%+1: GOSUB 2000
204 IF RC%<>0 THEN 210
205 PRINT KY$,NM$
206 K%=K%+1: IF K%<10 THEN 202 ELSE INPUT ">";Q$   ' .. PAUSE
207 IF Q$<>"END" THEN K%=0: GOTO 202
210 RETURN
247 '
248 ' ***** UPDATE RECORD
249 '
250 INPUT "SS#";A$: IF A$="END" THEN 270
252 II%=5:GOSUB 2000      ' .. FETCH RECORD TO BE UPDATED
254 IF RC%=1 THEN PRINT "** ERROR - RECORD DOES NOT EXIST":GOTO 250
255 PRINT "NAME: /";NM$;"/";: INPUT F$: IF LEN(F$)<>0 THEN LSET NM$=F$
```

(continued)

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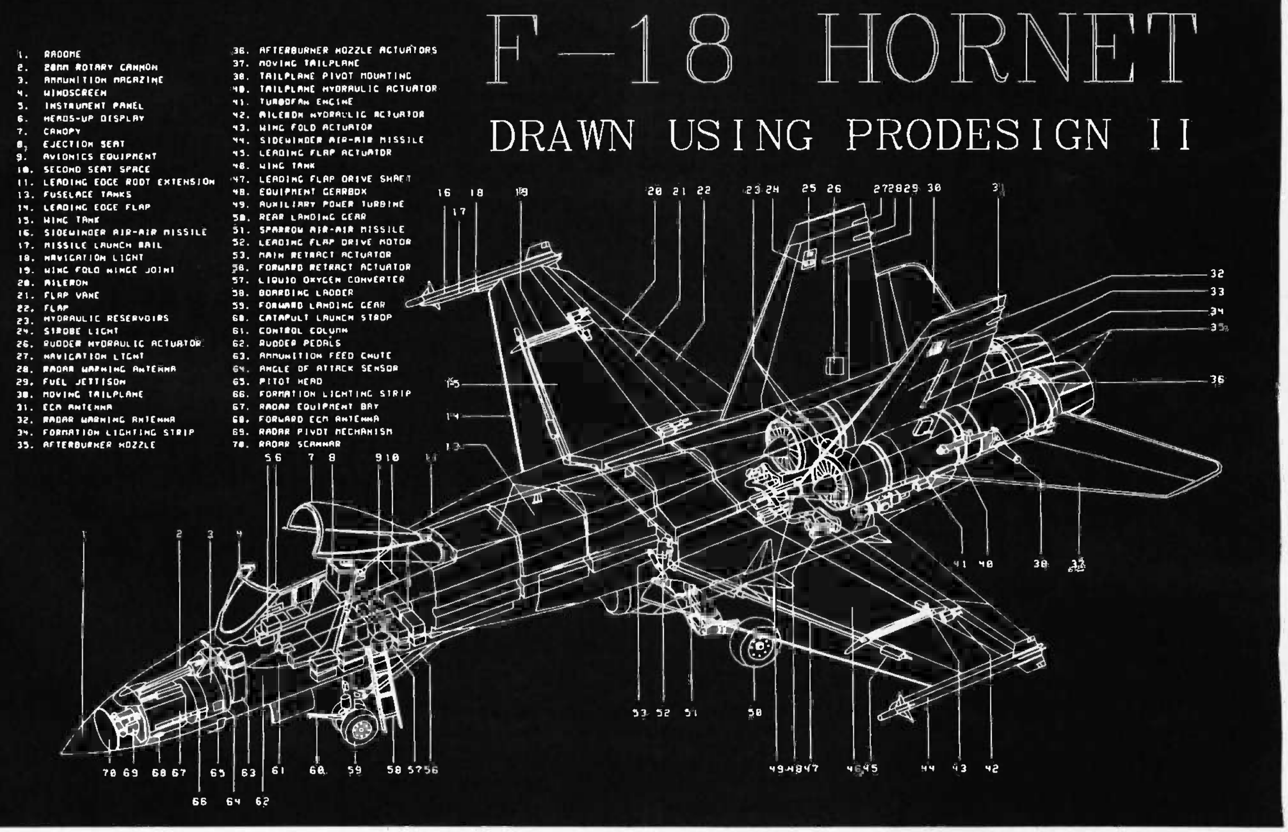

```
257 PRINT "BIRTH DATE: /";BD$;"/";: INPUT F$: IF LEN(F$)<>0 THEN LSET BD$=F$
258 PRINT "SEX: /";SX$;"/";: INPUT F$: IF LEN(F$)<>0 THEN LSET SX$=F$
260 PRINT "JOB CODE: /";JC$;"/";: INPUT F$: IF LEN(F$)<>0 THEN LSET JC$=F$
262 PRINT "STREET: /";A1$;"/";: INPUT F$: IF LEN(F$)<>0 THEN LSET A1$=F$
263 PRINT "CITY-STATE: /";A2$;"/";: INPUT F$: IF LEN(F$)<>0 THEN LSET A2$=F$
265 PRINT "ZIP CODE: /";ZP$;"/";: INPUT F$: IF LEN(F$)<>0 THEN LSET ZP$=F$
266 II%=3: GOSUB 2000   ' .. RESTORE UPDATED RECORD
268 PRINT " ": GOTO 250
270 RETURN
1995 '
1996 ' -----------------------------------------------------------------
1997 ' -  FILE MANAGEMENT SUBROUTINES (II%,MX%,F1$,A$,PT%,PT$, NX%,RC%)  -
1998 ' -----------------------------------------------------------------
1999 '
2000 RC%=0: IF II%<1 OR II%>8 THEN RC%=1: RETURN
2001 IF II%=1 THEN 2006:  ' ELSE STORE VARIABLES USED BY SUBROUTINES
2004 ZZ%(1)=J%: ZZ%(2)=JJ%: ZZ%(3)=K%:ZZ%(4)=LO%: ZZ%(5)=HI%; ZZ%(6)=Z%
2005 '
2006 ON II% GOSUB 2035,2080,2090,2100,2150,2200,2250,2280
2007 '
2008 IF II%=1 THEN 2010:  ' ELSE RESTORE VARIABLES USED BY SUBROUTINES
2009 J%=ZZ%(1): JJ%=ZZ%(2): K%=ZZ%(3): LO%=ZZ%(4): HI%=ZZ%(5): Z%=ZZ%(6)
2010 RETURN
2034 REM --- (1) SUBROUTINE (MX%,F1$) --- INPUT POINTERS AND KEYS
2035 IF MX%<1 THEN RC%=1: RETURN
2037 MR%=(INT((MX%+2)/64)+1)*64
2038 DIM PT$(64),PT%(MR%),KE$(MX%),ZZ%(8)
2040 OPEN "R",#1,UA$+":"+F1$,128  ' INDEX FILE
2042 FOR J%=1 TO 64: FIELD #1,(J%-1)*2 AS DU$, 2 AS PT$(J%): NEXT J%
2050 K%=0: IF LOF(1)=0 THEN 2062
2051 FOR J%=1 TO INT(MR%/64)
2052 GET 1,J%  ' .. INPUT RECORD CONTAINING 64 POINTERS
2054 FOR JJ%=1 TO 64: K%=K%+1: PT%(K%)=CVI(PT$(JJ%)): NEXT JJ%
2055 NEXT J%
2056 '
2057 IF PT%(MR%)=0 THEN 2062
2058 FOR J%=1 TO PT%(MR%)+PT%(MR%-1)
2059 GET 2, J%: KE$(J%)=KY$
2060 NEXT J%
2062 RETURN
2079 REM --- (2) SUBROUTINE (MR%,A$, RC%) -- ADD RECORD TO FILE
2080 GOSUB 2500 : IF K%>0 THEN RC%=1: GOTO 2088
2083 GOSUB 2520 : IF Z%>MR%-1 THEN RC%=2: GOTO 2088
2085 K%=-K%:GOSUB 2540   ' .. INSERT POINTER . PT%(K%)=Z%
2086 KE$(Z%)=A$
2087 PUT 2,Z% ' .. STORE NEW RECORD
2088 RETURN
2089 REM -- (3) SUBROUTINE --- REWRITE RECORD
2090 GOSUB 2500: IF K%<0 THEN RC%=1: GOTO 2098
2092 PUT 2,PT%(K%)   ' .. STORE RECORD
2098 RETURN
2099 REM --- (4) SUBROUTINE (MR%,A$,RC%) --- DELETE A RECORD
2100 GOSUB 2500: IF K%<0 THEN RC%=1: GOTO 2110
2102 Z%=PT%(K%): IF K%=PT%(MR%) THEN 2107
2104 FOR J%=K% TO PT%(MR%)-1: PT%(J%)=PT%(J%+1): NEXT J%
2107 JJ%=PT%(MR%-1)
2108 PT%(PT%(MR%))=0: PT%(MR%)=PT%(MR%)-1: PT%(MR%-1)=JJ%+1:PT%(MR%-2-JJ%)=Z%
2110 RETURN
2149 REM --- (5) SUBROUTINE (MR%,A$,NX%,RC%) --- READ RECORD BY KEY
2150 GOSUB 2500: IF K%<0 THEN RC%=1: GOTO 2155
2152 GET 2,PT%(K%)    ' .. INPUT RECORD
2153 NX%=K%
2155 RETURN
2199 REM --- (6) SUBROUTINE (MR%,NX%,RC%) --- READ RECORD BY SEQUENCE
2200 IF NX%<0 OR NX%>PT%(MR%) THEN RC%=1: GOTO 2205
2203 GET 2, PT%(NX%)
2205 RETURN
2249 REM --- (7) SUBROUTINE (MR%) --- RESTORE POINTERS
2250 K%=0: Z%=INT((PT%(MR%)-1)/64)+1
2252 FOR J%=1 TO Z%
2253 FOR JJ%=1 TO 64: K%=K%+1:LSET PT$(JJ%)=MKI$(PT%(K%)): NEXT JJ%: PUT 1,J%
2254 NEXT J%
2255 K%=INT(MR%/64): IF Z%=K% THEN 2259
2257 K%=(K%-1)*64: FOR J%=1 TO 64: LSET PT$(J%)=MKI$(PT%(J%+K%)):NEXT J%:PUT 1,
 INT(MR%/64)
2259 RETURN
2279 REM --- (8) SUBROUTINE -- DISPLAY FILE STATISTICS
2280 PRINT " ":IF PT%(MR%)=0 THEN PRINT "** NO RECORDS IN FILE": GOTO 2290
2282 PRINT "    ** FILE STATISTICS **": PRINT " "
2283 PRINT "  1. RECORDS IN FILE: ";PT%(MR%)
2284 PRINT "  2. DELETED RECORDS: ";PT%(MR%-1)
2285 PRINT "  3. LOWEST  KEY: ";KE$(PT%(1))
2286 PRINT "  4. HIGHEST KEY: ";KE$(PT%(PT%(MR%)))
2287 PRINT " "
2290 RETURN
2498 '
2499 REM --- SUBROUTINE (MR%,A$, K%) -- BINARY SEARCH
2500 IF PT%(MR%)=0 THEN K%=-1: RETURN
2502 LO%=0: HI%=PT%(MR%)+1
2504 M%=INT((LO%+HI%)/2)
2505 IF A$=KE$(PT%(M%)) THEN K%=M%: GOTO 2510
```

(continued)

```
2506 IF A$>KE$(PT%(M%)) THEN LO%=M%: ELSE HI%=M%
2508 IF LO%+1 <> HI% THEN 2504 ELSE K%=-HI%
2510 RETURN
2518 '
2519 REM -- SUBROUTINE (MR%,PT%,Z%) -- LOCATE FREE RECORD IN DATA FILE
2520 IF PT%(MR%-1)=0 THEN Z%=PT%(MR%)+1: GOTO 2530
2522 J%=PT%(MR%):JJ%=PT%(MR%-1)
2524 Z%=PT%(MR%-1-JJ%): PT%(MR%-1)=PT%(MR%-1)-1: PT%(MR%-1-JJ%)=0
2530 RETURN
2538 '
2539 REM -- SUBROUTINE (MR%,K%,Z%) -- INSERT POINTER INTO POINTER VECTOR
2540 IF K%=PT%(MR%)+1 THEN 2548
2542 FOR J%=PT%(MR%)+1 TO K%+1 STEP -1
2544 PT%(J%)=PT%(J%-1)
2545 NEXT J%
2548 PT%(K%)=Z%: PT%(MR%)=PT%(MR%)+1
2550 RETURN
2997 ' ------------------------------------------------------------------
2998 ' -                    PROGRAM TO INITIALIZE INDEX FILE                    -
2999 ' ------------------------------------------------------------------
3000 PRINT " ":PRINT TAB(5);"** INITIALIZE INDEX FILE **":PRINT " "
3001 INPUT "> DRIVE TO CONTAIN DATA";UA$
3002 INPUT "> FILE NAME";F$
3004 INPUT "> MAXIMUM NUMBER OF RECORDS FILE WILL HOLD";MX%
3006 MR%=(INT((MX%+2)/64)+1)*64
3008 DIM PT$(64)
3009 '------------------------- OPEN FILE AND SET POINTERS TO 0
3010 OPEN "R",#1,UA$+":"+F$,128
3012 FOR J%=1 TO 64: FIELD #1,(J%-1)*2 AS DU$,2 AS PT$(J%):NEXT J%
3014 ZR$=MKI$(0): FOR J%=1 TO 64: LSET PT$(J%)=ZR$: NEXT J%
3015 '------------------------- STORE BLOCKS OF ZERO POINTERS
3016 FOR J%=1 TO MR%/64
3018 PUT 1,J%
3020 NEXT J%
3022 PRINT " ": PRINT "   INITIALIZATION COMPLETE ON DRIVE";UA$
3025 END
```

deleted: A pointer is set up indicating that the space can now be used for storing a new record.

Parameters: II%=4, A$=key of record to delete.

5. Read Record by Key allows the record with the specified key to be read from the data file. This routine also returns the relative key sequence of the record in the variable NX%. This means, for example, that if the key value is the lowest in the file, NX% is set to 1.

Parameters: II%=5, A$=key of record to read, NX%=key sequence.

6. Read Relative Record reads the *n*th record—based on key sequence—in the file. For instance, if you want to read the record with the lowest key, set NX% to 1 and call this routine. Conversely, to read the record with the highest key value, set NX% to the number of records in the file before calling.

Parameters: II%=6, NX%=relative position of record to be read.

7. Store Index writes the values of the vector PT% back into the index file and must be called after records have been added or deleted. If these operations occur and the program ends without calling this routine, all your changes will be lost.

Parameters: II%=7.

8. Display File Statistics prints the following file information on the screen:

1. RECORDS IN FILE:
2. DELETED RECORDS:
3. LOWEST KEY:
4. HIGHEST KEY:

Parameters: II%=8.

A SAMPLE PROGRAM

To illustrate the use of these SKAM routines, let's consider a simple program for maintaining employee records (see listing 1). It uses a social security number as the key field for each record. [*Editor's note: Listing 1, which runs on* IBM PC*–compatible machines using* BASIC, *is available in a variety of formats; see the insert card following page* 368.]

The listing consists of three sections: (1) lines 1–270 are the sample program; (2) the SKAM routines are in lines 2000–2550; and (3) a short program to build and initialize the index file begins at line 3000. Referring to tables 2 and 3, let's look at the most important features of the code.

Any program using the SKAM routines must take care of some overhead:

(continued)

Table 2: *Description of the employee record-keeping program by* BASIC *code numbers.*

Lines	Description
16, 17	The data file is opened and its format defined. This file must be opened as logical file 2, and the variable used for the key (social security number in this case) must be KY$.
25	MX% is set to the maximum number of records to be contained in the data file, and F1$ is assigned the name of the index file. This information must be the same as that used in the index-file-initialization program.
30	A call is made to the file management routines to set up the data structure. The subroutines will allocate the vectors PT% and KE$ and read pointers and keys into them.
100–270	The subroutines in the sample program that direct the file maintenance operations on the employee file. By calling the appropriate SKAM routines, they provide an example of how to add, delete, and list records.

Table 3: *Description of the* SKAM *subroutines and index-file-initialization program by* BASIC *code numbers.*

Lines	Description
2000–2010	The control section of the file management routines that stores locally used variables and calls the desired routine.
2035–2062	Subroutine to input pointers from the index file and store them in vector PT% and to read keys from the data file and store them in KE$.
2080–2088	Subroutine to add a new record to the data file. It calls routines to insert the new pointer and locate a free space in the data file. The new record is stored in this location.
2090–2098	Subroutine to rewrite a record to the data file.
2100–2110	Subroutine to delete a record. The pointer to the record to be deleted is located and moved to the section in PT% containing pointers to deleted space.
2150–2155	Subroutine to retrieve a record with key value in A$.
2200–2205	Subroutine to retrieve a record based on its position in ascending key sequence. NX% contains the relative position.
2250–2259	Subroutine to write pointers in PT% back to the index file.
2280–2290	Subroutine to display certain file statistics.
2500–2510	Binary search routine. Using the pointers in PT%, the vector KE$ is searched to find a key matching A$. If a match is found, K% is set to the location in PT% pointing to the matched key; if no match, K% is set to the negative value of the location in PT% where it would be inserted.
2520–2530	Subroutine to locate the next free physical record in the data file. If any records have been deleted, it uses the space from the last one deleted; if there are no deleted records, the next position at the end of the file is used.
2540–2550	Inserts a pointer to a new record in PT%. The pointer is placed at PT%(K%), and all pointers above it are shifted up one position.
3000–3025	The program to create and initialize the index file. The size of the file is determined by the number of records the data file is to contain. For each 64 data records, one block of pointers is allocated in the index file. Additionally, there must be space at the end of this file for keeping count of the number of deleted and active records.

- The data file must be opened as logical file 2 (line 16).
- Variable KY$ must be defined as the key (line 17).
- Variables MX% and F1$ must be set to the maximum number of records in the file and the index filename, respectively.
- The SKAM routines must be called with II% set to 1 in order to initialize the data structure (line 30).

Four variables, KE$, PT%, PT$, and ZZ%, must be reserved for use by the file management routines. To minimize the number of reserved variables, the routines store all other locally used variables in vector ZZ% when the code is entered (line 2004) and restore them upon exit (line 2009).

The file management section stresses a modular, easily understood design. The sample program invokes this section by setting II% to the number of the desired operation and executing GOSUB 2000. In line 2006 the controlling section passes control to the required subroutine. A return code in variable RC% indicates the status of the operation.

Prior to using the SKAM routines, you must run the short initialization program shown at line 3000. This program asks for the filename and number of records to be contained in the data file. It then creates the index file and initializes the pointers. Note that if you give the name of an existing index file, the program will write over the old index.

CONCLUSION

For programs requiring single-keyed access to a file, I have found these routines to be an effective, timesaving approach to file I/O. I maintain the code in a software library and append it to programs needing keyed access, such as payroll, general ledger, and membership programs. At less than 100 lines of code, I think the routines offer one of the easier ways to begin accessing records by key values.

[*Editor's note: The keyed-access filing routines presented here are in* BASIC. *For a similar treatment of this method implemented in Pascal, see Bruce Webster's "A Simple File-Indexing Scheme" in the June* BYTE.] ■

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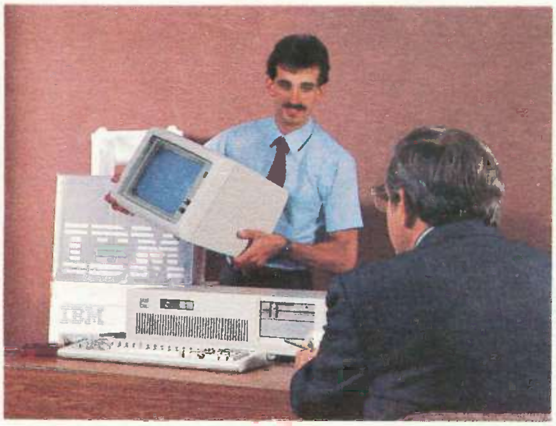

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REAL TIME UNDER REAL PASCAL

Two ways to interface a machine language routine to Pascal

Some critics of Pascal have complained about its inability to communicate with machine language or assembly language routines. If you need to do real-time or real-world programming in a Pascal environment, then access to the real machine is essential. Many Pascals have extensions that do allow such un-Pascal-like goings-on. For example, Apple, Microsoft, and DEC Pascals all provide tools that let you get at the guts of your machine. With such tools, it is not all that difficult to gain access to the real machine if you understand how variables and data are transferred from one procedure to another within a Pascal environment.

Let's say that you want to do some signal processing on data coming in from the outside to an Apple II. For example, you might want to analyze an audio signal to see what its power spectrum is. The data is available through a machine-specific device—an analog-to-digital converter (ADC) board. To find out what the power spectrum is, you have to gather the data and analyze and display the results. One numerical tool for analyzing and displaying these results is a fast Fourier transform, which is an efficient algorithm for finding the Fourier series that best characterizes a finite sample of a waveform. If you were writing the FFT program, you would most certainly want to do it in a high-level language. For this particular application, you might also have some filtering to do, so you would have to perform still other procedures for signal conditioning. You might want to see the results of such analysis as a graph, so you would use graphing routines. Note that you can perform all these functions using Pascal procedures. In other words, the signal is to come from the outside world, but everything else is to be done in the computationally comfortable higher-level language.

To feed the FFT routine, you want a set of 256 equally spaced samples of a real signal. You probably want to be able to control both the spacing and the source of the signal, and you want that frame of points available for direct processing in Pascal. If it is given that V1 is the name of the array to contain the 256 samples, CHANNEL is an integer that indicates where you would like your signal to come from, DELAY is another integer that specifies how long it is between samples, and FRAME is the name of your assembly language routine, then there are two ways you might proceed in constructing the interface between Pascal and assembly language. One way is to define the procedure FRAME with parameters CHANNEL and DELAY transferred by value and V1 transferred by address. You would call the assembly language routine as follows:

```
FRAME (CHANNEL, DELAY, V1);
```

(For an explanation of the terms "transfer by value" and "transfer by address," see the text box "The Communication Problem" on page 146.) The other way is to make all variables global so that both Pascal and assembly language can access them directly by name. The call to the assembly language routine would simply be FRAME without any parameters.

Figure 1 shows the relationship between the several segments of the

(continued)

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THE COMMUNICATION PROBLEM

There are two ways for a Pascal procedure to communicate with other routines: through a "transfer by address" or a "transfer by value." The difference between these calls is similar to the difference between giving someone an original document and giving him or her a photocopy. For example, in the procedure definition

PROCEDURE EXAMPLE(X,Y: INTEGER; VAR U,V:INTEGER)

the values of X and Y are transferred by value to the procedure and, therefore, any change that EXAMPLE makes in them is not returned to the calling routine. However, having the keyword VAR precede the variables U and V causes the address of the variables to be transferred; it does not cause the variables to be copied. Any change that the procedure EXAMPLE makes in U and V will change corresponding variables in the calling routine.

Listing A: *This program demonstrates the difference between transfer by data and transfer by address.*

```
PROGRAM TRANSFER;
TYPE Q = ARRAY [0..19] OF INTEGER;

VAR  N : INTEGER;
     J,K : Q;

PROCEDURE CHANGE(P:Q; VAR L:Q);

  VAR N : INTEGER;

  BEGIN
    FOR N := 1 TO 10 DO P[N] := 2;
    FOR N := 1 TO 10 DO L[N] := 2;
    WRITE('P) ');
    FOR N := 0 TO 19 DO WRITE(P[N]:3);
    WRITELN;
    WRITE('L) ');
    FOR N := 0 TO 19 DO WRITE(L[N]:3);
    WRITELN; WRITELN;
    WRITE('J) ');
    FOR N := 0 TO 19 DO WRITE(J[N]:3);
    WRITELN;
    WRITE('K) ');
    FOR N := 0 TO 19 DO WRITE(K[N]:3);
    WRITELN;
  END;

BEGIN { MAIN }
  FOR N := 0 TO 19 DO J[N] := 0;
  FOR N := 0 TO 19 DO K[N] := 3;
  WRITE('J) ');
  FOR N := 0 TO 19 DO WRITE(J[N]:3);
  WRITELN;
  WRITE('K) ');
  FOR N := 0 TO 19 DO WRITE(K[N]:3);
  WRITELN:WRITELN;
  CHANGE(J,K);
  WRITELN;WRITELN;
  WRITE('J) ');
  FOR N := 0 TO 19 DO WRITE(J[N]:3);
  WRITELN;
  WRITE('K) ');
  FOR N := 0 TO 19 DO WRITE(K[N]:3);
END.
```

program. The Pascal user is unaware of the stack, and so is the programmer who shares global variables between the assembly language routine and Pascal. However, in the procedure that passes variables through the call, a copy of CHANNEL and DELAY and the address of the first byte in the array (V1) are pushed onto the stack just prior to the transfer of control to FRAME. FRAME begins by pulling these three integers off the stack.

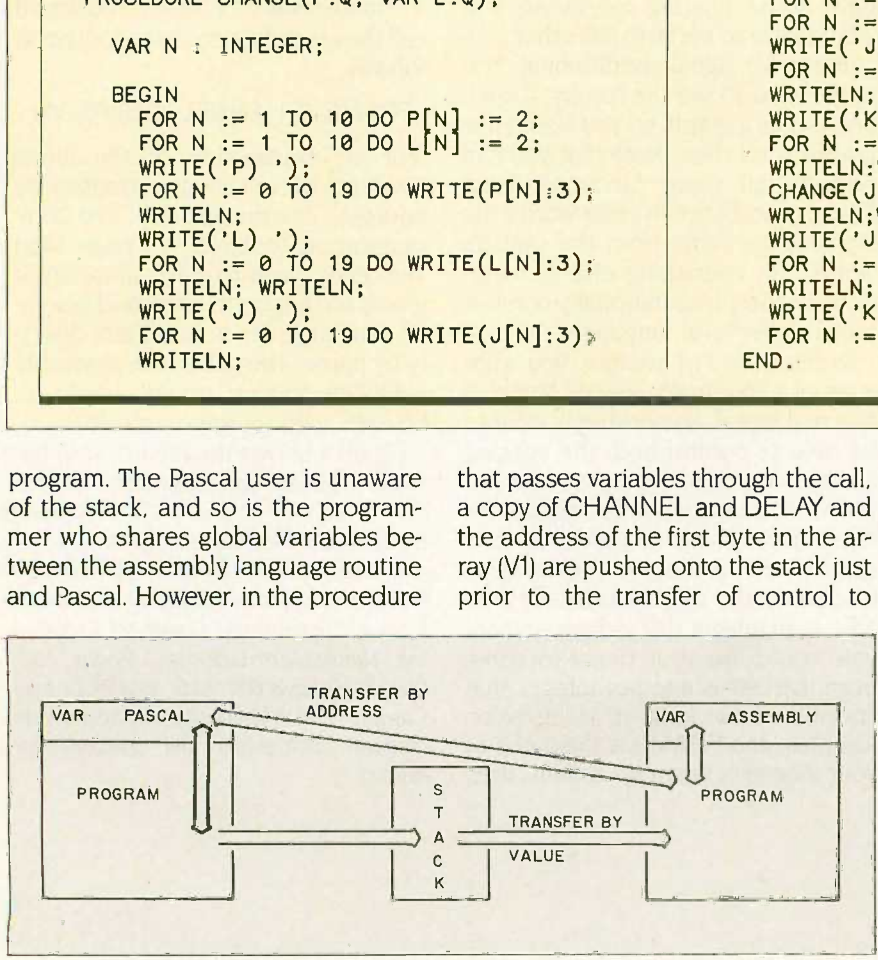

Figure 1: *The data-transfer routes. Direct use of global variables is shown, as well as a transfer of data through the procedure call that employs the stack as the transfer agent.*

I will first describe in detail the solution to the problem that passes parameters to the assembly language procedure on the stack. Then I will look at a side-by-side comparison of this method and the one that uses global variables.

[Editor's note: *The programs of listings 1, 2, and 3 are not meant to be run as such, since they require some specific hardware, but they are good illustrations of the techniques involved in interfacing machine language with Pascal. You can apply these techniques to your own problems.*]

THE UN-PASCAL PROCEDURE

The assembly language program written in Apple II TLA (The Last Assem-

This becomes a critical distinction when you are using structured data such as arrays or records. If data is transferred by value, the whole structure is copied over into a new area of memory. It doesn't take long to run out of memory this way, nor is it a good way to have a fast program. On the other hand, if you transmit the address of the structured data, it takes but one word (2 bytes) to know all about it, even if "it" is a huge, structured variable. All you transmit is the address of the first byte of the array.

Listing A and its accompanying output in figure A give a complete (if silly) demonstration of how the two types of transfer affect the "current" value of a variable. It is done with structured variables to show the details of that operation.

The first pair of rows in figure A are the original values of J and K, respectively. J is all 0s and K is all 3s. Then PROCEDURE CHANGE is called. It gets J as a transfer by value and K as a transfer by address. These become P and L in the procedure. Values 1 to 10 in P and L are changed. These two data vectors are then printed. Both have changed. Next, the global variables J and K are printed from the procedure, showing their current values. Note that J is still all 0s but K has now changed. In other words, CHANGE was able to act directly on K (and on J's clone, P), but it has no connection with J at all.

The last two lines are simply the final version of J and K written out by the main program. Note that J still retains its original values; K, of course, has been altered.

The observant reader will note that CHANGE did have access to J (and K) through the medium of global variables. After all, it printed them. Global variables also represent a transfer-by-address technique that differs only slightly in structure from what happened between K and L. With global variables, you have a public blackboard on which any routine can write and from which any routine can read. To use such a public facility, all users—readers and writers alike—must be constrained to using the blackboard in a prescribed manner. That means that every user must call the variables by the same name, that every user must know when another user is changing the data, and that if one user needs to fix the current value, a private copy of the public data must be made before some other user changes it.

```
The results of this program appear on the screen as:

J)  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
K)  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3

P)  0  2  2  2  2  2  2  2  2  2  2  0  0  0  0  0  0  0  0  0
L)  3  2  2  2  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3

J)  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
K)  3  2  2  2  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3

J)  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
K)  3  2  2  2  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3
```

Figure A: *The output from the program in listing* A.

bler) is shown in listing 1. It is not meant to be a superb lesson in assembly language programming, but rather an illustration of the transfer of data between Pascal and assembly language. Remember that the call to this program is FRAME (CHANNEL, DELAY, V1).

At the moment of transfer to FRAME, the stack will contain, in order, four 2-byte integers: the return address, the address of the first byte in V1, the value of DELAY, and the value of CHANNEL.

FRAME will first copy the four integers from the stack to local storage. Next it must set up for gathering data by entering the loop once to prime the ADC. Then FRAME will have to put the 256 values of data from the ADC into the appropriate locations in the Pascal data space and in standard integer format; data comes from the ADC as single bytes (XX) but must go to the P-machine as words (00XX). Finally, FRAME must return control to the calling routine.

The central point in this illustration is the connection to variables in the Pascal data space. Two words of data are transferred directly through the stack as well as two addresses. Each of these words is pulled in turn from the stack and stored at a local address. Then 256 bytes of data are gathered in TMP and transferred as words to the Pascal data space. (The data-collection and transfer functions are separated to make the loop faster.)

If you want to follow the assembly language program in detail, the following comments should be helpful. To span the full 256-word array, the local data pile is divided into two groups of 128 bytes. In the Pascal data space the address for the first 128 words runs from VX to VX+FF (hexadecimal) in steps of 2; for the second group of 128 words, addresses range from VQ=VX+100 (hexadecimal) to VQ+FF (hexadecimal). Note that VQ is generated at the top of the program. Using indexing after acquiring an indirect address (post-indexed indirect), the 6502 processor, with its 1-byte index register, can span a block of 128 words. As illustrated in figure 2, the 256 bytes of data in TMP must

(continued)

Listing 1: *The assembly language routine* FRAME *used to illustrate the passage of parameters through the call statement from Pascal.*

```
;-----------------
.MACRO PULL
;pulls a word off of the stack
;and stores it in location specified
;as in PULL RETURN.

 PLA
 STA %1          ;%1 means first argument of PULL
 PLA
 STA %1+1        ; the high-order byte of the word

.ENDM
;-------------------------------------------------

;-------------------------------------------------
.PROC FRAME,3
;the "3" means three words (6 bytes) of
;parameters (plus return address) will
;be on the stack.  LINKER will check
;agreement

;-------------------------------------------------
;FRAME GRABBER takes 256 8-bit data points and
;stores them in an array of bytes labeled TMP.
;After the data is grabbed, it is transferred
;to V1.  The delay between adjacent points is
;given by
;          t = 26.64 + 5*DELAY in microseconds.
;DELAY (<256) and CHANNEL (<16) are in the procedure
;call as FRAME(CHANNEL,DELAY,VX).

STOP    .EQU 0  ;Each of these sets aside 1 word of
CHANNEL .EQU 2  ;storage on page 0 (54 bytes
DELAY   .EQU 4  ;are available).
RETURN  .EQU 6
VX      .EQU 8
VQ      .EQU 0A ;space for (VX+100 hexadecimal)

        PULL RETURN     ;MACRO call pulls return address
                        ;off the stack and puts it in RETURN.
        PULL VX
        PULL DELAY      ;note that the order is the
                        ;reverse of the call's parameter list.
        PULL CHANNEL    ;at this point the transfer of
                        ;parameters through the stack is
                        ;complete.

        LDA VX          ;set contents of VQ
        STA VQ          ;to the address of
        CLC             ;VX + 100 hexadecimal
        LDA VX+1
        ADC #1
        STA VQ+1

        LDX #0FF        ;start with -1 (or 255) in index to
                        ;throw first datum away.
        STX STOP        ;put 255 in STOP just for first pass
                        ;to allow reading of 257 values.
        LDY CHANNEL
        JMP START
LOOP    LDY #0          ;set end point after first passage
        STY STOP        ;to get the full 256 point list.
START   LDY CHANNEL
        LDA 0C0D0,Y     ;assumes slot 5.
```

(continued)

Global variables provide a public blackboard on which the current status of each variable is always available.

become 256 words (512 bytes) in the Pascal data space. A byte is taken from TMP and put into the low-order (LO) byte of the appropriate element of the integer array in the Pascal data space. Then 00 (hexadecimal) is put in the corresponding high-order (HO) byte. After that is done for the 256 samples, all that remains is to push the return address back onto the stack and execute a return from subroutine (RTS).

A macro is used for the repetitive task of pulling 2-byte integers off the stack. Note that locations must be set up to receive that data. I have chosen to put them into page 0 to make the code block as small as possible.

The first step is to cycle the ADC once to get meaningful data into the ADC data register. The data that is received on the first LDA is garbage and should be ignored. It is put into location TMP+FF (hexadecimal), which will be written over when the 256th good point is taken. The second step is to change STOP to let the standard loop slide over 0 as the loop is entered for the first time. This resetting of STOP is done every time around the loop to keep the loop length identical. Note that the first good piece of data (from the second call to the ADC) goes into location TMP+0 and that a total of 256 equally spaced, good data points will be taken, the last going into TMP+FF (hexadecimal).

THE GLOBAL ALTERNATIVE

As I mentioned before, you have the option of using global variables. While this method is not generally recom-

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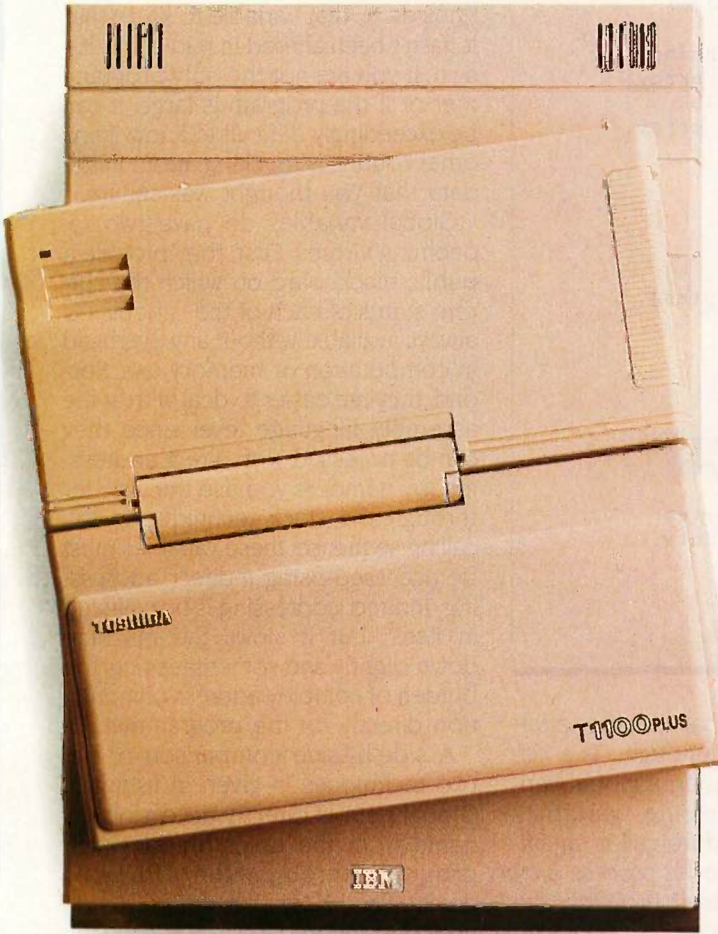

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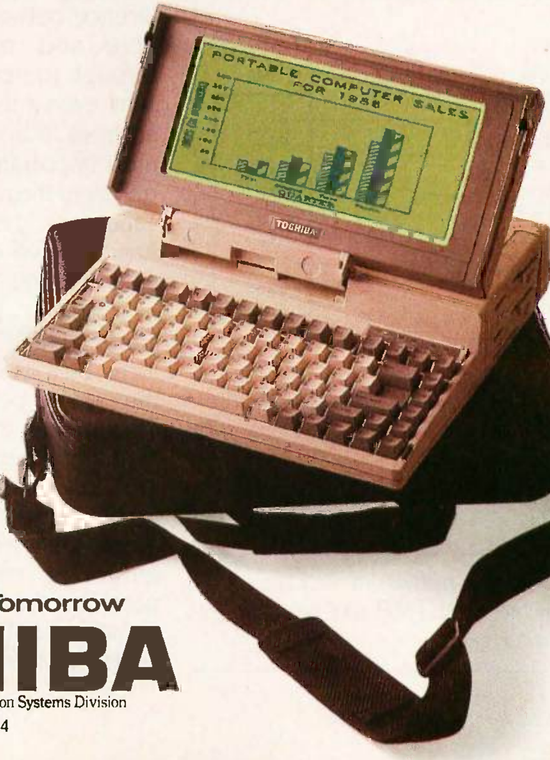

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```
        STA TMP,X
        INX
        LDY DELAY
INNER   DEY             ;delay loop runs 1 or more times.
                        ;0 would give 256 cycles.
        BNE INNER
        CPX STOP
        BNE LOOP
        LDY #0          ;Set up to load results into V1.
        LDX #0
        LDA #80         ;80 hexadecimal or 128 decimal
        STA STOP
AGAIN   LDA TMP,X       ;take a byte from the beginning
        STA (VX),Y      ;put it LO at beginning of array
        LDA TMP+80,X    ;take a byte from the middle.
        STA (VQ),Y      ;put it in LO at middle of array.
        INX             ;counting by bytes in TMP
        INY
        LDA #0          ;high order byte is 0
                        ;with this 8-bit ADC.
        STA (VX),Y
        STA (VQ),Y
        INY             ;counting by integers (2 bytes).
        CPX STOP
        BNE AGAIN
        LDA RETURN+1    ;Set up for return.
        PHA
        LDA RETURN
        PHA             ;return address is back on stack
        RTS             ;back to the calling routine.

TMP     .BLOCK 256,0    ;this is just a block of bytes
                        ;for temporary storage of data.
.END
```

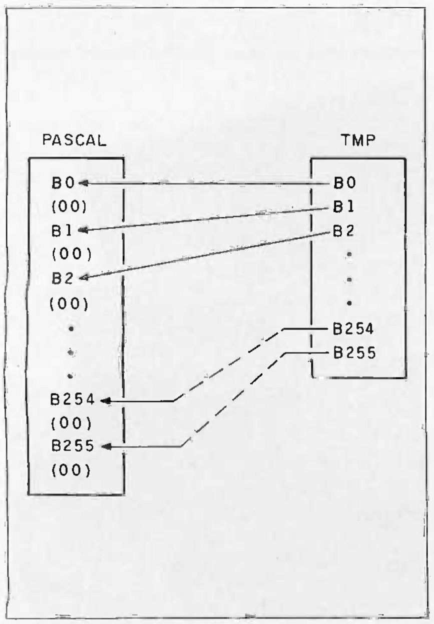

Figure 2: *The relationship between bytes in the array* TMP *and words in Pascal data space.*

mended, the global-variable alternative works well enough. The difference between using a global variable and transferring variables through the procedure call is significant, even if the transfer process is by address in both cases. Probably the most important difference is that, with transfers through the call, neither the caller nor the person being called has any idea of what the other uses as the name of the variables. The caller says, "Load your 256 points starting HERE." HERE is an address. It can be a different address each time the person being called is accessed. That makes the two procedures essentially independent of each other. The only thing that must be common is the agreed-upon transfer statement—the interface. For Pascal, the interface is the list of parameters passed in the call and the set of global variables defined for that program segment. If no global variables are employed, the procedure or function is almost independent of its surroundings.

However, there is a hidden dependence that shows up only if the called routine calls yet another routine and then another, and so on. If the subsequent routine has access to the same data, the first routine must know what the second and any subsequent routines do to that variable to know that it hasn't been altered in mid-computation. If you are not the only programmer or if the program is large, it can be exceedingly difficult to know if any other routine is mucking about in the data that you thought was secure.

Global variables do have two redeeming virtues. First, they provide a public blackboard on which the current status of each of the variables is always available without any overhead in computation or memory use. Second, they are easier to deal with at the assembly language level since they can be accessed with direct addressing (by name). If you use the transfer through the stack technique in the calling sequence, these variables must be accessed using indirect addressing. Indirect addressing is not difficult in itself, but it slows the machine down slightly and sometimes puts the burden of complex address computation directly on the programmer.

A side-by-side comparison of the two techniques is given in listing 2. Global data is directly accessible by name from the assembly language program through the .PUBLIC declaration. Note that the right side uses post-indexed indirect addressing (i.e., the full 2-byte address is fetched from page 0 and then indexed), while the left uses indexing of an absolute address provided by the LINKER (i.e., the LINKER installs the appropriate 2-byte address directly into the instruction). The two sets of code look similar and, apart from an extra machine cycle for the indirect instruction, they do the same thing in the same number of instructions. However, note the additional instructions on the right that generate the address of the 128th word of V1 (or, more properly for the column on the right, whatever array was passed in the call).

(continued)

Listing 2: *A side-by-side comparison of the two methods for interfacing assembly language to Pascal. On the left is the method that uses* V1 *as a global array. On the right is the method that passes parameters through the call, as in* FRAME (CHANNEL, DELAY, V1). *Notice the extra lines of code required on the right to set up variables for indirect addressing.*

```
.PUBLIC V1,CHANNEL,DELAY              VX .EQU  8
                                      VQ .EQU  10
             .
             .                              .
                                            .
                                          Pull VX
                                            .
             .
             .                              .
                                          LDA VX
                                          STA VQ
                                          CLC
                                          LDA VX+1
                                          ADC #1
             .                            STA VQ+1
             .
                                            .
                                            .
      LDY #0                              LDY #0
      LDX #0                              LDX #0
      LDA #80                             LDA #80
      STA STOP                            STA STOP
AGAIN LDA TMP,X                     AGAIN LDA TMP,X
      STA V1,Y                            STA (VX),Y
      LDA TMP+80,X                        LDA TMP+80,X
      STA V1+100,Y                        STA (VQ),Y
      INX                                 INX
      INY                                 INY
      LDA #0                              LDA #0
      STA V1,Y                            STA (VX),Y
      STA V1+100,Y                        STA (VQ),Y
      INY                                 INY
      CPX STOP                            CPX STOP
      BNE AGAIN                           BNE AGAIN
```

Listing 3: *The Pascal program that uses the version of the assembly language routine* FRAME *that passes parameters on the stack.*

```
PROGRAM GRABBER;

  USES NUMBER;  { library that contains a
           numerical entry routine, INTIN

  TYPE INTRAY = ARRAY [0..255] OF INTEGER;

  VAR L,M,N,K,DELAY,CHANNEL : INTEGER;
      V2,V1 INTRAY;
      VOLTS : ARRAY [0..255] OF REAL;
      A : REAL;
      PRINTFILE : TEXT;
```

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```
  PROCEDURE FRAME(DELAY,CHANNEL : INTEGER;
                  VAR VX : INTRAY); EXTERNAL;

  PROCEDURE DUMP;  {prints out the data}

    VAR K,M,N : INTEGER;

    BEGIN
    WRITELN(PRINTFILE);
    FOR K := 0 TO 15 DO BEGIN
      FOR M := 0 TO 15 DO BEGIN
        N := K * 16 + M;
        WRITE(PRINTFILE,VOLTS[N]:5:2,' ');
        END;
      END;
    WRITELN(PRINTFILE);
    WRITELN(PRINTFILE);
    WRITELN(PRINTFILE);
    END;

BEGIN {main}
REWRITE(PRINTFILE,'PRINTER:');  {open and output file}
WRITELN(CHR(12));   {clear screen; get DELAY and CHANNEL}

REPEAT
  GOTOXY(0,5);
  WRITELN('Enter delay as integer (1..256) in steps of');
  WRITE('5 microseconds from minimum of 26 microseconds:');
  DELAY := INTIN;
  IF (DELAY<0) OR (DELAY>255) THEN
    WRITE('DELAY OUT OF RANGE');
UNTIL (DELAY>-1) AND (DELAY < 256);

WRITE(CHR(12));  {erases error message}

REPEAT
  GOTOXY(0,5);
  WRITE('Enter channel number 0..15): ');
  CHANNEL := INTIN;
  IF (CHANNEL<0) OR (CHANNEL>15) THEN
    WRITE('CHANNEL out of range.  Reenter ');
UNTIL (CHANNEL>-1) AND (CHANNEL < 16);

A:= 1.25.5;
WRITELN(CHR(12));   {clears screen}
GOTOXY(0,5);
WRITELN('FRAME GRABBER STARTING');
WRITELN;
FRAME(CHANNEL,DELAY,V1);  {the first call to FRAME.}
WRITELN(CHR(12));   {clears screen}

REPEAT
  GOTOXY(0,5);
  WRITELN('Enter delay as integer (1..256) in steps of');
  WRITE('5 microseconds from  minimum of 26 microseconds:');
  DELAY := INTIN; {DELAY is 5 microseconds}
  IF (DELAY<0) OR (DELAY>255) THEN
    WRITE('DELAY out of range');
UNTIL (DELAY>-1) AND (DELAY<256);

WRITE(CHR(12)); {erases error message}
GOTOXY(0,5);
WRITELN('FRAME GRABBER STARTING');
WRITELN;
FRAME(CHANNEL,DELAY,V2);
WRITELN('Converting data to REAL.');
FOR N:= 0 TO 255 DO BEGIN
```

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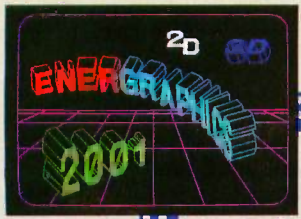

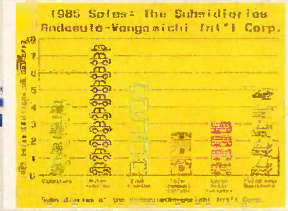

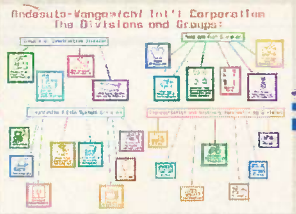

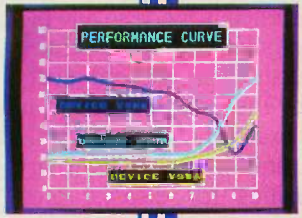

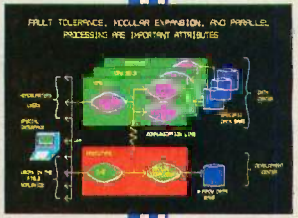

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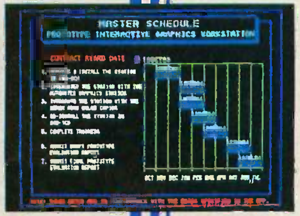

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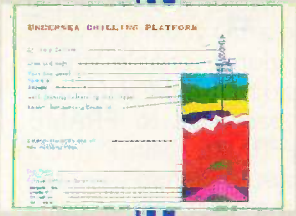

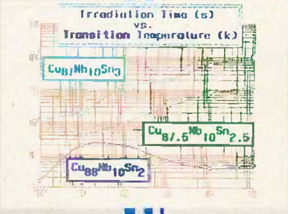

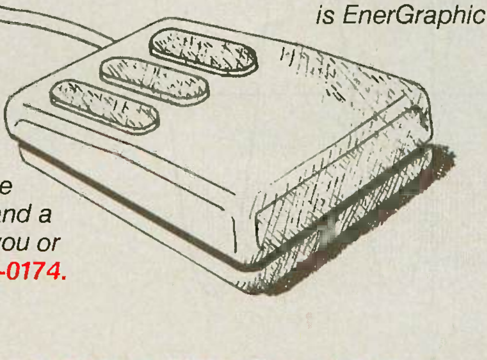

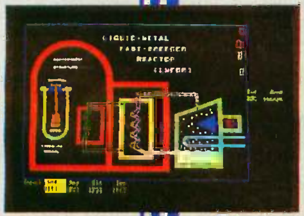

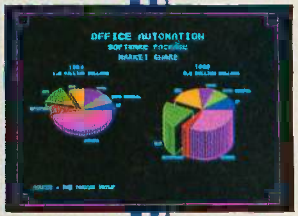

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```
    VOLTS[N] := V1[N];          {convert to REAL}
    VOLTS[N] := A*VOLTS[N]-5;   {change to volts}
    END;
  DUMP;
  FOR N := 0 TO 255 DO BEGIN
    VOLTS[N] := V2[N];          {convert to REAL}
    VOLTS[N] := A*VOLTS[N]-5;   {change to volts}
    END;
  CLOSE(PRINTFILE;
  END.
```

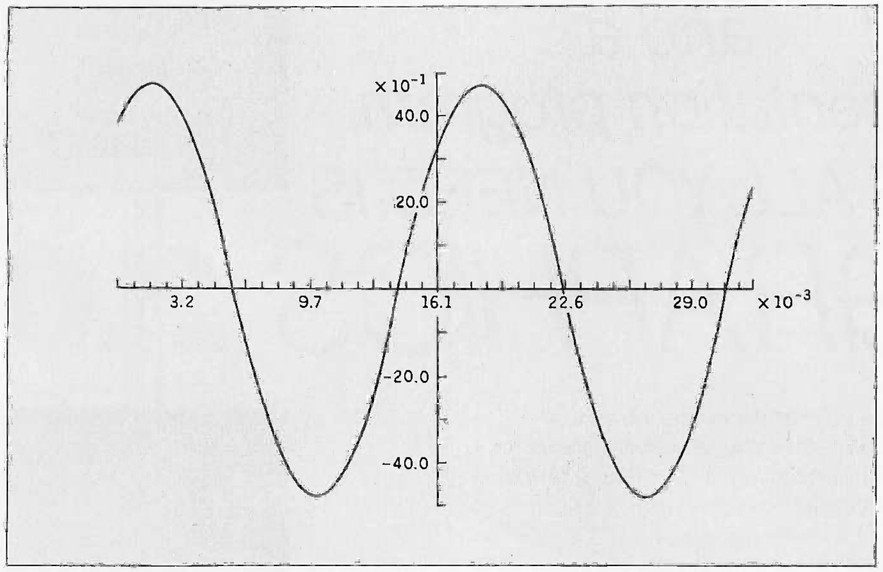

Figure 3: *The graph of the data taken from the* ADC *with* DELAY = 6 (*hexadecimal*).

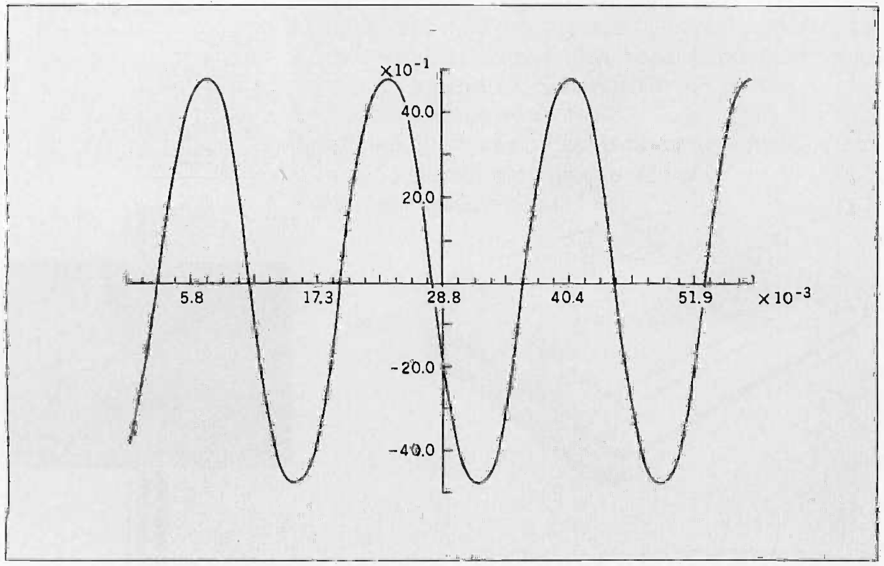

Figure 4: *The graph of the data taken from the* ADC *with* DELAY = 20 (*hexadecimal*).

On the left, you need only write V1+ 100 (hexadecimal) to have that address of the 128th word of V1.

Let me stress that in assembly language no reference is made in any of this data manipulation to data structure. Any structure that is there must be handled by the programmer. You have to know exactly how the data will be arranged, and if you do it wrong the opportunities for disaster are boundless.

For example, structured arrays of integers are arranged sequentially in memory. Each integer is distributed over two bytes with the low-order part of the integer in the byte at the lower address. This means the LO byte of integer #2 is the third byte from the start of the list. The .PUBLIC statement or the transfer of address through the stack provides you with access to the LO byte in the array being referenced, whether the array is an array of 1 or 100. After that, the counting is all yours.

THE PASCAL PART

To complete the example, listing 3 is a simple Pascal program that uses the assembly language routine in listing 1. The program simply gathers two blocks of data and prints them out. Its purpose is to show how the call is made, that it actually works, and that the transfer by address through the stack does enable you to apply FRAME to any array you might want. Had I used a global variable array, I would have had to use the data I obtained from each call to FRAME before calling FRAME again. Figure 3 shows the sinusoid plotted from the data taken on a 60-Hz signal using GRABBER with DELAY = 6 (hexadecimal). Figure 4 shows the sine curve with DELAY = 20 (hexadecimal).

CONCLUSION

This application shows that for those rare circumstances in a high-level program where you must descend into the depths to achieve timing, communications, or any other operation where machine language is sine qua non, the makers of many Pascals have made it possible for you to do just that. ■

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- Windows libraries.
- Programmer's reference.
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System requirements:

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*hard disk recommended

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	Microsoft C 4.0	Lattice C 3.0	Computer Innovation C 2.3	Aztec C86 3.2	Wizard C 3.0
Sieve of Eratosthenes (register)	82.9	151.4	172.3	88.0	91.9
Copy Block	86.9	231.7	199.0	123.8	189.5

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- Keyboard or optional mouse support.
- Enter in familiar SYMDEB or DEBUG commands.

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you've ever seen.

both at the same time. Open a window to view CPU registers and flags. Watch local and global variables as well. All while your program is running.

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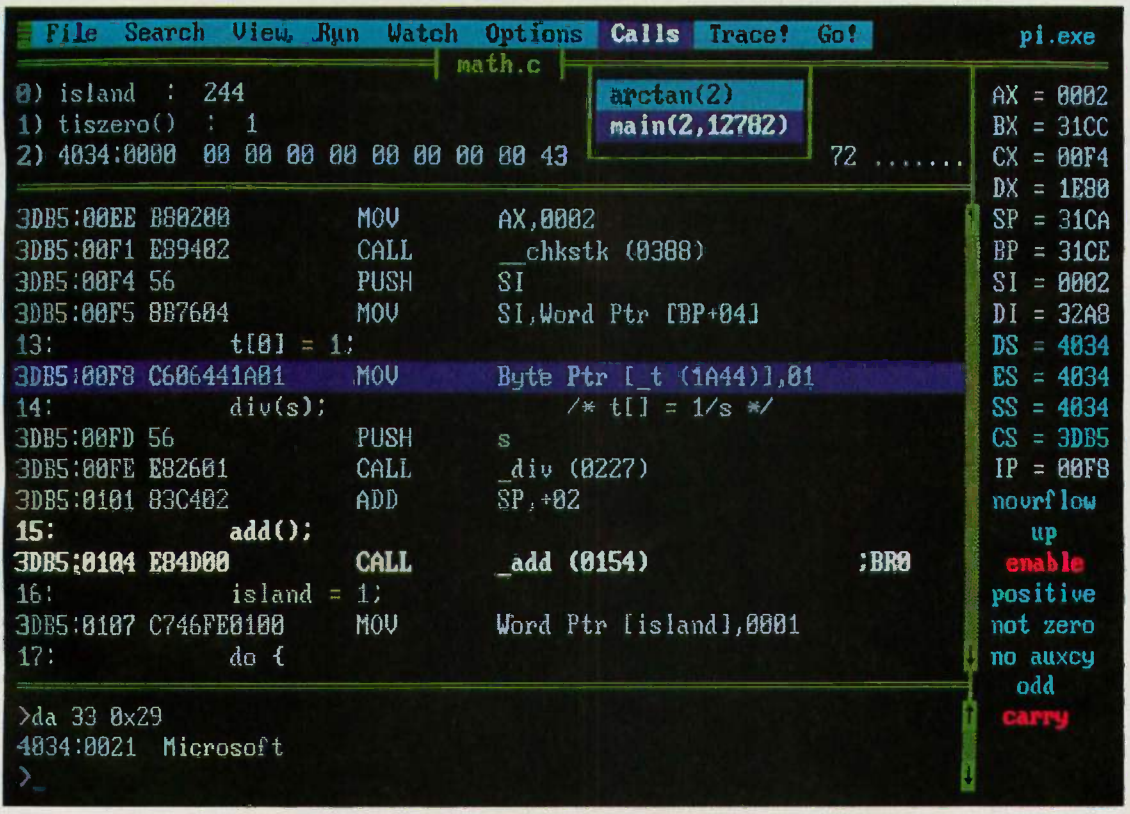

```
0) island    :  244                                   arctan(2)
1) tiszero()  :  1                                    main(2,12782)
2) 4034:0000  00 00 00 00 00 00 00 00 43                                72 ........

3DB5:00EE B80200          MOV       AX,0002                              AX = 0002
3DB5:00F1 E89402          CALL      __chkstk (0388)                      BX = 31CC
3DB5:00F4 56              PUSH      SI                                   CX = 00F4
3DB5:00F5 8B7604          MOV       SI,Word Ptr [BP+04]                  DX = 1E80
13:            t[0] = 1;                                                 SP = 31CA
3DB5:00F8 C606441A01      MOV       Byte Ptr [_t (1A44)],01              BP = 31CE
14:            div(s);                /* t[] = 1/s */                    SI = 0002
3DB5:00FD 56              PUSH      s                                    DI = 32A8
3DB5:00FE E82601          CALL      _div (0227)                          DS = 4034
3DB5:0101 83C402          ADD       SP,+02                               ES = 4034
15:            add();                                                    SS = 4034
3DB5:0104 E84D00          CALL      _add (0154)              ;BR0        CS = 3DB5
16:            island = 1;                                               IP = 00F8
3DB5:0107 C746FE0100      MOV       Word Ptr [island],0001               novrflow
17:            do {                                                         up
                                                                          enable
>da 33 0x29                                                              positive
4034:0021  Microsoft                                                     not zero
>_                                                                       no auxcy
                                                                           odd
                                                                          carry
```

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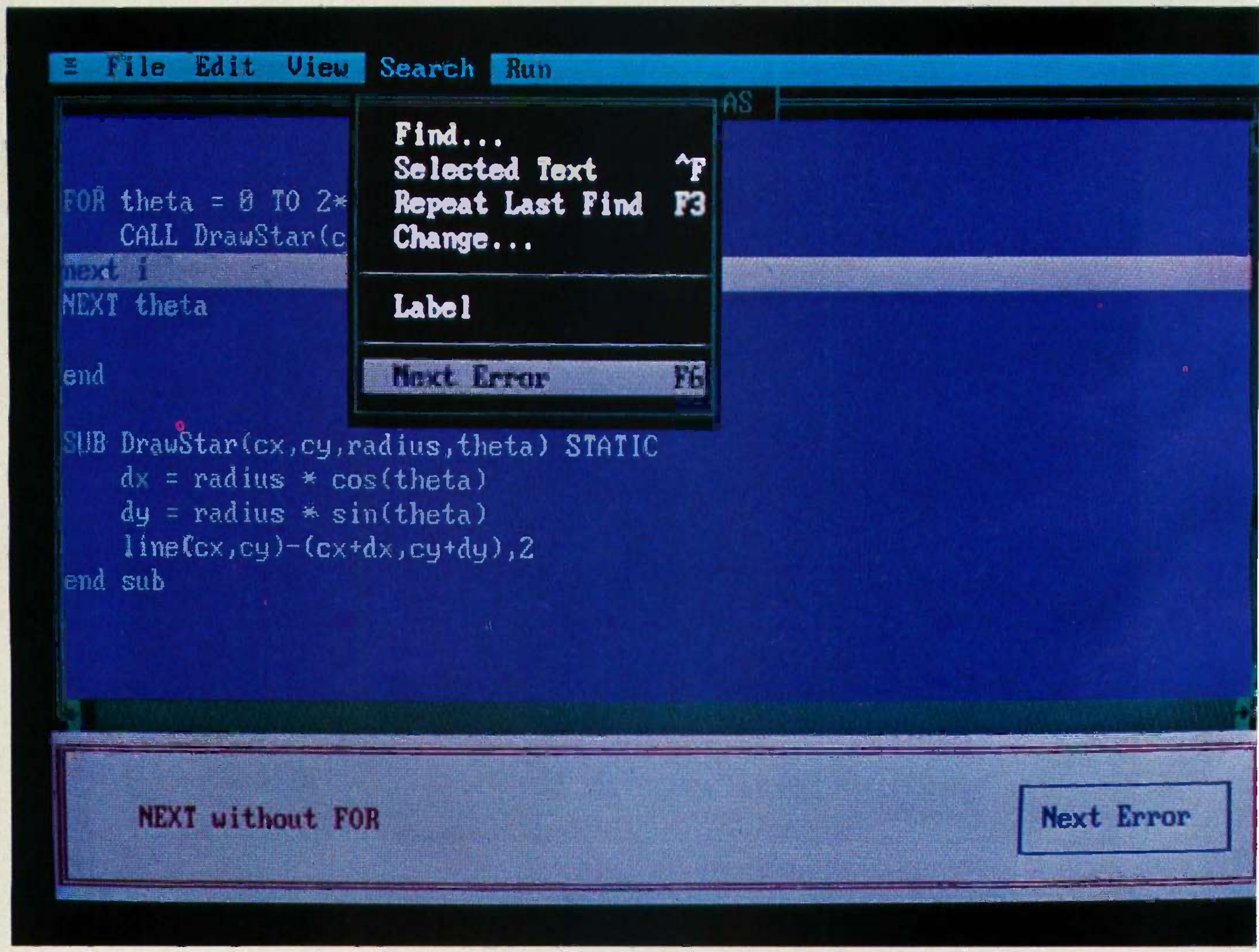

```
FOR theta = 0 TO 2*
    CALL DrawStar(c
next i
NEXT theta

end

SUB DrawStar(cx,cy,radius,theta) STATIC
    dx = radius * cos(theta)
    dy = radius * sin(theta)
    line(cx,cy)-(cx+dx,cy+dy),2
end sub
```

```
NEXT without FOR
```

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On the rare chance your program doesn't run 100% the first time out, we've got another surprise for you. The Microsoft QuickBASIC debugger. Our full-screen tracing lets you debug your programs while watching the source code execute. A line at a time, or with breakpoints. As easy as can be.

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Results of Sieve Benchmark	BASICA 3.1	Microsoft QuickBASIC 2.0
Seconds per iteration	78	0.52

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- Compile entirely in memory at speeds up to 6000 lines per minute. NEW!
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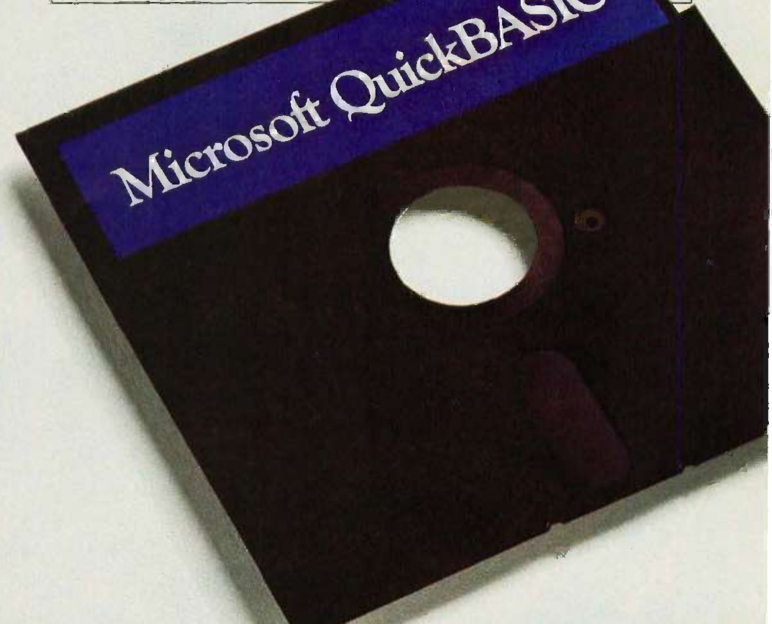

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68000 Machines

THE APPLE MACINTOSH GAVE US all a glimpse, back in February of 1984, of a glittering new future for personal computers. Many people had seen similar technology in the high-end workstations made by companies like Xerox, Apollo, and Sun. But these workstations were priced outside the range of the traditional personal computer; we drooled over them but didn't expect to be able to own one—until the Macintosh came along.

Soon after the Macintosh created a new wave of excitement in the personal computer world, Atari and Commodore began showing prototype machines that offered similar capabilities but with more power and at lower cost. Suddenly, it seemed that a new trend in personal computers was developing.

Inspection of the new machines, and many of the workstations they emulated, revealed a common component—a Motorola MC68000-series microprocessor. Closer investigation showed that the MC68000 had the horsepower and the easy programmability that lent itself to the creation of workstation-like machines. These machines had lots of memory, addressed linearly, and handled bit-mapped graphics with ease.

Many people began to see the MC68000 as an alternative to the Intel iAPX86-series microprocessor that powered the IBM PC–class machines. Today, there are avid MC68000 camps and equally avid Intel iAPX86 programmer cadres.

Sparked by all the interest in the new Commodore Amiga, the Atari ST series, and the Macintosh, BYTE began work on an extensive examination of the MC68000. Originally planning for a separate issue of the magazine, we put together a series of articles exploring the MC68000 and many of the machines it powers. Those articles make up this month's theme section and the continuing coverage of the MC68000 that will appear in our Features section over the next several months.

The coverage in the following pages includes a comparison of the entire MC68000 series by Motorola's Tom Johnson. There are, in fact, five different MC68000s, and Johnson explains what each is designed to do and, most important, how compatible they all are with each other.

In other articles, Mike Morton passes along some of the assembly language techniques he's acquired while helping to write software such as Lotus's Jazz for the Macintosh. Adam Webber shares some similar observations about the Macintosh and Amiga system software gleaned from his work in porting the True BASIC language to those two machines. A group of Hewlett-Packard engineers explains why the MC68000 is particularly well suited to the UNIX operating system. Mike Rothman explains the many faces of GEM and the other system software on the Atari ST. And Elaine Ditton and Richard Ditton look at writing animation software for the Amiga, the MC68000-based machine with the most raw computing power but also the rawest system software of the new wunderkind computers.

Follow-on articles in subsequent issues will include articles on debugging in an MC68000 environment, more assembly language programming techniques, and more advanced tutorials on the Atari ST, Amiga, Macintosh, and other MC68000 machines.

—G. *Michael Vose, Senior Technical Editor, Themes*


Color
AMIGA

68000 TRICKS AND TRAPS

BY MIKE MORTON

Some assembly language programming guidelines

THE ERA OF HIGH-LEVEL LANGUAGES has not made assembly language coding a dead art, even on modern microprocessors designed for executing compiled high-level code. Although personal computers are approaching the power of mainframes, the way to get the most out of any processor is to know when to use assembly language. The popular Motorola MC68000 processor is a good example; it has a fairly regular instruction set and instructions to support features of such languages as Pascal and C. Yet the instruction set is not perfectly orthogonal—warts in the design and implementation make the architecture interesting for hand-coded assembly programs.

The continuing usefulness of assembly language, even on this processor, is apparent in recent industry products. The Macintosh ROM, for instance, is written entirely in assembly language, yielding considerable savings in memory and speed.

In this article I'll survey some of the subtleties of the 68000 to help you avoid its pitfalls and exploit its oddities for better speed or memory use. I assume that you have some experience using the 68000; if not, see the bibliography at the end of this article.

TRAPS FOR THE BEGINNER

Most of the 68000's "traps" have a reason behind them; unintuitive aspects of the processor may actually be more useful, easier to implement, or correct in the view of the 68000 designers.

One trap is memory alignment. Although the 68000 supports byte, word, and long-word operations, word and long-word operands must be aligned on word boundaries (even addresses). This is because memory is grouped in words (2 bytes) and accessed via a 16-bit bus. Instructions must be word-aligned also, but assemblers and linkers normally do this for you.

Another trap is stack direction. The 68000 stack "grows" toward low memory. This means that to allocate stack space you should subtract from the stack pointer: SUB #size,SP. To deallocate space (or to discard previously pushed values), add to the stack pointer. Equally confusing, when allocating local storage with the LINK instruction, you must specify a negative displacement to be added to the stack pointer.

The stack pointer (SP) must stay word-aligned. If you push or pop a byte through the SP, the processor will move a word to or from the stack, placing the relevant byte in the high-order half of that word. Only the SP behaves this way; other address registers act the way you'd expect. This may seem an anomaly in an orthogonal architecture, but the SP must stay word-aligned so that words and long words are pushed to even addresses.

Shift and rotate instructions can operate on the byte, word, or long-word part of a data register, but shifts of memory operands can be only word size. Data registers can be shifted by up to 32 bits if the shift count is specified in another register or by up to 8 bits if the shift count is a constant given in the instruction. Memory can be shifted by only 1 bit.

The syntax of two-operand instructions may be reversed from other machines you're used to. For instance, the

(continued)

Mike Morton received his B.A. *in mathematics from Dartmouth College. He is currently a senior software engineer for Lotus Development Corporation* (161 *First St., Cambridge,* MA 02142).

68000 instruction MOVE.W D0,D1 is equivalent to LOAD D1,D0 on some other machines; that is, the contents of the D0 register are moved into D1. On the 68000, the destination register—the one affected by the instruction—is always second. The operand order for CMP instructions is also reversed from some older machines; therefore you would read CMP D0,D1 as "compare D1 to D0." (But beware: Some assemblers reverse the order of the operands from Motorola's standard; UNIX assemblers often do this.)

The 68000 provides the comparison operations shown in table 1. This includes not only all six possible relationships between two numbers, but also whether numbers are compared as signed or unsigned quantities. (Comparing the word values 0006 and FFFE hexadecimal depends on how the numbers are interpreted. If they're signed numbers, 6 is greater than −2. But if they're addresses, they're unsigned, and 0006 is a lower address than FFFE.)

The confusing thing is that the expected unsigned equivalents of BLT and BGE are not BHS (branch on higher or same) and BLO (branch on lower). Instead, Motorola uses BCS and BCC, respectively. The processor is perfectly orthogonal, providing for all types of comparisons. But the mnemonics are asymmetrical on the unsigned side (unless you use a nonstandard assembler or define your own macros).

(The distinction between signed and unsigned comparisons comes up rarely, since they are the same unless one of the values involved has the high-order bit |the sign bit| set. However, when the distinction is significant, it can lead to trouble. An operating system's disk allocator may sort disk blocks using a BGT instruction. After some years, a site tries to configure a system with more than 2^{31} bytes of disk storage. Everything grinds to a halt because BGT compares 80000010 hexadecimal to 7FFFFFF0 hexadecimal and incorrectly finds the latter address to be greater. A BHI instruction would have compared and sorted the addresses correctly.)

A note on using the condition codes: After a TST instruction, the overflow (V) condition code is cleared. This means that after TST, BLT is equivalent to BMI, and BGE is the same as BPL. Stylistically, BMI and BPL make more sense after a TST unless the value being tested is the difference of two other values.

Table 1: *This table shows which branch instructions will result in a branch taken when testing for a given relationship of* D1 *to* D0 *after a* CMP D0,D1 *instruction.*

Relationship	Signed	Unsigned
D1 < D0	BLT	BCS (branch on Carry Set)
D1 < = D0	BLE	BLS
D1 = D0	BEQ	BEQ
D1 ≠ D0	BNE	BNE
D1 > D0	BGT	BHI
D1 > = D0	BGE	BCC (branch on Carry Clear)

TRAPS FOR EXPERTS

Some quirks of the 68000 are less intuitive and regularly catch seasoned programmers. Some of these aspects of the implementation suggest design difficulties and tradeoffs in the processor; others reflect the designers' ideas on what constitutes good programming.

Addresses and data are different. Most assemblers quietly assemble MOVE #0,An as a MOVEA (move to an address register) instruction without nagging the programmer about the distinction between MOVE and MOVEA. But the 68000 treats data and address values very differently.

Address operations (MOVEA, ADDA, etc.) are never byte-size.

Word values are sign-extended to 32 bits before being used in address operations. Thus, ADDA.W D1,A2 extends the low-order word of D1 before adding it to A2. In the 68000, there is no such thing as a 16-bit address, so a word-size value is converted to 32 bits before being used in address operations.

Address operations never set condition codes; most data operations do. This is useful in subroutines that return information in the condition codes:

```
TST.W D0            ; Set condition codes to
                    ; return to caller.
MOVE.L (SP)+,A0     ; Pop return address into A0.
ADD.W #params,SP    ; Deallocate <params> bytes
                    ; of parameters.
JMP (A0)            ; Return with condition codes
                    ; still set.
```

(Note that the MOVE and ADD are translated into MOVEA and ADDA by the assembler.) The condition codes set by the TST.W are unaffected by the remainder of the exit sequence.

Another trap concerns loop operations. A loop ending with a DBcc instruction (such as DBEQ) loops until the condition cc is true; this instruction can be thought of as "decrement and branch back if condition false." This is confusing since, if you were to write out several instructions to replace a DBEQ, they would contain a BNE to jump back to the top of the loop, not a BEQ.

If the condition being tested for is not detected (or if you're using DBRA), the loop will stop when the counter reaches −1, not 0. If you want the loop always to be executed once, you should enter it at the top with the count already decremented by 1. For example, to search for the first null (zero) byte in a table of *N* bytes pointed to by A1:

```
    MOVE.W #N-1,D0    ; Start the loop counter
                      ; one too low.
LOOP                  ; Come here to test
                      ; another byte.
    TST.B (A1)+       ; Is A1's byte zero?
                      ; (Advance after testing)
    DBEQ D0,LOOP      ; If not zero AND D0 is
                      ; still >=0, loop back.
```

(continued)

This loop will execute at most *N* times. It corresponds to Pascal's "repeat. . .until" construct. For the equivalent of "while. . .do," which doesn't necessarily enter the loop:

```
   MOVE.W #N,D0        ; Start the loop counter normally.
   BRA LOOPSTART       ; Don't fudge D0; jump to
                       ; the loop end first.
LOOP                   ; This is the loop head.
   TST.B (A1)+         ; Is A1's byte zero?
                       ; (Advance after testing)
LOOPSTART              ; Enter here to check count
                       ; before looping.
   DBEQ D0,LOOP        ; If not zero AND D0 is
                       ; still > =0, loop back.
```

If you're using DBcc, don't forget to initialize the condition codes so the DBcc doesn't fall through when you jump to it. In the code above, the MOVE.W #N, D0 "primes" for the loop.

Also remember that the data register used to control the loop is decremented as a word quantity. If it's possible to have more than 2^{16} iterations, you have to nest two DBcc loops. For example, to checksum a list of bytes whose length is specified in the long word D0:

```
        MOVEQ #0, D3      ; Initialize checksum.
        MOVE.W D0,D1      ; Low word of loop length in D1.
        MOVE.L, D0,D2     ; Get high word of loop length
        SWAP D2           ; in D2 to use for outer loop.
        BRA.S START       ; Enter at the end of the loop.
LOOP:   ADD.B (A1)+,D3    ; Add the next byte into sum.
START:  DBRA D1,LOOP      ; Inner loop: Loop on low word of
                            D0.
        DBRA D2,LOOP      ; Outer loop: Loop on high word.
```

Small adjustments to the stack pointer can be done with ADDQ (or SUBQ) #n,SP, but these instructions can change it by at most 8 bytes. The fastest way to change it by more than 8 bytes is with LEA n(SP),SP.

The 68000 does not allow you to execute a MOVE instruction with a destination relative to the program counter (PC). In the view of the 68000 designers, code should not patch itself. If you must change a table in the middle of code, you must point to it with an instruction like LEA TABLE(PC),An and then alter it through An. (Self-modifying code is especially bad for 68000 programs that may someday run on the 68020, because the 68020's instruction cache normally assumes that code is pure.)

For no apparent reason, the CLR instruction always reads from an operand before clearing it. But unlike BCLR, CLR doesn't set the condition codes. Never use CLR to write a zero to a memory-mapped device address if the device will be affected by the read. The Scc instruction and MOVEs from the status register also read before writing but are less likely to cause problems.

Don't confuse the EXG and SWAP commands. EXG exchanges the 32-bit contents of two registers. SWAP swaps the 16-bit halves of a single data register.

When indexing into an array, remember to multiply the index register by the "stride" (bytes per element) of the array. For instance, if D0 holds an index into an array of long words pointed to by A1, you must multiply the index by 4 to convert from long words to bytes:

```
MULU #4,D0               ; Turn the array index into
                         ; a byte offset.
MOVE.L 0(A1,D0.L),D1     ; Pick up the long-word
                         ; array element in D1.
```

The EOR instruction must have a data register for the source, except for the immediate form of the instruction, EORI.

CODING FOR SPEED: PRINCIPLES

The secret of efficient code on the 68000 can be described using one word: "registers." Suppose, for example, that you have two 32-bit variables. If you keep them in registers, the time to add one to the other with ADD.L D0,D1 is 8 clock periods. If they're in memory pointed to by address registers, the time to add them with MOVE.L (A0),D0 and ADD.L D0,(A1) is 32 clock periods, four times slower! The moral of the story is simple: Work hard to keep frequently used quantities in registers.

You can learn this important rule and others by studying instruction timing information (such as the tables in the *M68000 16/32-bit Microprocessor Programmer's Reference Manual*). Times are given in clock periods, which I'll call cycles; a 10-MHz processor executes 10 cycles per microsecond. In general, the tables give the base time for each instruction. Most base times must have additional times added in for the operands. For instance, the time to execute AND.W D0,(A1)+ is 8 cycles for a word-size AND-to-memory and 4 more cycles for the (A1)+ destination operand. (The source operand is "free" because it's a register.) Thus, the entire instruction takes 12 cycles, or 1.2 μsec on a 10-MHz processor.

When you're trying to save a few cycles in a crucial loop, timing tables can be useful as more than just a reference. They provide a concise summary of the architecture—sort of a shopping list of the instructions available and the cost of each. When you're trying to avoid preconceived notions of which instructions are suited to solving a problem, this summary can remind you of alternatives and encourage lateral drift in your thinking.

CODING FOR SPEED: BASIC RULES

The MOVEQ, ADDQ, and SUBQ instructions are great. For instance, it's faster to zero all 32 bits of a data register by using MOVEQ #0,Dn than it is to use CLR.L Dn. Remember that these instructions are limited to small numbers: MOVEQ can load values from −128 to 127 into a data register; ADDQ (SUBQ) can add (subtract) only values from 1 to 8 to (from) its destination.

DBcc is especially efficient; use it whenever you can. (But beware the traps described above.)

Not all assemblers automatically produce "short" branches (branches with 8-bit displacements). Check the output of your assembler to see if it emits a short branch whenever possible. If not, you may have to use BRA.S, BSR.S, and Bcc.S in your source code instead of BRA, BSR, and Bcc.

(continued)

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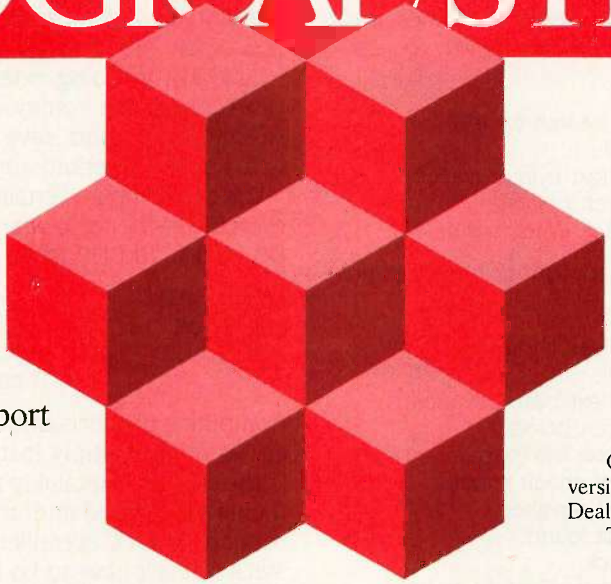

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Because a taken short branch is slower than an untaken one, try to avoid taking most branches. For instance, if you have a loop searching for a null, the simple way to search is with

```
LOOP                   ; Here to search for the
                       ; next null.
    TST.B (A3)+        ; Check next byte; advance
                       ; the search pointer.
    BNE.S LOOP         ; Loop back if not found.
```

It takes only a bit more space to "unroll" one or more iterations of the loop:

```
LOOP                   ; Here to search for the
                       ; next null.
    TST.B (A3)+        ; Check next byte; advance
                       ; the search pointer.
    BEQ.S FOUND        ; If zero, exit the loop.
    TST.B (A3)+        ; Not zero: check another
                       ; byte and advance.
    BNE.S LOOP         ; If still not found,
                       ; loop back.
FOUND                  ; Come here when A1 points
                       ; one past the null byte.
```

If the character tested generally isn't zero, the BEQ.S usually goes untaken and is faster. You can unroll any number of iterations, adding TST.B/BEQ.S pairs until the extra space consumed is no longer worth the diminishing increase in speed (or the branches become long branches).

Addressing with (An)+ is faster than with −(An). If you have the choice of which direction to go in a search or other loop through memory, move upward. (Note that this is not true for the destination operand of a MOVE instruction.)

Because (An) addressing is faster than x(An), access to the first element of a data structure is faster than to the others. (This is also useful with Pascal records, C structures, etc.)

The MOVEM instruction is a very efficient way to stack or unstack a large number of registers. But if you have to push only two registers, or pop three, MOVEM is no faster than moving them one at a time.

Don't assume that long operations are always slower than word-size ones. For instance, word address operations can be slower than long ones because of the time to sign-extend a word value.

As with other machines, never multiply or divide by a power of 2 when you can shift instead. Although shifts are time-consuming, they're always faster than a multiplication or division. So, you can use the ASL (arithmetic shift left) instruction to multiply by a power of 2 and use ASR (arithmetic shift right) to divide by a power of 2. (Be careful here—the right shift is not the same as a division if the contents of the register are negative. For example, −1 divided by 2 should be zero, but −1 shifted right by 1 bit is −1, rounded incorrectly.) Don't forget that the multiplication instructions produce a long-word result from a word operand; shifting doesn't.

To multiply by 2, add a register to itself instead of shifting: ADD Dn,Dn. In fact, if you are multiplying a word operand by 4, you can do it faster with two ADD instructions than with a single shift by 2 bits.

Similarly, in doing extended-precision arithmetic, you can replace the common operation ROXL #1,Dn with ADDX Dn,Dn and save 2 or 4 cycles, depending on whether the operands are words or longs.

You can compute certain multiplications faster with shifts even if they're not powers of 2. For instance, to multiply D0 by 17, add D0 to 16 times D0:

```
MOVE D0,D1          ; Copy D0 to D1.
LSL #4,D0           ; Compute 16 x D0 in D0.
ADD D1,D0           ; Add original value in to
                    ; compute 17 x D0.
```

Computing products this way is still faster than the 40-plus cycles for a multiply instruction.

The cost of maintaining the stack can be lessened if arguments are deleted after the call by the caller, not the subroutine. (Most C compilers use this stack protocol.) If the stack doesn't have to be cleaned up after every call, you can allow debris from several calls in a row to accumulate as long as it's easy to keep track of how much there is. Typically, you can let it pile up until you reach a branch, then unstack it all with an ADDQ (or LEA if there's more than 8 bytes to remove).

Finally, don't ignore the 68000's "higher-level" instructions. Even at the assembler level, instructions such as PEA, LINK, UNLK, and CHK can be very useful.

CODING FOR SPEED: SOME COOKBOOK EXAMPLES

Here are a variety of things you can do to save time when you're scraping for cycles. Some are useful in many applications; others are very specialized. The more obscure ones are examples of the kinds of tricks that the 68000 can do.

Remember that timings will not be the same on the 68000's relatives (the 68008, 68010, 68020, etc.). If you're working on one of these processors, recompute the timings or, when you're not sure which of two approaches is faster, measure the speed of both. Timings for the 68020 will be especially hard to compute because of its sophisticated prefetch and instruction caching.

You should also know that not all computers run the processor at the advertised speed. For instance, the Macintosh's 68000 runs at 7.8 MHz, but it can't always operate at this speed because the screen is memory-mapped and "steals" some memory cycles. Thus, the effective speed of the Macintosh is about 6 MHz, but only memory cycles are slowed down—CPU cycles are unaffected. So operations done mostly within the CPU (such as multiply, divide, and long register shifts) run at nearly full speed. The lesson in all this is that timings are hard to compute or intuit; you may want to time various pieces of code for yourself to see which is faster.

It is said that one doesn't really know how to use a tool until one knows three ways to abuse it. Here are some of my favorite ways to abuse the 68000.

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Fast subroutine calls. Although JSR and RTS provide a simple subroutine call-and-return, the cost of pushing the return address on the stack is significant. For a very frequently called subroutine, you can change the call to store the return in an address register as in

```
   LEA RETURN,A0      ; Return address goes in A0.
   JMP routine        ; Jump to the subroutine.
RETURN                ; A0 points to this spot.
```

Then to return, just JMP (A0). By avoiding use of memory, this saves 8 cycles. (Note that the LEA instruction references the label RETURN with PC-relative addressing.)

Also, if you end a subroutine with

```
JSR lastsub           ; Call one last subroutine
RTS                   ; and return.
```

and lastsub doesn't alter the stack, you can save a whopping 24 cycles by using "tail recursion" to replace the two instructions with a single

```
JMP lastsub           ; "Call" lastsub and
                      ; it'll return for us.
```

Finally, if you call a subroutine and then branch somewhere else, you can avoid extra jumping around. For instance,

```
JSR sub               ; Make a call
JMP next              ; and go somewhere else.
```

can be made slightly faster with

```
PEA next              ; Push a fake return address
JMP sub               ; and "call."
                      ; sub will RTS to next for us.
```

(All of the above work for BSR and BRA as well as JSR and JMP.)

Quick test for zero. If you want to test whether a register is zero and don't mind trashing the value, use DBRA Dn,NOTZERO instead of combining TST.W Dn with BNE NOTZERO.

If you want to do an *N*-way branch depending on a value, you'll usually want to index into a jump table and transfer to the appropriate address. A "case" statement is typically implemented this way. But if you have a very small number of values and want to handle the lower values more quickly, a series of DBRAs can do this conveniently. For example, if you want to branch based on a register that contains 0, 1, or 2,

```
   DBRA D0,NOT0        ;Decrement; jump if it wasn't
                       ; zero.
       <handle zero case>
NOT0                   ; Come here if not zero.
                       ; D0 has been decremented.
   DBRA D0,NOT1        ; Decrement; jump if original
                       ; D0 wasn't one.
       <handle one case>
NOT1                   ; Not one. D0 has been
                       ; decremented twice.
   DBRA D0,ERROR       ; Decrement; if not originally
                       ; two, error.
       <handle two case>
```

Checking for membership in a small set. If you want to see if a number is in a set of several numbers, you can create a bit mask corresponding to the set. For instance, if the set is {0,1,3,5}, the mask has those bits set and the bit map is 00101011 (2B hexadecimal). You can test for membership in this set with

```
BTST D0,#$2B           ; Is D0 in {0,1,3,5}?
```

If your set is composed of more than eight elements you have to move the mask into a data register first.

Quick comparisons. To check the value of a data register with CMP.L #xxx,Dn takes 14 cycles. If the value be-

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ing tested for is small enough to fit in a MOVEQ, it's shorter and faster to put the value in a temporary register:

```
MOVEQ #xxx,D0       ; Set up value to look for
CMP.L D0,Dn         ; and do the comparison.
```

If the value xxx is between −8 and 8, and you don't mind altering the data register, you can just use SUBQ #xxx,Dn (or ADDQ, as appropriate) instead of a CMP. Then you can use a conditional branch just as you would after a CMP. This works for word or long-word comparisons.

Picking up an unaligned word. The straightforward approach is to load 1 byte, shift it into position, and load the second byte. The faster way (28 cycles instead of 38) is to exploit the stack pointer's odd behavior when byte quantities are pushed on the stack:

```
MOVE.B (A0)+,-(SP) ; First byte to high half of
                   ; new word on stack.
MOVE.W (SP)+,D0    ; Pop that new word to D0.
                   ; First byte in place.
MOVE.B (A0),D0     ; Second byte in place.
```

Clearing address registers. MOVE.L #0,An takes 12 cycles, while SUB.L An,An takes only 8 and is shorter. (CLR doesn't work with address registers.)

Avoiding long shifts and rotates. The time the 68000 takes to shift a register is proportional to the distance being shifted: 2 additional cycles for every bit. Thus, never rotate a long word more than 16 bits in either direction or a word more than 8 bits. (Remember that to shift by more than 8 bits, you have to put the shift count into a data register. In the examples that follow, the bit count is *not* a constant; the value is bracketed to show this.)

```
ROL.L <16+x>,Dn  =  ROR.L <16-x>,Dn
ROL.W <8+x>,Dn   =  ROR.W <8-x>,Dn
```

In shifting 16 bits or more, the first 16 bits of the shift can be done with a SWAP to save 26 cycles in each of these cases:

```
LSR.L <16+x>,Dn =
  CLR.W Dn          ; Clear bits that swap up
  SWAP Dn           ; and LSR.L #16,Dn.
  LSR.W <x>,Dn      ; Now finish the shift.

ASR.L <16+x>,Dn =
  SWAP Dn           ; Slide down 16 bits.
  EXT.L Dn          ; Sign-extend to a long word.
  ASR.W <x>, Dn     ; Finish up, sign-extended.

LSL.L <16+x>,Dn =
  LSL.W <x>Dn       ; Shift x bits in low half.
  SWAP Dn           ; Shift 16 more bits.
  CLR.W Dn          ; Throw away bottom half.
```

And some long-word operations of less than 16 bits can be optimized with SWAP. Long shifts between 11 and 15 bits can be speeded up with

```
LSL.L <x>,Dn =
  SWAP Dn             ; Rotate left by 16 bits.
  ROR.L <16-x>,Dn     ; Undo to x-bit left rotate.
  AND.W #mask,Dn      ; Remove bottom x bits.
```

```
LSR.L <x>,Dn =
  AND.W #mask,Dn      ; Remove bottom x bits.
  SWAP Dn             ; Rotate right by 16 bits.
  ROL.L <16-x>,Dn     ; Undo to x-bit right rotate.
```

Fast sign-extend. While there are instructions to sign-extend bytes into words or words into long words, what if you have a signed 12-bit field (from unpacking a record or reading a DAC)? The standard way to sign-extend this to a full 16-bit word is with

```
LSL.W #16-12,Dn   ; Shift so 12-bit field is left-justified.
ASR.W #16-12,Dn   ; Shift it back down sign-extended.
```

If you know that the bits outside the 12-bit field are zero, you can do this without shifting. In general, if you want to sign-extend an *N*-bit field to 16 bits, define "mask" to be $-(2^{(N-1)})$—a mask with the bottom $N+1$ bits clear. Then the sign extension can be done using a temporary register:

```
MOVE.W #mask,D0    ; Build mask with high N+1 bits set.
ADD.W D0,Dn        ; Negative: top bits=0.
                   ; Positive: top bits=1.
EOR.W D0,Dn        ; Flip so top bits are correct.
```

This is always at least as fast as the shifting method, which gets slower as *N* increases. Sign-extending to a long word is faster this way if *N* is 3 or more.

Loading large constants. To move certain values into the upper half of a data register, you might code MOVE.L #00xx0000,Dn. It's faster to replace this single instruction with two:

```
MOVEQ #xx,Dn      ; Move value to lower half
                  ; and clear upper half.
SWAP Dn           ; Swap—put things in position.
```

Clearing the upper half of a data register. Instead of doing this with AND.L #$FFFF,Dn, it's quicker to use

```
SWAP Dn     ; Swap high and low halves.
CLR.W Dn    ; Clear high half while it's low.
SWAP Dn     ; Put things back in place.
```

CONCLUSIONS

Esoteric coding techniques continue to be important in pushing processors to their limits. A machine such as 68000, which is oriented toward executing compiled high-level languages, can still be appropriate for tight hand-crafted solutions. A programmer who needs the utmost in performance can exploit quirks in an instruction set to great advantage. ■

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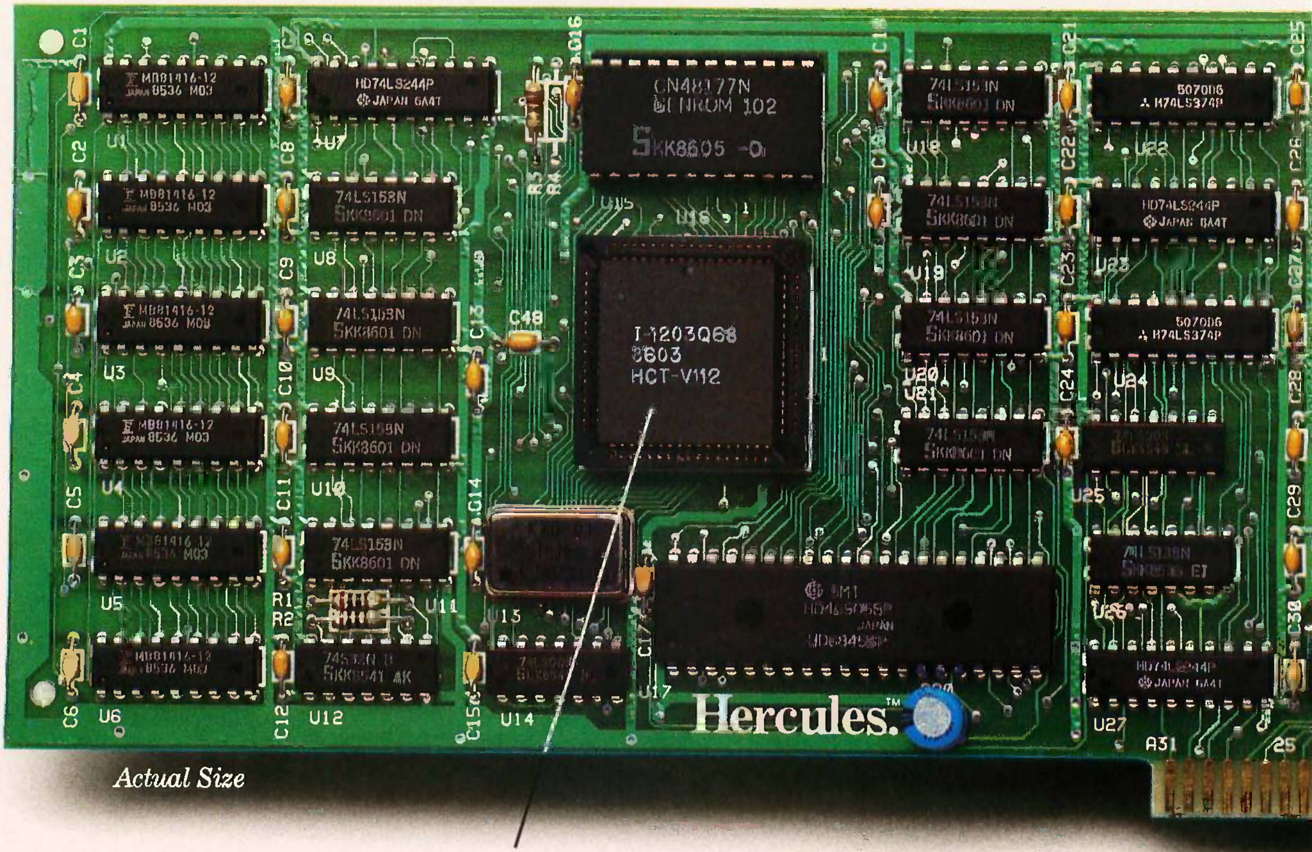

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Instead of 256 canned, unchangeable ones.

The future according to RamFont. With all these characters and fonts to work with, software will never be the same again.

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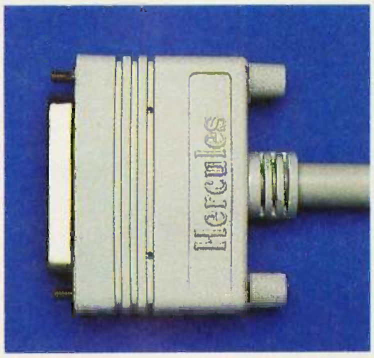

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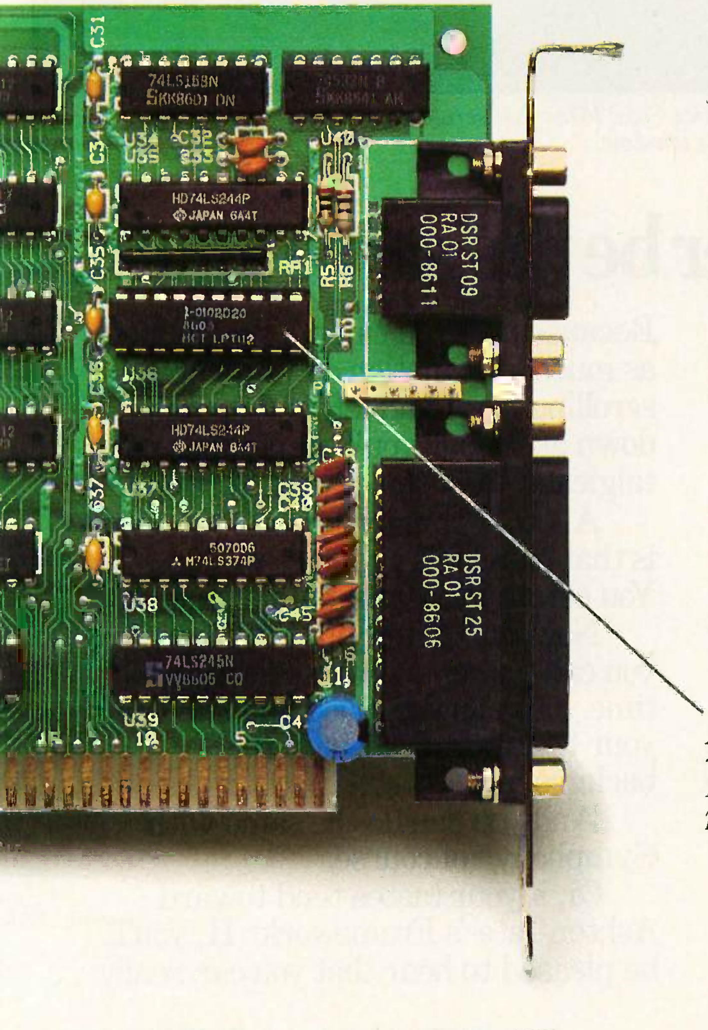

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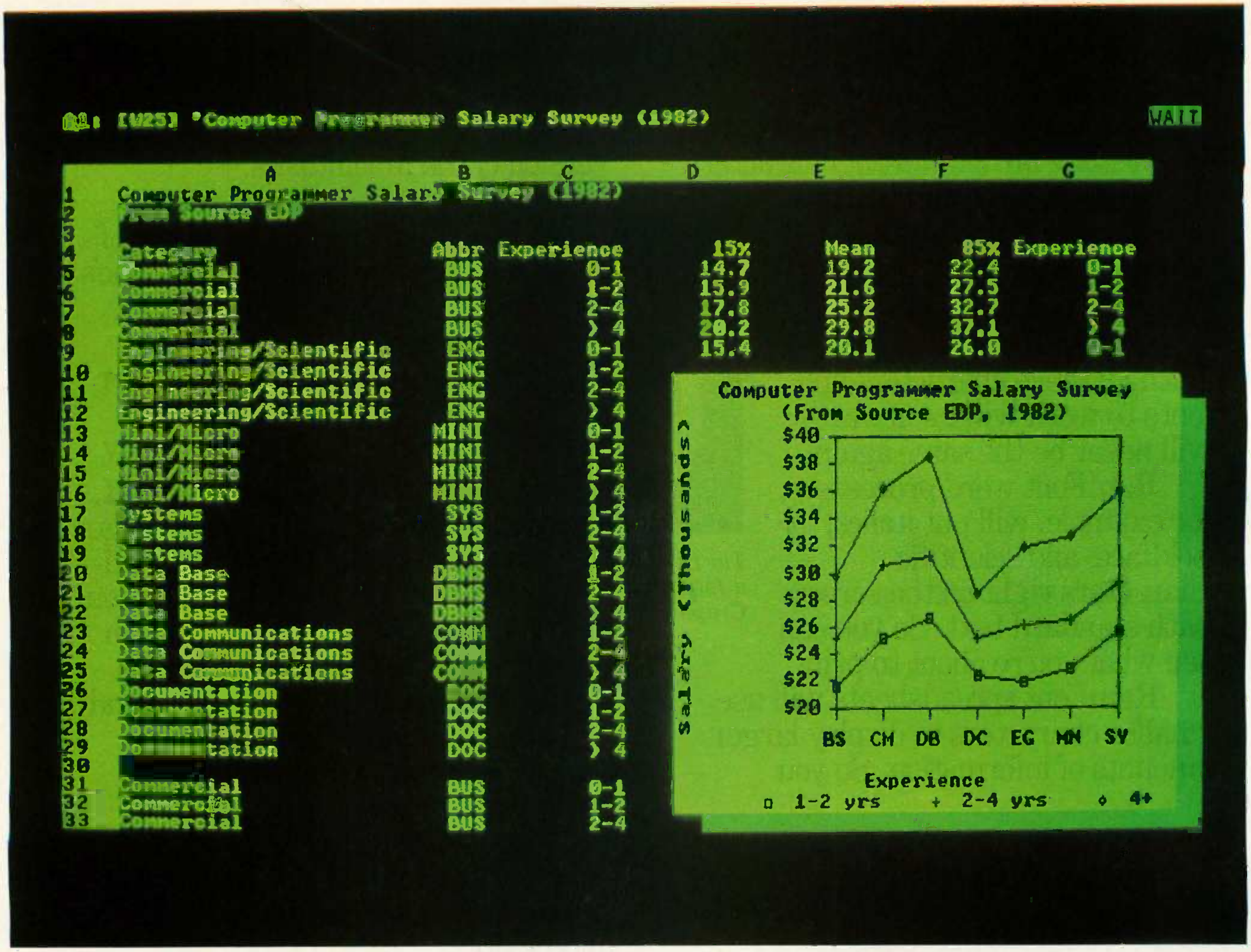


```
A1: [W25] 'Computer Programmer Salary Survey (1982)                          WAIT

              A                   B       C            D         E          F         G
1  Computer Programmer Salary Survey (1982)
2  From Source EDP
3
4  Category                      Abbr Experience      15%       Mean       85% Experience
5  Commercial                     BUS        0-1      14.7      19.2       22.4       0-1
6  Commercial                     BUS        1-2      15.9      21.6       27.5       1-2
7  Commercial                     BUS        2-4      17.8      25.2       32.7       2-4
8  Commercial                     BUS        > 4      20.2      29.8       37.1       > 4
9  Engineering/Scientific         ENG        0-1      15.4      20.1       26.0       0-1
10 Engineering/Scientific         ENG        1-2
11 Engineering/Scientific         ENG        2-4
12 Engineering/Scientific         ENG        > 4
13 Mini/Micro                    MINI        0-1
14 Mini/Micro                    MINI        1-2
15 Mini/Micro                    MINI        2-4
16 Mini/Micro                    MINI        > 4
17 Systems                        SYS        1-2
18 Systems                        SYS        2-4
19 Systems                        SYS        > 4
20 Data Base                     DBMS        1-2
21 Data Base                     DBMS        2-4
22 Data Base                     DBMS        > 4
23 Data Communications           COMM        1-2
24 Data Communications           COMM        2-4
25 Data Communications           COMM        > 4
26 Documentation                  DOC        0-1
27 Documentation                  DOC        1-2
28 Documentation                  DOC        2-4
29 Documentation                  DOC        > 4
30
31 Commercial                     BUS        0-1
32 Commercial                     BUS        1-2
33 Commercial                     BUS        2-4
```

Lotus 1-2-3 Rel. 2 in the RamFont mode of the Graphics Card Plus: fast scrolling, a 90-column by 38-row screen and a pop-up graphics window.

Software will never be the same again.

The trouble with most new hardware introductions is that there isn't any software available to introduce them to.

Not so with the new Hercules Graphics Card Plus.

It runs everything the original Hercules Graphics Card runs.

Better yet, it comes complete with the software you need to start using the revolutionary new RamFont mode right now with some of the world's favorite programs.

Lotus blossoms.

Of course, if you want to talk about the world's favorite programs, you have to start with Lotus® 1-2-3.®

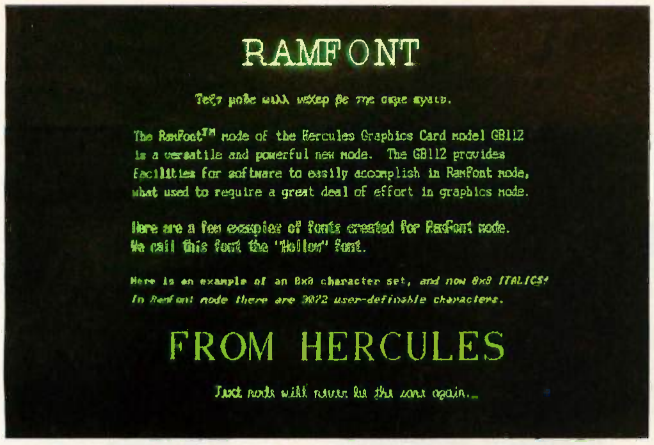
You won't recognize Release 2. Because now you can put nearly twice as much information on your screen, scrolling right and left and up and down at speeds you'll remember nostalgically from the days of Version 1A.

Another thing you won't recognize is that cute little graphics window. You can thank RamFont for that.

Now that RamFont is with us, you can pop up a graphics window any time you're in the mood and still keep your 1-2-3 spreadsheet in the background.

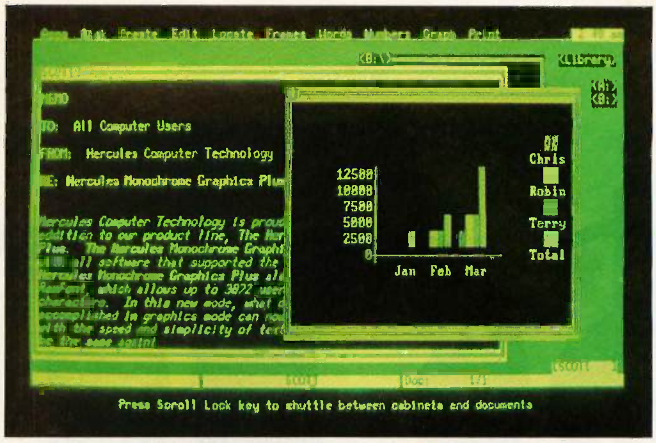
And you can do the same with Symphony,™ of course.

Or, if your tastes tend toward Ashton-Tate®'s Framework™ II, you'll be pleased to hear that you can really



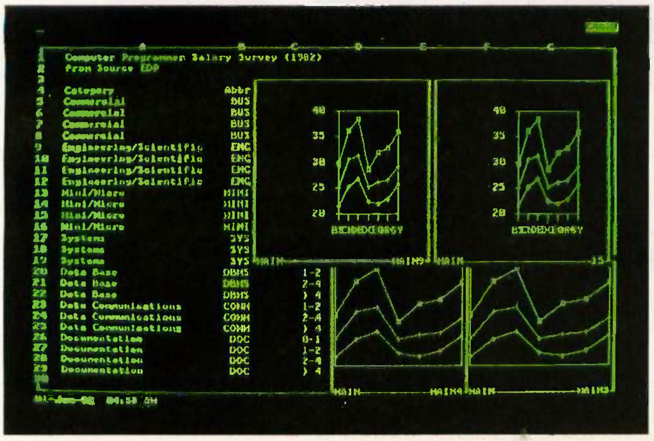
```
RAMFONT

The RamFont™ mode of the Hercules Graphics Card model GB112
is a versatile and powerful new mode.  The GB112 provides
facilities for software to easily accomplish in RamFont mode,
what used to require a great deal of effort in graphics mode.

Here are a few examples of fonts created for RamFont mode.
We call this font the 'Hollow' font.

Here is an example of an 8x8 character set, and now 8x8 ITALICS!
In RamFont mode there are 3072 user-definable characters.

FROM HERCULES

Text mode will never be the same again._
```

The Graphics Card Plus in RamFont mode showing multiple fonts created using FontMan,™ a Hercules program that comes free with each Card.



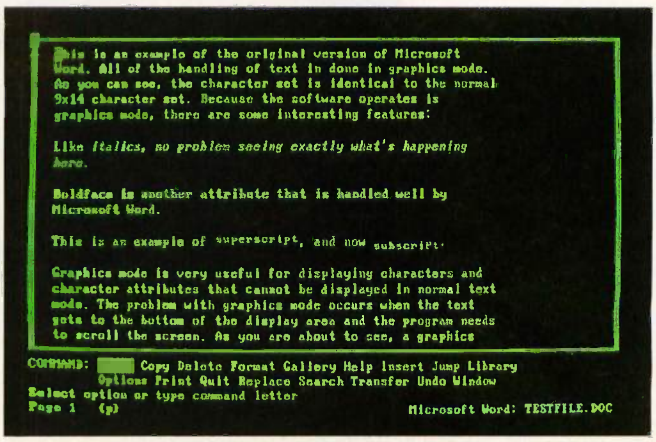
```
MEMO

TO:   All Computer Users

FROM:  Hercules Computer Technology

RE: Hercules Monochrome Graphics Plu

Hercules Computer Technology is proud
addition to our product line, The Her
Plus.  The Hercules Monochrome Graphi
   all software that supported the
Hercules Monochrome Graphics Plus al
RamFont, which allows up to 3072 user
characters.  In this new mode, what c
accomplished in graphics mode can now
with the speed and simplicity of text
be the same again!

Press Scroll Lock key to shuttle between cabinets and documents
```

Ashton-Tate's Framework II with italics and boldface and speed in the RamFont mode of the new Hercules Graphics Card Plus.



```
1   Computer Programmer Salary Survey (1982)
2   From Source EDP
3
4   Category                      Abbr
5   Commercial                    BUS
6   Commercial                    BUS
7   Commercial                    BUS
8   Commercial                    BUS
9   Engineering/Scientific        ENG
10  Engineering/Scientific        ENG
11  Engineering/Scientific        ENG
12  Engineering/Scientific        ENG
13  Mini/Micro                    MINI
14  Mini/Micro                    MINI
15  Mini/Micro                    MINI
16  Mini/Micro                    MINI
17  Systems                       SYS
18  Systems                       SYS
19  Systems                       SYS
20  Data Base                     DBMS    1-2
21  Data Base                     DBMS    2-4
22  Data Base                     DBMS    > 4
23  Data Communications           COMM    1-2
24  Data Communications           COMM    2-4
25  Data Communications           COMM    > 4
26  Documentation                 DOC     0-1
27  Documentation                 DOC     1-2
28  Documentation                 DOC     2-4
29  Documentation                 DOC     > 4
```

The programmable RamFont is so flexible, Symphony can mix true text and graphics.



```
This is an example of the original version of Microsoft
Word. All of the handling of text in done in graphics mode.
As you can see, the character set is identical to the normal
9x14 character set. Because the software operates is
graphics mode, there are some interesting features:

Like italics, no problem seeing exactly what's happening
here.

Boldface is another attribute that is handled well by
Microsoft Word.

This is an example of superscript, and now subscript.

Graphics mode is very useful for displaying characters and
character attributes that cannot be displayed in normal text
mode. The problem with graphics mode occurs when the text
gets to the bottom of the display area and the program needs
to scroll the screen. As you are about to see, a graphics
COMMAND:       Copy Delete Format Gallery Help Insert Jump Library
        Options Print Quit Replace Search Transfer Undo Window
Select option or type command letter
Page 1    {p}                           Microsoft Word: TESTFILE.DOC
```

Microsoft Word in RamFont mode: italics, boldface and small caps—plus speed and lots of it, at last.

burn rubber with its word processor.

The revealed Word.

Speaking of word processors, remember a couple of pages ago how we said they would be forever changed? Well, the change has already begun.

For example, the Hercules Graphics Card Plus with RamFont makes Microsoft® Word a whole new program.

Suddenly the italics, boldface, superscripts and subscripts scroll superfast. Which means you don't have to twiddle your thumbs waiting for the screen to catch up with your fingers.

More to come.

As time goes by, more and more major programs will take advantage of the extraordinary capabilities of RamFont.

Which gives you two choices.

You can buy a Hercules Graphics Card Plus and look forward to getting your socks knocked off.

Or you can buy another card and watch while technology leaves you and your socks behind.

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Just make sure you're sitting down.

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Graphics Card Plus

Inquiry 156 for End-Users. Inquiry 157 for DEALERS ONLY.

UNIX AND THE MC68000

BY ANDREW L. ROOD, ROBERT C. CLINE, AND JON A. BREWSTER

A software perspective on the MC68000 CPU *architecture and* UNIX *compatibility*

THE MOTOROLA MC68000 CPU architecture is well suited to UNIX implementation; its linear, 32-bit addressing simplifies the system programmer's task by allowing direct access to the entire memory address space at all times. The 68000's dual-state architecture also maps conveniently into the UNIX user and kernel modes. The CPU TRAP instruction provides a disciplined way to move from user to supervisor state during a kernel call, and the RTE (return from exception) instruction simplifies the return from supervisor to user state.

The MC68000 architecture provides a powerful yet simple interrupt organization that includes seven levels of interrupt priority. The multiple priority levels are used in UNIX implementations to help organize the kernel device-driver code in an environment comprised of high-speed mass storage devices and low-speed user I/O devices (terminals).

I/O devices are used in a memory-mapped manner rather than having a set of I/O-specific instructions. This allows the UNIX implementer to write device drivers in a high-level language, manipulating I/O devices as though they were memory-resident data structures.

MC68000 ARCHITECTURE OVERVIEW

In this article, we use the programmer's model rather than the hardware implementation when discussing the MC68000 CPU architecture. The MC68000 is a general-register processor; the CPU incorporates a number of internal registers that can be loaded from main memory, manipulated, and stored in main memory. This is different from a single-accumulator CPU such as the Intel 80286, where most operations happen in one register (the accumulator), or a stack-oriented machine such as the Hewlett-Packard 3000, where all operations occur on the stack. (See figure 1 for a description of the registers.)

Actually, the program counter, stack pointers, and status registers are not considered general registers. The remaining registers are broken into two types, address registers and data registers. Each type has a set of dedicated instructions that enrich its general capability. For example, data registers can handle byte (8-bit), word (16-bit), and long word (32-bit) data. The address registers can be used as software stack pointers and are intended for address calculations.

There are two distinct CPU stack registers (see figure 1), one for each state, and a small set of privileged instructions whose operation is state-dependent. If a user program attempts to execute a privileged instruction, a trap will occur so that the

(continued)

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Robert C. Cline earned a B.S. in mathematics from the University of Massachusetts and an M.S. in computer science from Indiana University. He is a Software Research and Development Engineer at Hewlett-Packard's Corvallis Workstation Operation.

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The authors can be contacted at Hewlett-Packard, Corvallis Workstation Operation, 1000 Northeast Circle Blvd., Corvallis, OR 97330.

kernel can arbitrate the violation. The CPU architecture provides vectored interrupts and seven levels of interrupt priority. (Note that access to the interrupt-level mask is a privileged facility.) The MC68000 architecture provides no I/O instructions. I/O is presumed to be performed in a memory-mapped manner using the normal LOAD and STORE instructions.

A QUICK UNIX SUMMARY

The UNIX system is a multitasking operating system designed for software development. It has become popular because of its simplicity of design and the ease with which it can be ported to a variety of machine architectures. The simplicity and portability are due mostly to the fact that 90 percent of the system's code is written in the high-level language C.

UNIX is a process-oriented system. The management of processes in the UNIX system is fairly simple. Each runnable process (program) is placed in a list. These processes are ordered by a priority system. Each process shares the CPU via a time-slicing, round-robin, scheduling algorithm where the process with the highest priority gets to use the CPU first. The time slicing is normally governed by a periodic interrupt that occurs each time a system clock ticks.

The UNIX system is oriented around two states of operation: operating system, or kernel, state, and user state. All driver activity, process management activity, and low-level file management activity occur in the kernel state. Processes normally run in the user state. Each time a kernel intrinsic (operating system request) is called by a process, a state transition changes the user state to the kernel state. When the intrinsic has finished, the state is changed back to the user state. This provides some insulation of user processes from the system internals.

The memory management primitives in the UNIX system make no assumptions about the sophistication of memory management hardware available to them. UNIX systems have been implemented with no memory management and with sophisticated, paged, segmented systems. Even a memory protection scheme can be dispensed with if the system being designed is to be just an applications engine.

Due to the multiprocessing nature of a UNIX operating system, some sort of memory protection is recommended if you intend to do software development on the machine. This is to prevent experimental software from writing over memory occupied by its neighboring processes and destroying them. It is entirely up to the implementer to say how much memory management power is required. Such a decision boils down to the trade-off between price, performance, and design schedule.

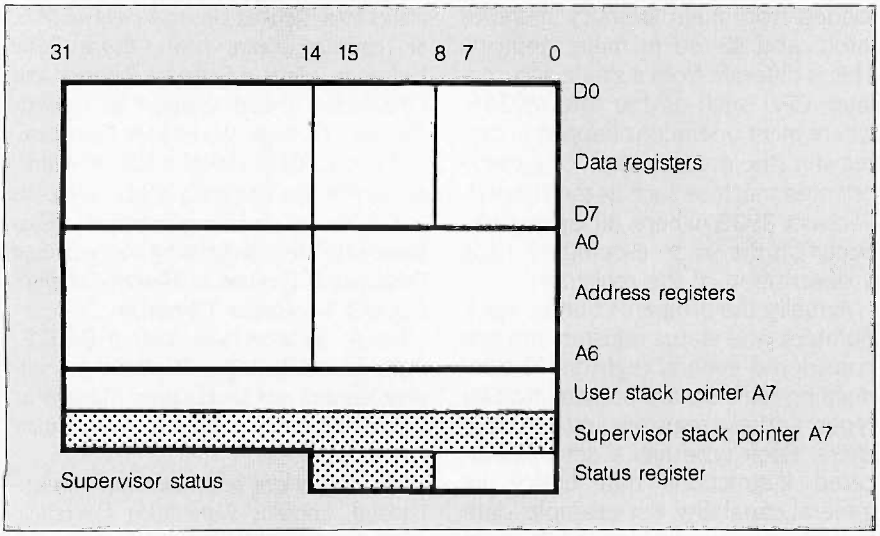

Figure 1: *The* MC68000 CPU *register model.*

The I/O system of UNIX is designed around two generic device models: the block device and the character device. Block devices are those, such as disk and tape devices, that treat data in blocks. Character devices are those, such as data terminals, that handle data one character at a time. Strict conventions exist in the system as to how devices of each type are to be accessed. Such a well-defined interface makes driver writing easier. Because driver writing makes up the bulk of the work for most operating system ports, the device model of the UNIX operating system makes porting less trying than with many other less organized systems.

LINEAR ADDRESS SPACE

The MC68000 family of processors has a large linear address space in which each memory address is 32 bits long. This allows up to 4 gigabytes of memory to be directly addressed. Since only 24 address lines are brought out of the MC68000 and MC68010 processors, only 16 megabytes are accessible in those members of the family. (The MC68020 presents all 32 bits of address.) This linear addressing scheme sharply contrasts with segmented addressing schemes, which have a small local address range and a way to relocate the local address range within a larger global addressing range.

Linear addressing may be the single most important feature of the MC68000 processor family. It greatly simplifies the task of implementing an operating system and makes large, complex working sets of segment pointers for managing process images unnecessary. (It is also the single biggest difference between the MC68000 and the Intel 80286 CPUs.)

Theoretically, a system with the address reach of a segmented architecture is as powerful as the MC68000 with its large linear reach. However, it is easier for programmers to use the linear addressing scheme (a programmer in this context is an assembly language programmer or a compiler writer).

The reasons to write in assembly

(continued)

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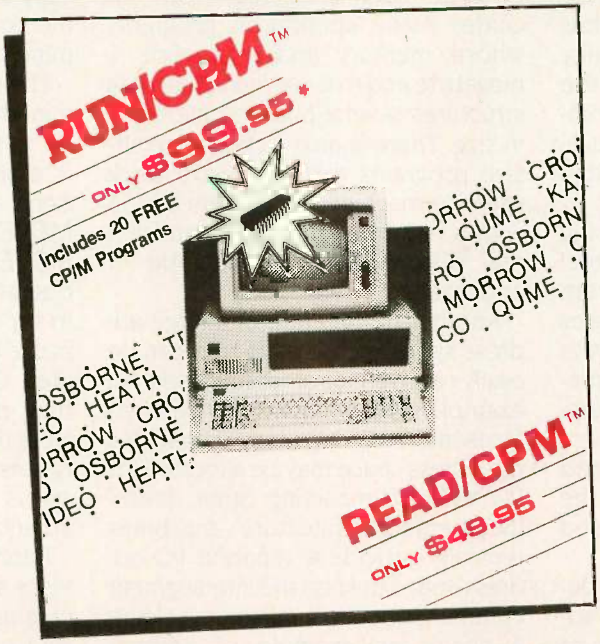

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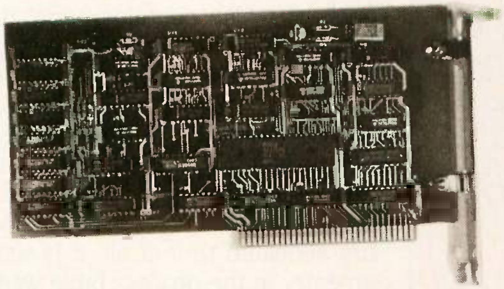

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language are varied, but it often comes down to speed, space optimization, and minimal complexity. Keeping the compiler writer's job easy has paid off in two ways: first, high-quality compilers were available early in the MC68000 life cycle; second, the compilers have been of high enough quality to reduce the amount of assembly language programming.

One drawback of linear addressing is that the code density of the actual machine instructions may suffer from the presence of many long addresses (the top byte of which is nearly always 0). This problem is alleviated somewhat by short (16-bit) relative addressing modes. However, UNIX implementations prefer separate instruction and data areas, and, consequently, the relative addressing modes are used infrequently.

Address space management becomes easy with a large, linear address space. The compiler needs to be concerned with only three spaces: code, data, and stack. Also, the operating system can quickly allocate and deallocate any number of easily accessible memory fragments. Very large processes such as those for expert systems can be designed easily because you don't have to be concerned about the overhead involved in passing control between routines in different code segments.

The same can be said for the use of large data structures. UNIX includes many application programs whose memory image exceeds 1 megabyte and that use individual data structures several hundred kilobytes in size. There is also a class of recursive programs that are heavy stack users. A machine such as the 80286 with a 64K-byte stack limit can be a real disadvantage in this type of application.

Another nice feature of a large address space is that parts of it can be easily reserved for other functions. An example is mapping I/O device interfaces into memory. Many megabytes of address space may be allocated for I/O without impacting other needs. (Segmented-architecture machines typically provide a separate I/O address space to keep the intersegment communication to a minimum.) Figure 2 shows an example of address allocation.

DUAL PROCESSOR STATES

The MC68000 is a dual-state processor. The processor has two stack registers, one used while in the supervisor state and the other used while in the user state. When an instruction is executed that changes the CPU state, the stack is automatically changed as well. The CPU provides status lines coming off-chip to allow support chips (such as an external memory management unit) to determine the current CPU state.

The state of the CPU can be determined by reading the supervisor state bit in the CPU status register. There is a small set of privileged instructions, including STOP, RESET, RTE, MOVE to SR, AND, EOR, OR, and MOVE (word) IMMEDIATE to SR, that operate differently in user state than in supervisor state. In user state they cause a privilege violation and associated CPU fault. In supervisor state they modify the CPU as indicated. Note that any instruction that explicitly sets the supervisor portion of the status register (SR) is a privileged instruction.

Interrupts are dispatched in supervisor state even if the CPU was processing in user state when the interrupt occurred.

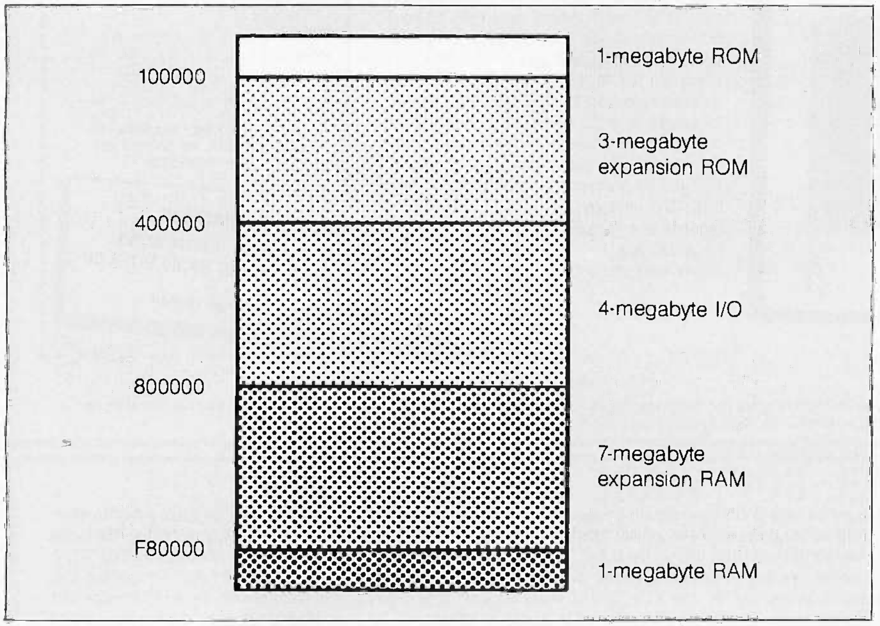

Figure 2: A *typical* MC68000 *address allocation scheme.*

UNIX USE OF DUAL STATES

In UNIX a process is a user task that has resources allocated to it, including main memory, CPU time, I/O processing, and space in system tables. It is by time-slicing processes that UNIX performs multitasking.

Figure 3 shows a memory-oriented picture of a process. Normal processes have a kernel and user side, each of which contains code, data, and stack. Process 0, the original process, acts as the scheduler in the system. Process 0 is unique in that it has no user side, only a kernel side.

A zombie process is a process that has no user side and no kernel side; in fact, a zombie process has no memory allocated to it at all. It is simply an entry in the process table waiting to be deallocated.

UNIX kernel code normally executes in the supervisor state of the CPU, and the UNIX user code normally executes in the user state of the CPU. In the UNIX framework there is a distinguished user called the superuser. The concept of a superuser should not be confused with the supervisor or kernel portion of a process. A superuser process is a normal process from the CPU perspective,

(continued)

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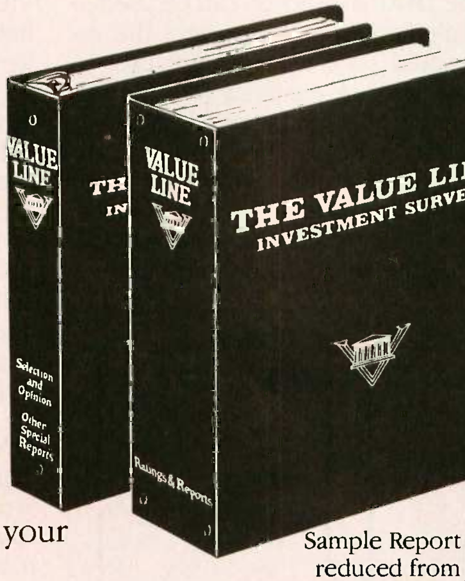

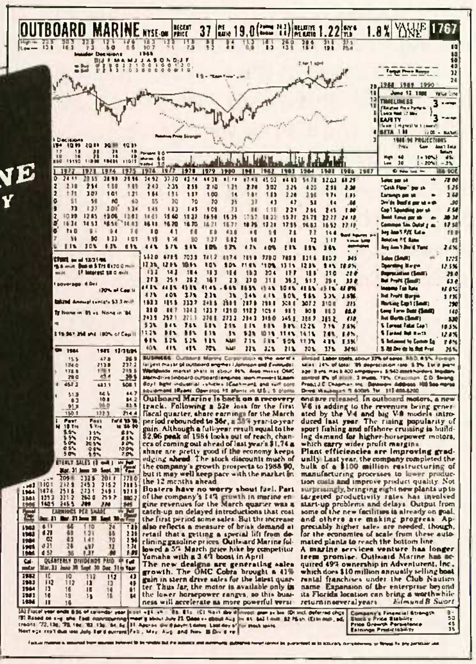

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but one that is distinguished by the superuser process identification number (pid). The pid is checked by the operating system during certain critical operations, for example, mounting new file-system devices.

Only superuser processes are allowed to perform these operations. Any process (even those belonging to the superuser) has both a kernel side, which executes in the supervisor state of the CPU, and a user side, which executes in the CPU's user state.

In contrast to the dual privilege levels associated with UNIX, the 80286 processor provides four levels of privilege, each protected from the levels above it. For more sophisticated operating systems than UNIX this four-state CPU can provide a good implementation vehicle. In the UNIX environment it is not immediately clear that four CPU states are required or even useful.

TRAP DISCIPLINE

The TRAP instruction can be used to implement kernel calls and the associated state change from user to supervisor. A matching RTE instruction is used to return to the user state. The register environment can be used to pass information to the kernel, such as the type of kernel call being made. (The registers must be saved explicitly by the kernel as desired.)

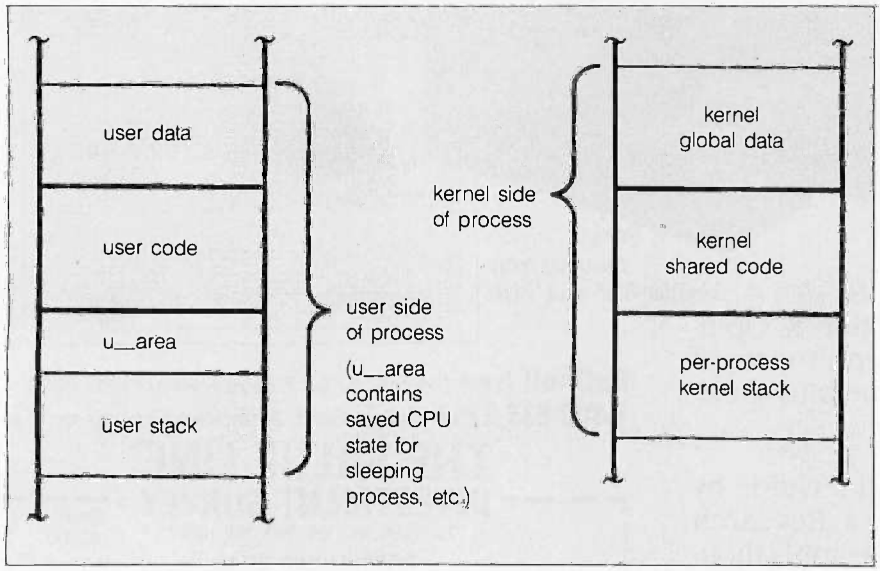

Figure 3: A *graphic description of a process, showing user and kernel elements.*

THE USER VIEW OF A KERNEL CALL USING TRAP

```
;
; Syscall(callno,arg1,arg2)
;
;          Perform the kernel call indicated by callno.
;          Send arg1 and arg2 (typically pointers) to the
;          kernel as part of the call.
;
Syscall move.l  4(sp),d0       ; Get the kernel call number.
        move.l  8(sp),d1       ; Get the first argument (arg1).
        move.l  12(sp),d2      ; Get the second argument from
                               ; the stack.

        trap    #1             ; Trap to supervisor state.

        rts
```

The kernel call is a frequently used operation, but typically a costly one. Overhead involved in trapping to the kernel includes TRAP and RTE instructions, register state save and restore, kernel call decode and dispatch, and kernel call implementation. See the text boxes "The User View of a Kernel Call Using TRAP," below, and "The Kernel View of a Kernel Call" on page 186.

The 80286 processor implements a more complex state-transition mechanism using call gates to allow procedures to transfer control to the same or more privileged levels. This scheme is more complex than the MC68000 implementation of CPU state transition, and it is exactly this added complexity that makes UNIX implementation with the 80286 more difficult.

UNIX CONTEXT SHIFTING

Context shifting in the UNIX system is the operation of putting the currently executing process to sleep and resuming the execution of some other process. Because of the process orientation of UNIX, and its time-slicing algorithms for scheduling, context shifting is frequently performed.

Context shifting occurs either at the end of a kernel call or in response to some interrupt during user state processing (e.g., the heartbeat interrupt from the system clock). Context-shift overhead includes saving the currently executing process state, selecting a new process to run, and restoring the state of the new process. (See the text boxes "CPU State Save in a Context Shift" on page 188 and "CPU State Resume in a Context Shift" on page 190.)

The 80286 provides a complex task environment that allows high-performance context shifting between tasks. As with the privilege architecture of the 80286, the task separation mechanism is more powerful than is required in a UNIX implementation.

KERNEL VIEW OF CONTEXT SHIFTING

The kernel view of context shifting involves two functions: sleep and switch (see figure 4). Sleep is a function that,

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THE KERNEL VIEW OF A KERNEL CALL

```
; trap
;
;    The address of this routine is placed in memory at the
;    address of vector 33 (the TRAP 1 vector); that is, at
;    memory location 132 decimal. When the TRAP #1 instruction
;    is executed, the CPU generates an internal exception and
;    automatically transfers to this routine in supervisor
;    state. The user return address and status register are
;    saved on the supervisor stack.
;
;    On entry it is presumed that the registers contain:
;              d0 ... the kernel call number
;              d1 ... first argument to the kernel call
;              d2 ... second argument to the kernel call
;    Typically the arguments are pointers into the user's data
;    space.
;
trap   movem.l  #0xFFFE,-(sp)      ; Save registers d0–d7 and a0–a6.
       move.l   usp,a0
       move.l   a0,-(sp)           ; Save the user stack pointer.

       move.l   d0,-(sp)
       move.l   d1,-(sp)
       move.l   d2,-(sp)           ; Push the incoming parameters so
                                   ; a high-level language routine
                                   ; can access them using standard
                                   ; compiler parameter passing
                                   ; techniques.

       jsr      C-trap             ; Call a C handler to perform
                                   ; the desired kernel call.

;
; After the kernel call, this process may be context-shifted
; out. We have saved the user stack pointer with the register
; set so that we can do a complete restore later after some
; other user process has run.
;

       add.l    #12,sp             ; Strip the parameters off
                                   ; the stack.

       move.l   (sp)+,a0           ; Get the saved user stack
                                   ; pointer.

       move.l   a0,usp             ; Restore user stack pointer.

       movem.l  +(sp),#0x7FFF      ; Restore registers a6–a0 and
                                   ; d7–d0.

       rte                         ; Return from exception back
                                   ; to the user, restoring the
                                   ; CPU status and returning
                                   ; to user state of the CPU.
```

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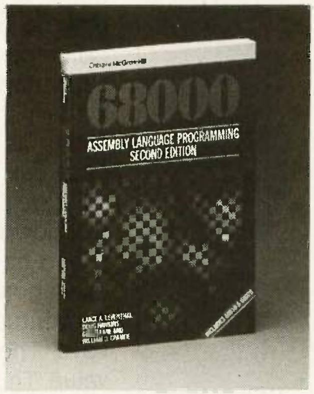

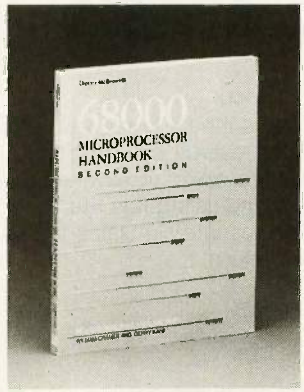

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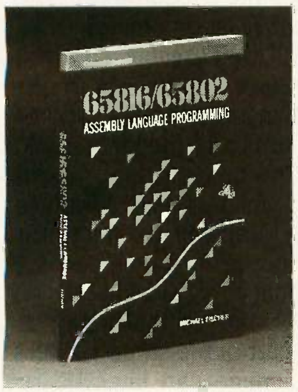

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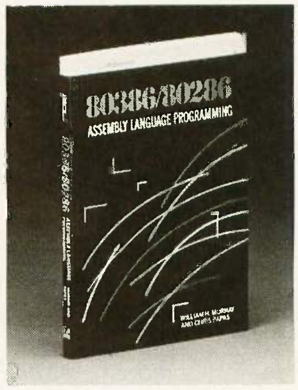

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when called, returns after some interval, during which other processes may have executed. Switch is the function that actually performs the selection of a new process and transfers control to that process.

The kernel also provides a wakeup function. Wakeup is used to make a process (which has been sleeping, waiting for some external event) ready to run. This is typically after the event has occurred.

CPU STATE SAVE IN A CONTEXT SHIFT

```
;
; save(save-area)
;
;       The function save( ) saves the CPU register state
;       in preparation for a later resume call. Registers
;       and user stack pointer are saved in save-area[17].
;       This save call returns 0, indicating it is the first
;       return from save. When resume simulates the second
;       return from save, it will return 1.
;
;       The save-area will look like:
;
;
;                      user stack ptr                      [16] = usp
;
;                                                          [15] = a7
;                      saved registers                     [14] = a6
;                      a7,a6,a5,. . . ,a1,a0               . . .  . . .
;                      d7,d6,d5,. . . ,d1,d0               [1]  = d1
;                                       < - - - save-area  [0]  = d0
;
;

save:   move.w    #0x2700,sr       ; Go to high-priority supervisor
                                   ; state to prevent interrupts during
                                   ; this function call. This also clears
                                   ; the rest of the status bits.

        move.l    4(sp),a0         ; Get address of register save-area.

        movem.l   #0xFFFF,(a0)+    ; Save all registers.

        move.l    usp,a1           ; Get user stack pointer.

        move.l    a1,(a0)          ; Save the user stack pointer.
;
; At this point other processing may occur, for example, the saving
; of other types of process description information, especially
; the stack image that contains the return address for this call.
;
;

;
; Note that a1, a0, and d0 are used as working registers here although
; they are also saved with the rest of the registers.
;

        move.l    #0x0,d0          ; The return value for this save
                                   ; call is 0. For this example the
                                   ; return value is presumed to be in
                                   ; d0 upon return from function call.

        move.w    #0x2000,sr       ; Go to low-priority supervisor
                                   ; state and enable interrupts.

        rts
```

Figure 4 shows sleep in a context switch. Sleep calls switch, which in turn performs two operations; it saves the current process's state and then selects the next process to run and runs it. Switch uses two critical functions to perform this: save and resume. Save is a function that, when called once, returns twice. Resume is a function that never returns. Resume actually transfers to some other save, acting as the second return for that save call.

Figure 5 shows an example of control flow from process A to process B and back again to process A. The execution of a sleep call in process A eventually calls switch, which calls save. The save call first returns a 0 value. This call also saves the state of process A for later resumption. Control after the first return from the save call continues into a resume call. This transfers control to process B. Later, process B will itself execute a resume call that transfers control back to process A. This resume (from B) acts as the second return of the save call in process A. This time the save returns the value 1, which causes switch to return to the sleep call, which returns to the user process.

Save's primary responsibility is to save the CPU state so that it can be included as part of the saved process image. The image can later be resumed.

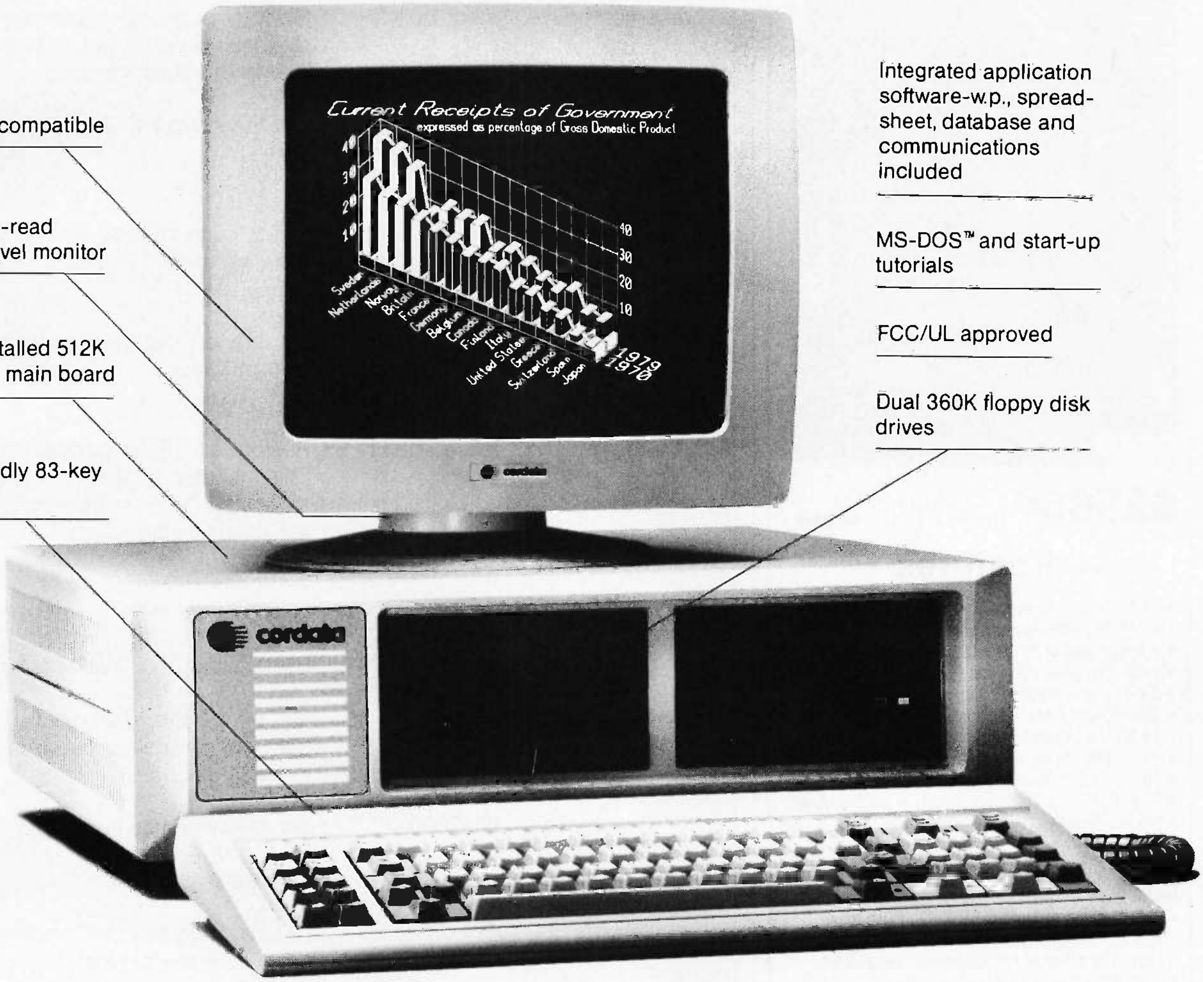
UNIX FORK PARADIGM

In UNIX all processes are created by making copies of existing processes, except, of course, the first process, which is handcrafted by the kernel during system boot-up. This process then splits in two using a fork( ) operation. Each child of this first process in turn can divide as many times as needed to create processes to perform all tasks desired.

To perform a new task, a child process may overlay itself with a new program image using an exec kernel call. Figure 6 shows the fork operation pictorially and demonstrates why the term fork was chosen for this operation.

(continued)

How to tell the men from the toys.



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Inquiry 94

CPU State Resume in a Context Shift

```
;
; resume(save-area, . . . . )
;
;        Resume the process whose saved CPU state is at save-area.
;
resume  move.w    #0x2700,sr        ; Go to high-priority supervisor
                                    ; state so you don't get interrupted
                                    ; during this state transition.

        move.l    4(sp),a0          ; Get the pointer to the CPU saved
                                    ; state.

;
; Here you may access other parameters, such as memory management
; information about how to map the new process.
;

; Before resuming the new process, its image must be appropriately
; restored (and possibly mapped using an MMU).
;

        movem.l   (a0)+,#0xFFFF     ; Restore all CPU registers.
                                    ; This includes a7, the
                                    ; supervisor stack pointer that
                                    ; still points to the return
                                    ; address of the original call.

        move.l    (a0),a1           ; Get the user stack pointer.

        move.l    a1,usp            ; Restore the user stack pointer.

        move.l    #0x1,d0           ; Get a 1 as the return value for
                                    ; the upcoming simulated return
                                    ; to save( ).

        move.w    #0x2000,sr        ; Go to low-priority supervisor
                                    ; state, that is, reenable
                                    ; interrupts.

        rts                         ; Return using the return address
                                    ; copy from the original call
                                    ; to save.
```

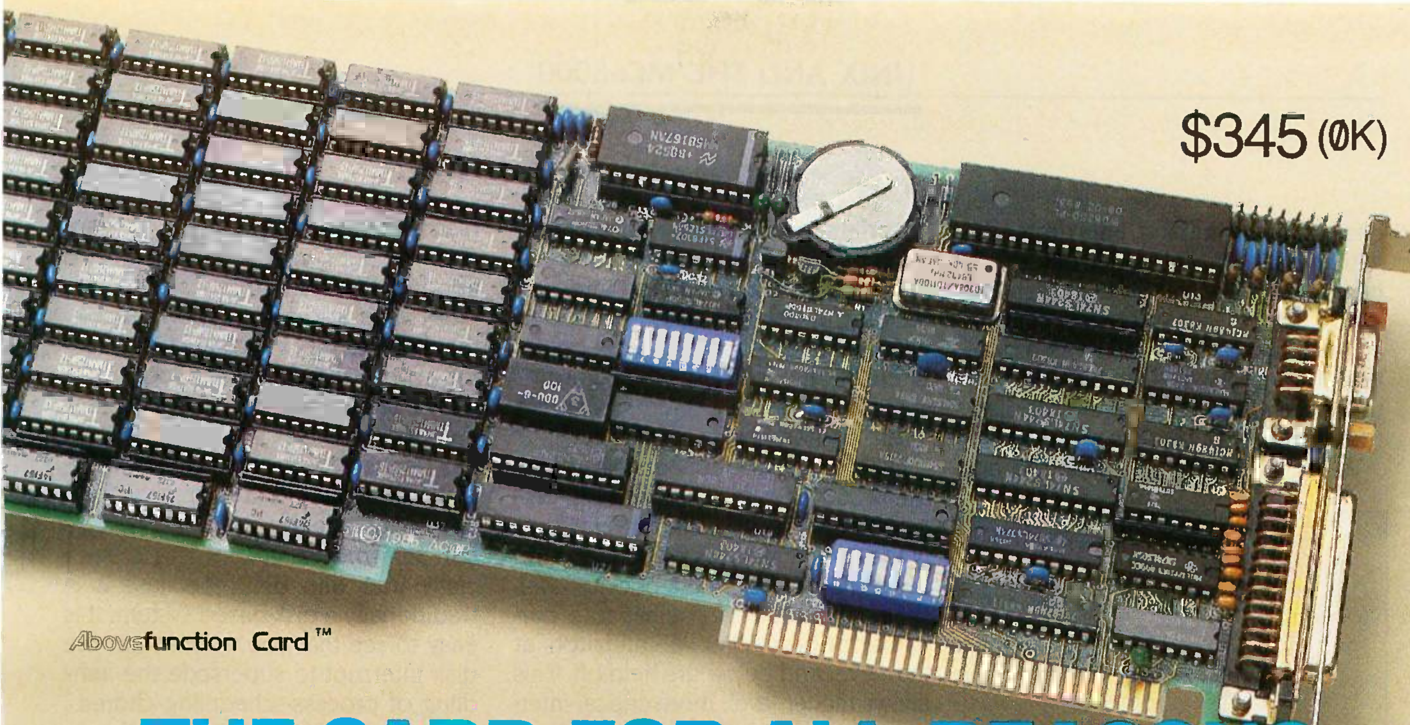
The programmer's view of the fork call is that of a function, fork( ), which, when called once, returns twice. (See the text box "A Programmer's View of Fork( )" on page 196). It returns once in the calling process with the pid of the new process created. It returns a second time in a new process that is an exact copy of the original except that the new process has a different pid number and the fork call returns the value 0.

During the context shift operation the kernel function save is used to save the process state and prepare a second flow of control to be used in the new process. Rather than terminating in a resume call, the first return from the save continues as the control flow in the parent process. (See the text box "A Kernel View of Fork( )" on page 198.)

Interrupt Handling and UNIX

The MC68000 processor provides a great deal of flexibility for the system

(continued)



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designer in handling interrupts. As with most processors, all interrupts can be handled in a vectored fashion. This is where each interrupt, internal and external, is associated with a location in memory (the vector address) that holds the address of the handling routine for that particular interrupt.

When an interrupt occurs, the appropriate location in memory or vector is used to fetch the starting address of the appropriate interrupt handler, and control is transferred to it (this is also how things work on the Intel 80286 processor). Figure 7 shows how vectored interrupts access interrupt handlers.

```
sleep( )
{
   . . .
   switch( )
   . . .
}

switch( )
{
   . . .
   if (save(proc) == 1)
      return
   . . .
   <select new process>
   . . .
   resume(new process)
}
```

Figure 4: **Sleep** *in a context switch.* **Sleep** *calls* **switch**, *which saves the current process state and then selects the next process to run and runs it.*

But this is all the 80286 really offers; the MC68000 offers a seven-level processor priority scheme for selectively masking interrupts. Each interrupting device is assigned a priority level. When the processor is set to a particular priority level, all interrupts at that level and below are held off. This allows higher-level, more critical interrupts to supersede the handling of lower-level, less critical interrupts. The Intel 80286 allows only for the turning on and off of all interrupts simultaneously, which is much less flexible.

This selective masking of interrupts is very useful to the UNIX system. Consider a low-priority event, the scheduling event triggered by a periodic interrupt from the system clock. While the scheduling of a process must occur in the multiprocessing UNIX system, it is not crucial that it be done at a precise moment. Any time the scheduling process is taking place, another interrupt can be handled without harm to the overall operation of the system.

```
Process A executing
  . . .
  sleep( )
    --> switch( )
          . . .
            --> save(A) . . .[saves the CPU state of process A]
            <-- returns . . .[on first return save( ) returns 0]
          . . .
          <select process B>
          . . .
          resume B ---------> Process B executing
                                . . .
                                sleep( )
                                  --> switch( )
                                        . . .
                                          --> save(B)
                                          <-- returns 0
                                        . . .
                                        <select process A>
                                        . . .
                    <-------------- resume(A)
                <-- returns . . . [on second return (from a resume) ]
                                  [save( ) returns 1                ]
      <-- returns
Process A continues execution
```

Figure 5: *Context shift control flow.*

Consider also a high-priority event, the disk interrupt indicating that a sector on the disk has been located. If this interrupt is not serviced immediately, the disk will rotate beyond the desired sector and time will be lost waiting for it to come around again. Such delays could impact system performance greatly. This is especially true with UNIX because it is traditionally a disk-based system. It is easy to see that you would want the disk interrupt to supersede the handling of process-scheduling chores.

On the MC68000 this is easily accomplished by making the disk interrupt a higher priority than the clock interrupt. This allows the disk interrupt to supersede the scheduling process and ensure that it is serviced immediately to prevent any disk performance loss.

On processors where interrupts cannot be selectively masked by priority, the disk interrupt would have to be held off while the scheduling interrupt is handled. Unless external interrupt priority hardware was provided, the disk sector would be missed and system performance would suffer. From the preceding example you can see the advantages of the MC68000 interrupt system for UNIX implementations.

You can also see that it is not necessarily just an advantage for a UNIX system. The situation described in the example could arise in many systems today. The MC68000 interrupt architecture provides the flexibility necessary to build an efficient interrupt control system.

C LANGUAGE COMPATIBILITY

UNIX, the MC68000, and C are all well suited for each other. C itself is a good systems programming language. In fact, 90 percent of the UNIX operating system and most of the user programs for UNIX are written in C. Since the MC68000 allows for a very efficient C compiler, this in turn provides an efficient UNIX implementation.

The compiler writer's task is made easy by the MC68000. The portable

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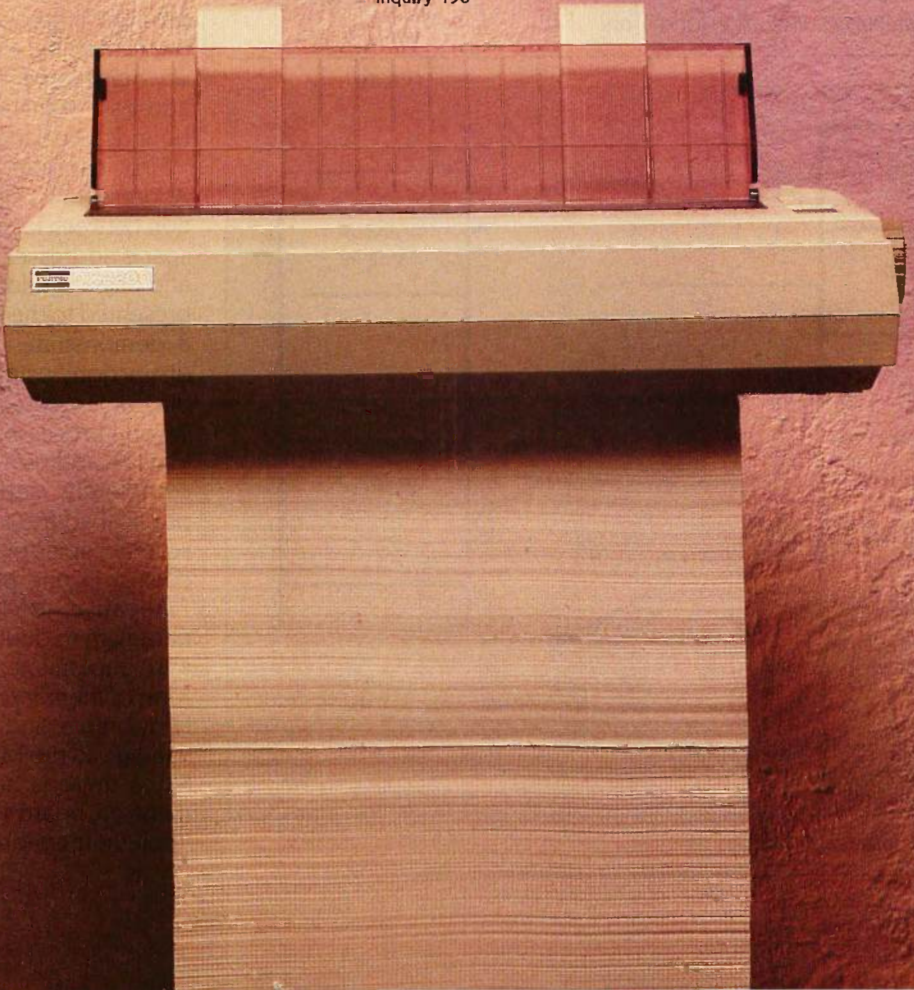

C compiler was designed for a register machine with two types of general-purpose registers. Setting up the data and address registers as these two types works very well. The MC68000's nearly orthogonal instruction set helps keep code generation straightforward. (An orthogonal instruction set is one in which any registers can be used with any instructions and with any addressing modes.)

The result of having a CPU that supports an efficient compiler is a code density (number of assembly instructions per C statement) that is good enough for libraries, system work, and even I/O drivers. The C programmer does see the CPU peeking through now and then even though C is a high-level language. For example, proper use of the register statement requires CPU knowledge.

C on the MC68000 also allows for efficient pointer/integer arithmetic. This is due to the 32-bit linear address space. An integer and a pointer are both 32-bit quantities.

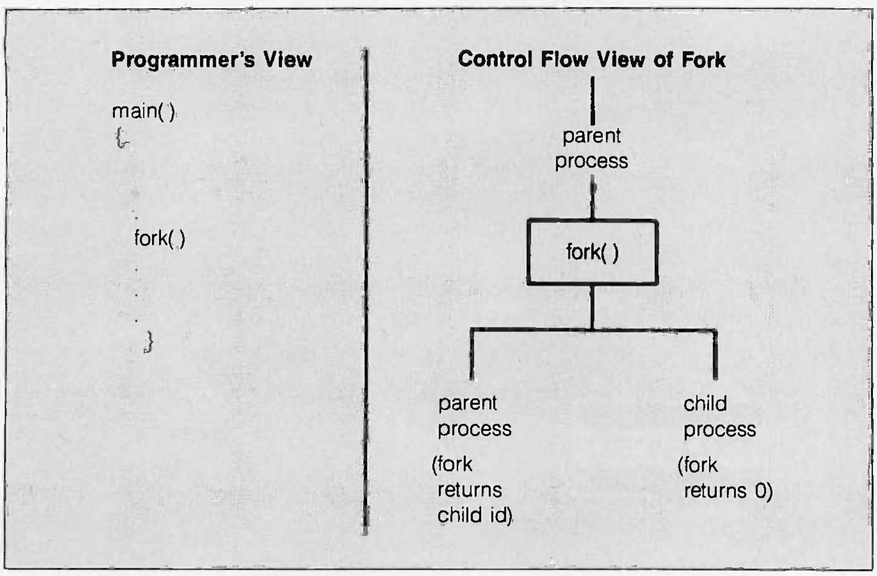

Figure 6: *The programmer's view of a* fork( ) *call.*

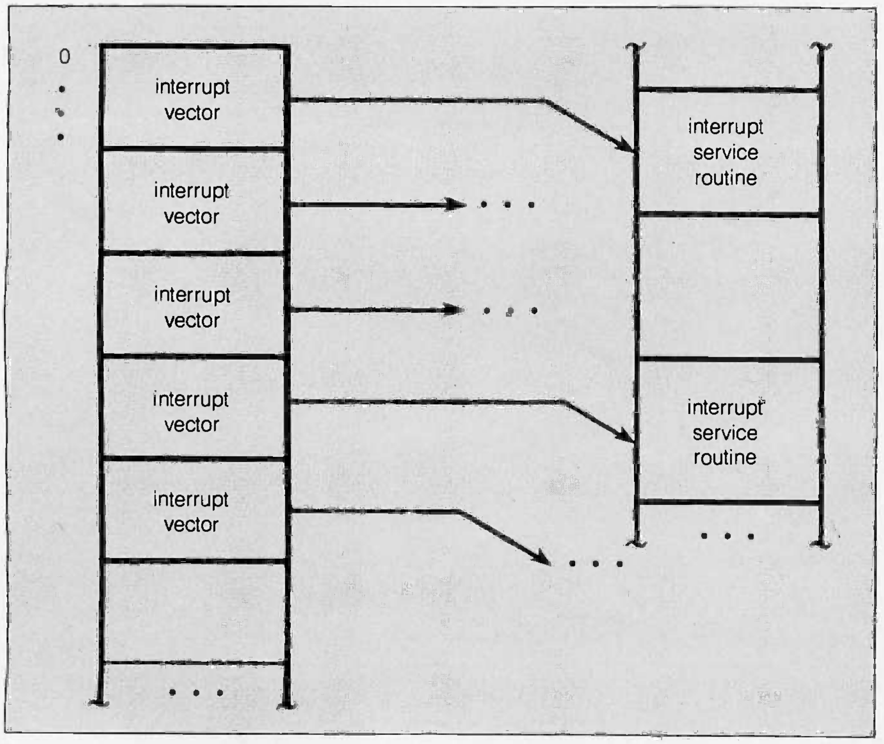

Figure 7: *Vectored interrupts.*

MISSING FEATURES

The MC68000 has some weaknesses with regard to UNIX implementation, primarily the omission of features that are typically implemented separately from the CPU using other VLSI support or discrete implementations. One point in favor of the MC68000 is that its architecture generally does not prohibit or impede external implementation of missing features.

The most glaring omission in the MC68000 family is memory management. The MC68000 philosophy is to do nothing for memory management rather than do a partial job. The MC68000 CPU generates 32-bit logical addresses. If these are to be translated into physical addresses, off-processor hardware to perform the translation must be provided. (Memory management typically consists of address translation and address bounds checking.)

First, consider address translation. Address translation involves a distinction between logical addresses (name-space addresses used in a program) and physical addresses, those that are presented to the main memory. Figure 8 demonstrates this logical/physical distinction using a system block diagram. Address translation allows several processes to use an identical logical address space while using completely separate portions of physical address space. This permits several copies of the same process to coexist in one physical memory.

Because UNIX uses the fork paradigm to duplicate user processes and implement multitasking, some form of memory management is highly desirable, and here there is an advantage to the MC68000 philosophy. Since there is no memory management on board the MC68000, UNIX implementers are forced to choose

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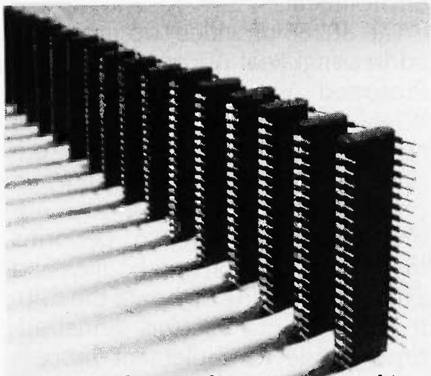

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their own style of memory management hardware and can select the trade-off between performance, price; and design schedule that is best for their target market.

MC68000 UNIX implementations on the market range in memory management unit complexity from no extra hardware to an MMU providing segmentation and paging. Memory management also involves memory protection, often implemented by bounds registers that are compared to user logical addresses. Memory protection allows several processes to coexist in the same physical memory without overwriting each other or reading each other's data.

A PROGRAMMER'S VIEW OF FORK( )

```
main()
{
          /*
           * Simple fork example program.
           */
          int child-pid;

          /* . . . */

          child-pid = fork();

          if (child-pid == 0)
               {
               /*
                * This is executing in the child process.
                */
               printf(" Hi from the child process. \ n");
               /*
                * At this point the child process may
                * overlay itself with another command
                * using an exec call; the fork-exec sequence
                * is the "normal" way to start a new program.
                *
                * Here the new program "factorize" is called
                * to overlay the child process image.
                */
               execv("factorize",argv);
               }
          if (child-id > 0)
               {
               /*
                * This is executing in the parent process.
                */
               printf(" Hello from the parent process. \ n");
               printf(" My child's id is %d \ n",child-pid);
               }

          if (child-pid == -1)
               {
               /*
                * This is executing in the parent process,
                * but the fork( ) failed, so there is no
                * child process.
                */
               printf(" FORK FAILED! Awk! \ n");
               }
}
```

Memory protection is highly desirable in a multiuser environment to protect users from each other. Although the MC68000 itself does not provide any form of memory protection, it does incorporate VLSI MMUs, the MC68451 and the MC68851. The MC68451 MMU provides memory translation in a segmented fashion and memory protection associated with each segment. The MC68851 provides address translation and bounds checking in a paged environment.

The 80286 provides two modes of addressing: Real Address Mode and Protected Virtual Address Mode. When operating in Real Address Mode, the CPU issues logical addresses, as does the MC68000. When operating in Protected Virtual Address Mode the 80286 performs memory translation and bounds and privilege checking on board the CPU. It is possible to use this virtual address mode to implement process separation in UNIX. This area is one in which the 80286 architecture makes implementation of UNIX easy, in that the implementer is not required to add external memory management hardware.

INTERRUPTIBILITY

The 68000 CPU is not restartable for all instructions. If the execution of a given instruction causes a fault (e.g., because of an MMU bounds violation), that instruction cannot necessarily be restarted transparently. Transparently here implies that the restart occurs in such a manner that the interrupted process cannot detect that the interrupt and restart have occurred.

Some MC68000 instructions can be aborted in such a manner that the internal CPU status cannot be recovered and restored. Such instructions cannot be restarted transparently. In a paged memory environment a CPU exception is typically generated by an MMU when a desired page is not in main memory. If the CPU cannot be restarted following the abortion of any instruction, the CPU cannot be used reliably in a paged memory environment.

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A KERNEL VIEW OF FORK( )

```
/*
 * Newproc is the internal, kernel form of the fork( )
 * system call. Newproc creates a duplicate of the
 * calling process and introduces it to the system.
 */
newproc( )
{
/* . . . */

/*
 * The new process memory image is duplicated. A new
 * entry in the procedure table is allocated and it is
 * filled with information about this new process.
 */
/* . . . */

if (save(save-area) == 1)
    {
        /*
         * When save returns with the value 1 (after a
         * corresponding call to resume) this copy of the
         * process continues execution. The two processes
         * are duplicates of each other, but traditionally
         * this process is the parent process. This
         * process is the one that originally called
         * fork( ) and is the one to which the kernel
         * will return the process number of the child.
         */
        /* . . . */
        return(1);
    }
/*
 * This flow of control will become the child process.
 * At this point any additional processing that is
 * necessary to make the child ready to run is performed.
 * The kernel will return a 0 value to the fork( )
 * call for this flow of control.
 */
/* . . . */
return(0);
}
```

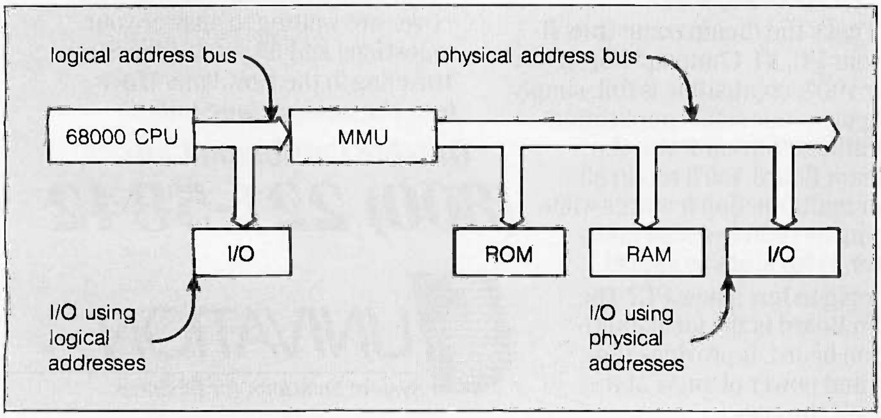

Figure 8: *Address translation.*

Bounds checking can also be used to detect user stack underflow and allow stack growth and process restart. The user memory bounds are set to the end of the user's stack. When an underflow occurs, the MMU generates a bounds violation. The exception handler for the bounds violation can allocate more memory for stack, remap the process, and restart the process. If the CPU cannot be restarted, the process cannot be guaranteed to recover properly after the stack region is expanded by the kernel.

The MC68010 and MC68020 do allow restart of any instruction. On MC68000 UNIX implementations it is possible to implement automatic stack growth using software conventions. A simple test is performed in the preamble to every procedure call to see if sufficient stack is available. This can be accomplished by touching the deepest possible region of use on the stack, using a dummy TST.B instruction. If the test fails, causing a CPU exception and kernel allocation of more stack, the process can be restarted at the instruction after the dummy TST.B instruction. Since this is a software convention, all programs wishing automatic stack expansion must conform to the convention to operate properly.

The text box "Recovery and Restart After a Bus Exception" on page 200 shows a typical bus error exception handler that calls a high-level language routine to implement user stack expansion and process remapping.

COPROCESSORS

The MC68000 family allows for multiple CPU environments. In the UNIX environment there is the possibility for much parallel processing if multiple processors are available. The MC68000 bus operates asynchronously. This aids in configuring buses with a multimaster capability that support multiple CPUs using the same memory and peripherals. Many types of coprocessors are common to UNIX implementations, including floating-point coprocessors, graphics coprocessors, and DMA (direct memory ac-

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cess) processors. Because UNIX is a multitasking system with multiple processes executing at any time, the operating system easily manages multiprocessor environments.

For example, the operating system may initiate a disk transfer on behalf of a process, start the operation on a DMA coprocessor, put that process to sleep, and continue executing another process. Similarly, processes may be put to sleep while graphics coprocessors operate on a user's terminal. The MC68000 family includes the MC68881 floating-point coprocessor, which can be used effectively in a UNIX environment.

SUMMARY

The MC68000 architecture provides a powerful yet simple programmer's model that makes UNIX implementation easy. The difficult programmer's model is a primary weakness of the typical segmented architectures in use in today's UNIX microcomputers, and in overcoming that, the MC68000 became a good choice for UNIX implementation. There are also other good choices, such as those UNIX products on the market that use segmented architectures and others that use stack architectures. Still, a majority of implementations use the MC68000 family.

The MC68000 has many architectural features that help UNIX implementation, including a large linear address space, dual-state processor, and a seven-level interrupt priority scheme. The processor architecture is conducive to using the C programming language, which is the primary development language for UNIX. Further, the MC68000 is a general-register processor that makes UNIX implementation easy because UNIX was originally developed on machines with similar architectures.

The weak side of the MC68000 architecture involves the omission of helpful features, in particular on-board memory management. This desirable feature represents the main advantage of the 80286, but when all factors are taken into account, it is apparent that the architecture of the Motorola MC68000 CPU processor is very well suited to UNIX implementation. ■

RECOVERY AND RESTART AFTER A BUS EXCEPTION

```
;
; The address of this routine is placed in ROM at the bus address
; vector location: vector number 2, memory address 8. Control
; transfers to this location at bus error time.
;
; Typically an MMU will cause a bus error when a bounds violation
; occurs (e.g., during stack underflow or page fault).
;
; At entry the stack will look like this:
;
; sp + 14
;
; sp + 12      Program
;               Counter          . . .  Restore during process restart
; sp + 10
;              Status Register   . . .  Restore during process restart
;
;              Instruction       . . .  Examine; verify stack underflow
;               Register
;                                . . .  Examine; verify stack underflow
;              Access Address           and determine how much memory
;                                       to allocate
;
; sp + 2
;                                . . .  Function Code; I/N bit; R/W bit
;
; sp—>
;
bus-fault      movem.l  #0xFFFE, - (sp)    ; Save d0-d7 and a0-a6.
                                           ; These will also be
                                           ; available to C-bus-handler.

               jsr      C-bus-handler
;
; A high-level language routine can examine the access address
; and instruction register to determine the reason for the
; fault. If the instruction being executed was a TST.B
; instruction and the access address is "slightly" below
; the stack, this may represent a stack underflow that
; requires stack expansion and process remapping.
; If this was not an implicit stack expansion request,
; the user process should be sent a signal indicating that
; the bus error occurred.

; Here the PC should be decremented and the aborted instruction
; restarted. Since the proper status cannot be assured on a
; 68000 CPU, the restart is not attempted. On the presumption
; that the bad instruction was a dummy TST.B, bus-fault simply
; restores what status it can and returns to the user.
;

               movem.l  (sp) + ,#0x7FFF    ; Restore the registers.

               addq.l   #8,sp              ; Strip fcode, access address,
                                           ; and instruction register
                                           ; off the stack.

               rte
```

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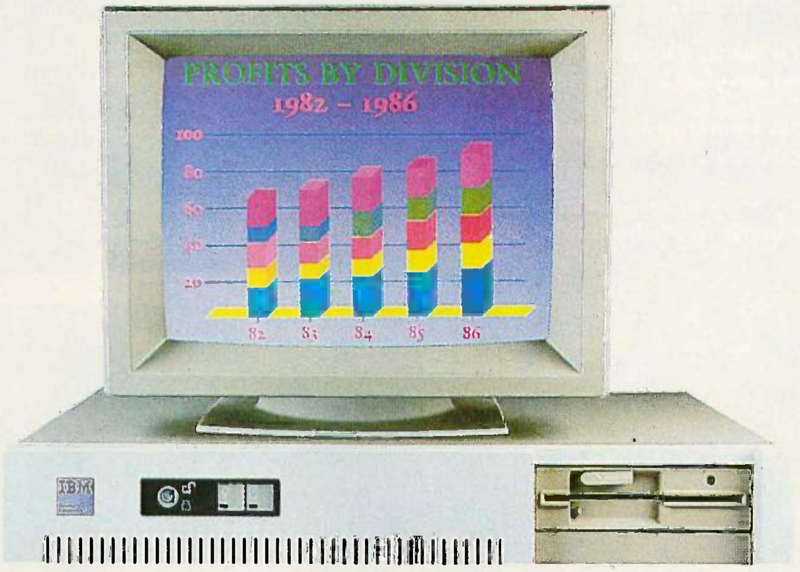

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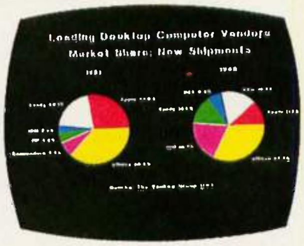

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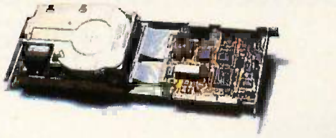

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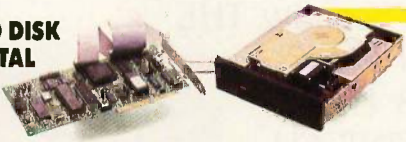

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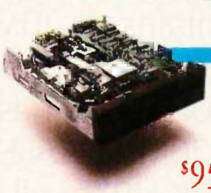

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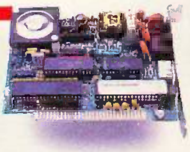

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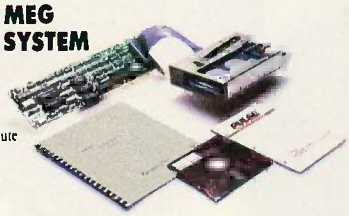

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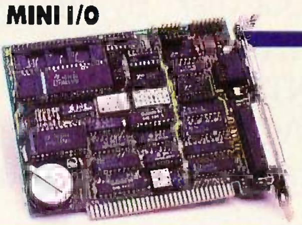

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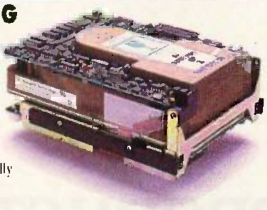

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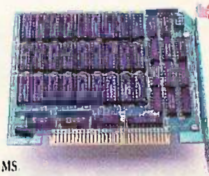

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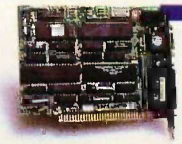

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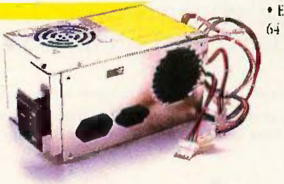

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A COMPARISON OF MC68000 FAMILY PROCESSORS

BY THOMAS L. JOHNSON

A look at the architecture and hardware and software compatibility

SINCE ITS 1979 introduction, the Motorola MC68000 microprocessor family has grown to five members: the original 16-bit MC68000; the MC68008, an 8-bit data bus version of the MC68000; the MC68010, a virtual memory/virtual machine version; the MC68012, an extended address version of the MC68010; and the MC68020, a full 32-bit virtual memory/virtual machine microprocessor (see figure 1).

Each family member includes architectural enhancements that offer certain advantages, in terms of software, hardware, and system design. However, the extent of software and hardware compatibility between the family members varies.

FAMILY OVERVIEW

The major external differences are in the number of address, data, and various control lines (see table 1).

The MC68000 family uses a three-wire function code that transmits to the system the processing state of the processor on a bus-cycle-by-bus-cycle basis. This allows the designer to maintain in the system hardware the memory privilege distinctions maintained within the processor. For the MC68000 and MC68008 these function codes can indicate either supervisor mode or user mode, program accesses or data accesses, and interrupt acknowledge bus cycles. The MC68010 and MC68012 use the same encodings on the function code pins but change the name of the interrupt acknowledge space to "CPU space." A CPU space access indicates either interrupt acknowledge or breakpoint acknowledge. The MC68020 expands CPU space accesses to include coprocessor communications and access-permission-level checking, which can be used in sophisticated memory management schemes to implement ring protection architectures. All encodings are done in an upwardly compatible manner, such that systems that recognize an interrupt acknowledge on an MC68000 will work properly even when an MC68020 is inserted in the system. (See figure 2.)

USER PROGRAMMING MODEL

To the user programmer, there is absolutely no difference in the on-chip resources available for any of the processors in the family. Thus, once a model has been assimilated, no retraining is needed when changing from one family member to any other. The base architecture for the user incorporates eight totally undedicated 32-bit data registers, which can be accessed as bytes, words, or long words (32-bit values) and used for either the source or destination of any operation that will allow the use of a data register (i.e., all arithmetic, logical, and data movement operations). Users also have at their command eight 32-bit address registers that can be accessed as either 16-bit or 32-bit entities. Only one of these registers may be considered dedicated—A7 is the implicit user stack pointer for subroutine calls and so forth.

Rounding out the user model is an 8-bit condition code register and a full 32-bit program counter. The condition code register contains not only the "normal" condition bits for arithmetic

(continued)

Thomas L. Johnson is a staff engineer at Motorola Inc. (6501 William Cannon West, Austin, TX 78735-8598).

and logical operations (zero, carry, overflow, negative), but also a bit for extended-precision operations (extended).

The inclusion of 32-bit structures foreshadowed the design of the full 32-bit MC68020—setting the stage for upward compatibility of user-level code in the future processors.

SUPERVISORY PROGRAMMING MODEL

A look at the supervisory-level programming model (figure 3) finally reveals the differences in functionality of the family members. Whereas the user-level program has access only to user-level resources, the supervisory-level program has access not only to the complete user-level model, but also to the full supervisory-level programming model for that processor. Note that the supervisor stack pointers are also referred to as A7. An automatic context switch concerning these stack pointers occurs as flow changes from supervisory to user level and back again without the necessity of loading and reloading stack pointer registers. Table 2 encapsulates all of the resources available to the supervisory-level program on the various processors.

Progressing from the MC68000 to the MC68020, more instructions are available to manipulate the additional supervisory resources, and each model is a proper subset of the next higher processor. Thus, code that manipulates the condition code register on the MC68008 (the 8-bit version of the MC68000) will execute intact on any other of the processors.

This form of "supersetting" the resources on newer family members ensures upward compatibility and is maintained within the family for the supervisor and user programming models, the instructions (to the bit level), the address modes, and all data types.

ADDITIONAL SUPERVISORY-LEVEL RESOURCES

The vector base register (VBR), introduced on the MC68010, allows a supervisory-level program to relocate the 1K-byte exception vector table to anywhere in the physical address map of the processor. This exception vector table is used in the MC68000 family to route specific exceptions to the appropriate handler within the supervisory code space. The vector table consists of 256 four-byte entries, each of which may be used to point to the entry address of its specific handler. Of these 256 vector entries, 37 to 39 vectors (depending on the processor) are dedicated to handling predefined exceptions such as bus errors, TRAP instructions, and so forth. An additional 26 vectors have been reserved for future expansion of functionality, and 192 vector entries can be defined by the user.

The alternate function code registers (SFC and DFC) allow the supervisor to retrieve and modify data in *any* address map (user or supervisor, program or data). On all family members, the function code outputs are driven automatically based on the

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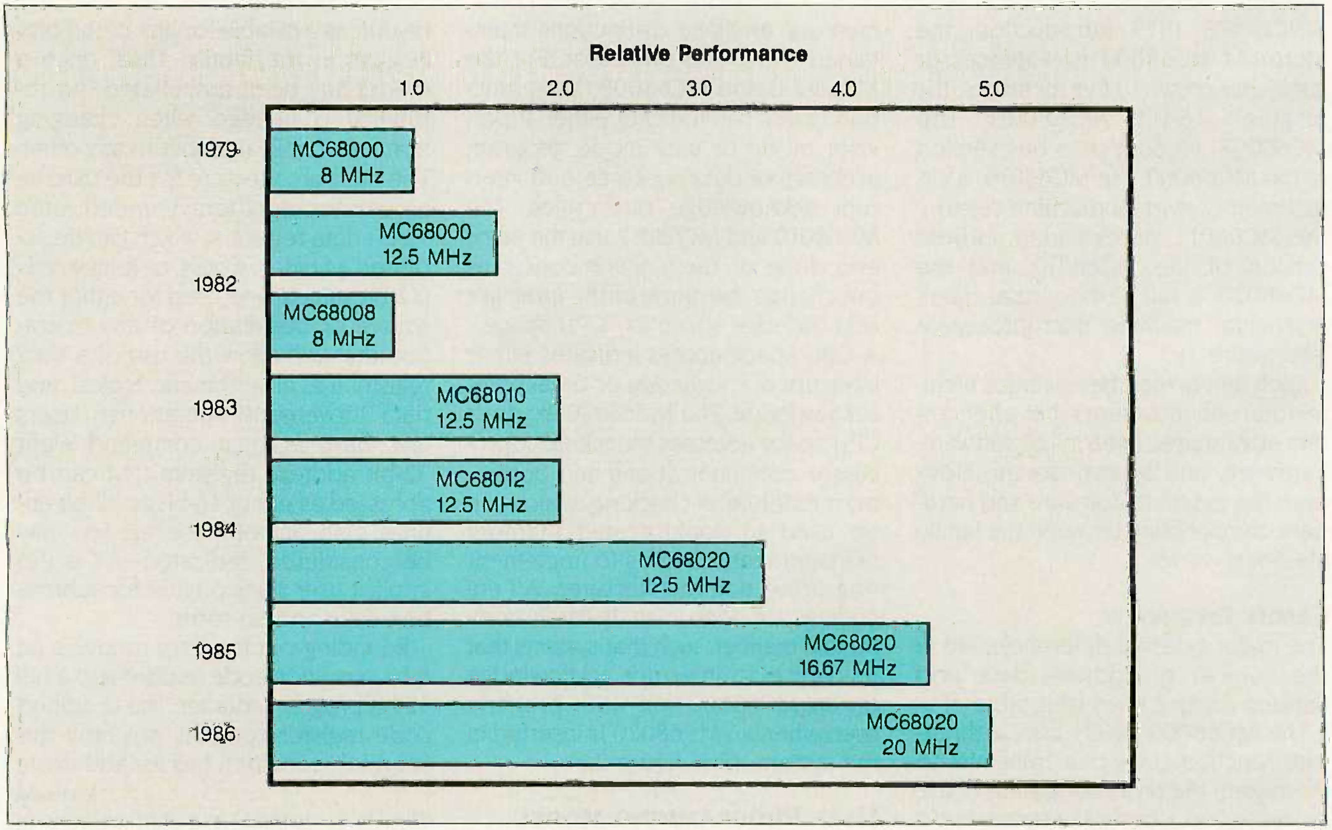

Figure 1: *The* MC68000 *family genealogy.*

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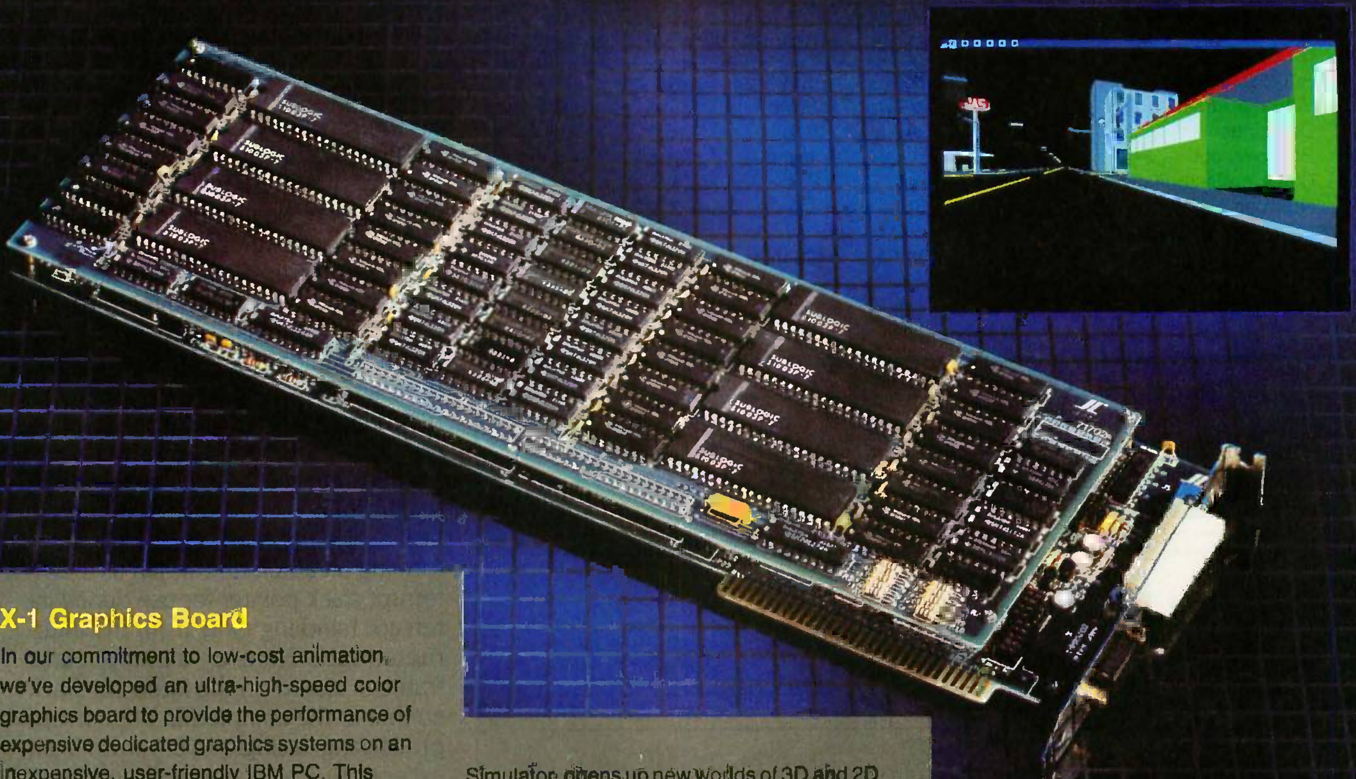

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type and location of the memory bus cycle, and these outputs may be used to enforce hardware protection in the memory subsystem. Because the MC68000 and MC68008 are not virtual machine processors, they have no need to override this hardware-enforced protection, but the MC68010, MC68012, and MC68020 processors require this ability. The alternate function code registers allow these newer processors to perform that function to control the virtual environment.

The two cache control registers introduced in the MC68020 (the cache control register—CACR, and the cache address register—CAAR) allow the supervisor to control the on-chip instruction cache memory (64 four-byte entries) for that device. The cache powers up as disabled, and the supervisor, at its discretion, may choose to enable it at some later time. Additionally, the supervisor can selectively invalidate cache entries.

The MC68020 status register contains an additional bit for control of the hardware tracing mechanism built into all the family members. The MC68000, MC68008, MC68010, and MC68012 can trace any given instruction or sequence of instructions when the supervisor enables the tracing mechanism. The MC68020 can also trace only on a program change of flow instruction, such as branch or jump.

Table 1: A *pin-out comparison.*

	MC68000	MC68008	MC68010	MC68012	MC68020
Address lines	24	20/22	24	31	32
Virtual address range	16Mb	1Mb/4Mb	16Mb	2Gb	4Gb
Data lines	16	8	16	16	32
Bus protocol	async	async	async	async	async
Clock cycles/bus cycle	4	4	4	4	3
Number of data strobes	2	1	2	2	1
Number of transfer acknowledges	1 (DTACK)	1 (DTACK)	1 (DTACK)	1 (DTACK)	2 (DTACK)
Function code lines	3	3	3	3	3
Bus arbitration lines	3	2/3	3	3	3

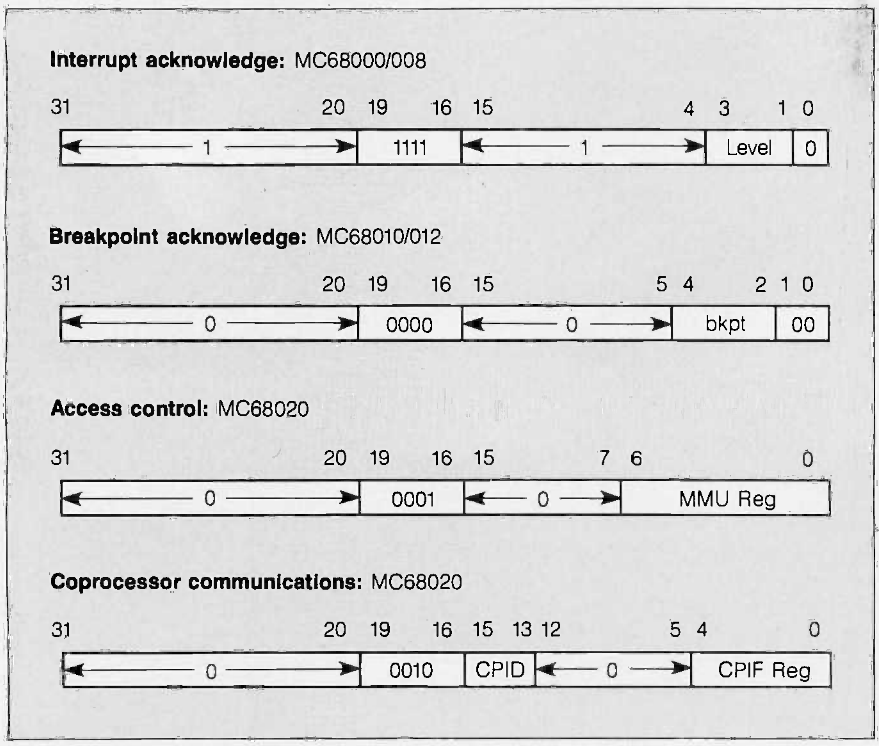

Figure 2: *CPU space address bus encodings* (FC0–2 = 111).

The only other added supervisory resource is the master stack pointer (MSP), also new on the MC68020, which allows the separation of task-related and non-task-related exception stacking. In use, the MC68020 powers up and loads the interrupt stack pointer as the active supervisory stack pointer. This is the equivalent to the power-up sequence of any other family member in which the single supervisory stack pointer is loaded. At some later time, the operating system may choose to enable the master stack pointer by enabling the MSP bit in the status register (the stack pointer select bit). From that point on (until disabled), all common program exceptions, including TRAPs and divide-by-zero, that occur will cause state information to be saved on the master stack until an interrupt occurs.

Since interrupts are asynchronous events that will normally have no bearing on the task currently executing in a multitasking environment, it is desirable to separate the interrupt-related information from the task-related information. This is accomplished by first stacking the task-related information from the current task on the master stack and then performing an automatic switch to the interrupt stack pointer for use during interrupt handling away from the interrupted task. Here, a "dummy" stack frame is stored on the interrupt stack so that at the completion of interrupt processing, a single RTE (return from exception) instruction will automatically cause a switch back to the master stack pointer, for reloading the previously saved task state and resumption of that task. The benefit is that the supervisor need not provide stack space for interrupts that may occur during normal task execution and may be unrelated to the currently executing task.

INSTRUCTION SETS

On the MC68020, the RTE instruction can perform a large number of dis-

(continued)

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crete functions (check for dummy frame, change stack pointers, reload state); however, this is the same instruction used on the MC68000, MC68008, MC68010, and MC68012. The function performed by the RTE will relate to the resources and functionality available on the respective processors. Thus, for the MC68000 and MC68008 to return from interrupt processing or normal exception handling, this instruction simply restores the status register and program counter of the suspended task from the supervisory stack pointer, whereas on the MC68010 and MC68012 it also checks the stack format and can reload the more substantial amount of information for the saved internal state. On all processors, the RTE instruction performs whatever is necessary to return from an exception.

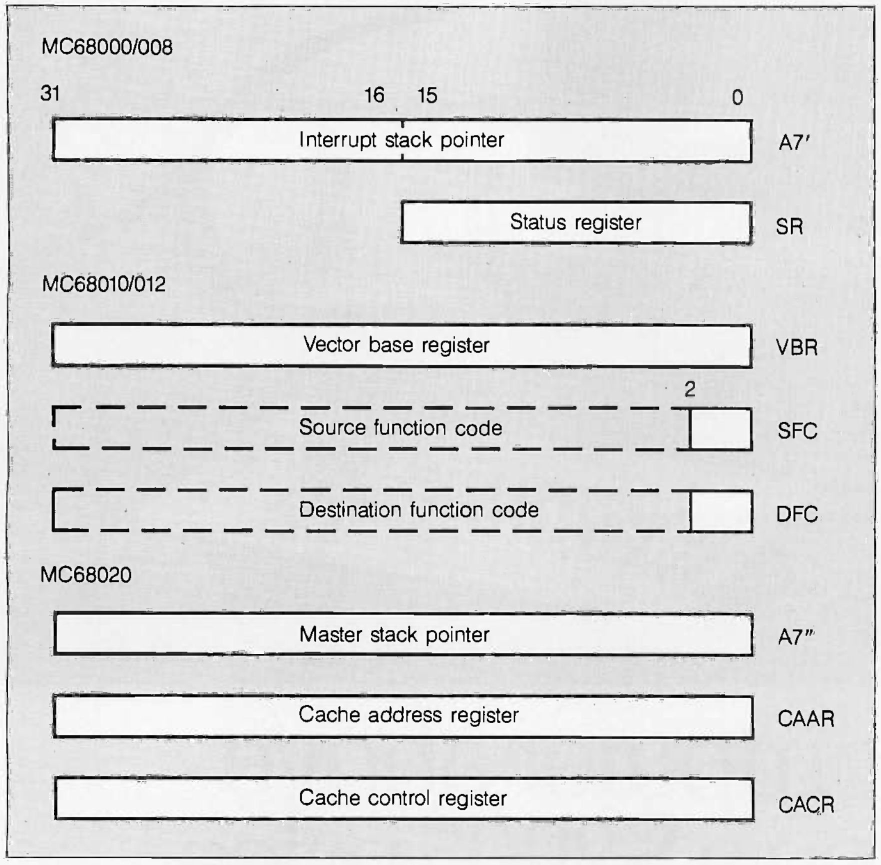

Figure 3: *The supervisory programming model.*

Table 2: *A comparison of supervisory resources.*

	MC68000/008	MC68010/012	MC68020
Status register			
Hardware trace bits	1	1	2
Supervisor state bit	yes	yes	yes
Interrupt mask bits	3	3	3
Stack pointer select	no	no	yes
Stack pointers			
Interrupt stack	yes	yes	yes
Master stack	no	no	yes
Vector base register	no	yes	yes
Cache control registers	no	no	yes
Alternate function codes	no	yes	yes

The instruction set of the base architecture, that of the MC68000, consists of a set of user-available instructions and a set of *privileged* instructions for control of sensitive system resources. The later family MPUs enhanced this instruction set (see table 3).

ADDRESS MODES

As with the instruction sets, the address modes are also upwardly compatible from one family member to another. All address modes on MC68000 family processors can be generally divided into four main categories: *data*, if an address mode may refer to data operands; *memory*, if the address mode may be used to refer to operands in memory; *control*, if the processor needs absolutely no knowledge of the size of the operand prior to calculation of the effective address; and *alterable*, if the mode may refer to writable operands (see table 4). Since it is possible to refer to an alterable data operand in memory, it follows that any given mode may be classified in more than one category.

The address modes in table 4 are exactly the same for the MC68000, MC68008, MC68010, MC68012, and MC68020 microprocessors. These modes provide a substantial amount of flexibility and power. For instance, the (An)+ and −(An) modes allow for the maintenance of up to eight stacks per task, a particularly attractive capability in the artificial intelligence arena. To these modes, the MC68020 adds one more mode: memory indirect. The memory indirect mode has a large number of variations and can best be illustrated by the syntactical expressions

([bd,An],Xn.size*scale,od) and

([bd,An,Xn.size*scale],od)

In these new modes, bd and od refer to optional sign-extended 8-, 16-, or 32-bit base and outer displacements; An, to an optional base address register (A0–A7); Xn, to an optional index register (D0–D7 or A0–A7); size, how much of the index register is to be used (16 or 32 bits); and scale, to a scaling factor for the index register (1, 2, 4, or 8).

(continued)

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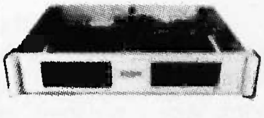

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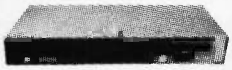

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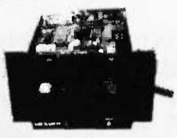

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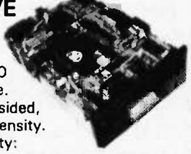

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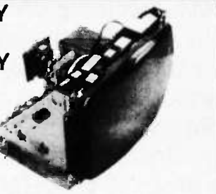

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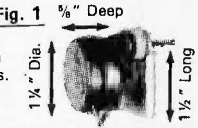
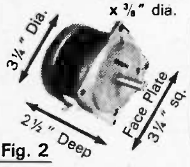


Fig. 2



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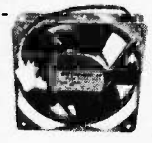

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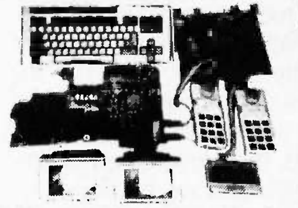

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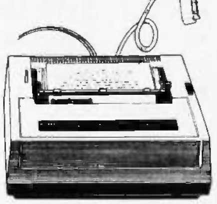

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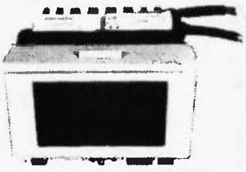

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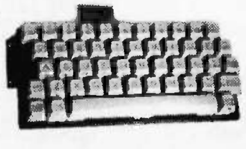

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Because the memory indirect mode allows any of the base displacement, base address register, index register, and outer displacement to be optional, and allows the index register to be added to the address calculation either before or after the first address access (pre- and post-indexing), any conceivable combination of these modes is allowed. This includes displaced memory indirect ([bd],od), data register indirect (Dn); and register doubly indirect ([Rn]).

The addition of these new modes, however, in no way impacts the compatibility of the earlier modes. Any address mode legal for the MC68000, MC68008, MC68010, and MC68012 operates exactly the same on the MC68020.

VIRTUAL OPERATION

Due to the internal architecture of the processors, there are three basic machines: the MC68000/008 architecture, the MC68010/012 architecture, and the MC68020 architecture. In a nutshell, any user-level code written to execute on the MC68000/008 will execute unchanged on any of the other processors, and any user-level code written to execute on the MC68010/012 will execute unchanged on the MC68020. This upward compatibility applies even to the binary level. The major difference between the processors insofar as exception processing is concerned is in the state frame information that is stored as a result of an exception in support of virtual memory and virtual machine operation.

Virtual memory is a technique that allows all tasks executing on a processor to behave as if each had at its disposal the entire addressing range of the processor, regardless of the amount of physical memory present in the system. Virtual machine is a technique in which all processor and system resources required by a task appear to be present, even if not implemented. To support the virtual memory capability, any given instruction must be "abortable" and in some manner "restartable."

For example, suppose that task A is executing a 32-bit memory-to-memory MOVE instruction and the physical piece of memory required for the destination operand is not currently available. The fetch of both the instruction and the source operand are successfully accomplished, but when the write to the destination is attempted, the memory manager indicates a "not-resident" fault by means of a bus error or fault line to the processor. The processor must then save the state of task A, find an empty piece of memory (possibly by swapping a currently resident piece to a disk), load the target piece of memory from the disk, restore task A, and allow the MOVE instruction either to restart or complete. So, from the time of the fault until the completion of the MOVE instruction, task A was not executing but has no indication of this fact.

Although all MC68000 family processors have the "abort" capability

(continued)

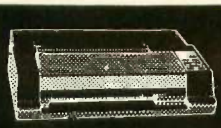
Table 3: *A comparison of instruction sets.*

	MC68000/008	MC68010/012	MC68020
Data movement	7	9	9
Arithmetic/logical	17	17	18
Binary-coded decimal	5	5	7
Single operand	9	9	9
Shift and rotate	8	8	8
Bit manipulations	4	4	4
Bit-field manipulations	0	0	8
Branches (16 conditions)	3	3	3
Exception-related	5	7	8
Control	12	13	20
Coprocessor generic instructions	0	0	7
Total	70	75	101

Table 4: *The base architecture address modes.*

Mode	Syntax	Data	Memory	Control	Alterable
Data register direct	Dn	•			•
Address register direct	An				•
Address register indirect	(An)	•	•	•	•
Address register indirect with post-increment	(An)+	•	•		•
Address register indirect with pre-decrement	–(An)	•	•		•
Address register indirect with displacement	d(An)	•	•	•	•
Address register indirect with index	d(An,Rx)	•	•	•	•
Absolute short	xxx.W	•	•	•	•
Absolute long	xxx.L	•	•	•	•
PC relative with displacement	d(PC)	•	•	•	
PC relative with index	d(PC,Rx)	•	•	•	
Immediate	#xxx	•	•		

Dn refers to any of the eight 32-bit data registers, D0–D7.
An refers to any of the eight 32-bit address registers, A0–A7.
Rx refers to any 32-bit register, D0–D7 or A0–A7.
d refers to an 8- or 16-bit sign-extended displacement.
+, – refer to the automatic post-incrementing/pre-decrementing of the specified address register by 1, 2, or 4 depending on the size of the target operand (1, 2, or 4 bytes).



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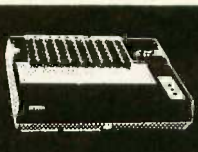

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via the bus error (BERR) input of the processors, the MC68000 and MC68008 are not virtual memory processors and therefore do not have all the features necessary to support virtual memory. Specifically, insufficient internal processor state information is available on receipt of a bus fault to allow recovery of the faulted instruction. The other family members (MC68010, MC68012, and MC68020), however, save sufficient state information to allow complete restoration of the faulted instruction. The faulted instruction should be recovered by one of two methods: *instruction restart*, in which the processor is "backed up" to the start of the instruction that caused the fault, or *instruction continuation*, in which the faulted instruction is allowed to complete execution from the point of the fault. The choice of method may seem to be a matter of computer science dogma, but actually it is of practical importance. The advanced address modes on the MC68000 family and the desire to protect the user from "processor thrashing" caused the designers of the MC68000 family to choose the instruction continuation method.

INSTRUCTION CONTINUATION

Processor thrashing can be a very debilitating problem for virtual memory systems. The example used above can also be used to illustrate this problem. In the example, it was assumed that the op code and source operand fetches occurred without incident, but a fault was taken on the operand write. Since most memory replacement algorithms look for unmodified segments to be swapped out (because these segments don't need to be written to a disk prior to releasing the memory space), a good candidate can be the page containing the source operand. If this segment is chosen to be swapped with the destination page, then when the instruction is restarted (rather than continued), the instruction will once again fault—this time for the fetch of the source operand. Thrashing has now begun, with the source and destination areas continually being swapped with one another (since no writes to memory will ever occur), and the instruction will never complete. Some replacement algorithms also factor the "age" of an area into the selection process, so the thrashing will normally be limited to two restarts. However, most operating systems will dispatch a new task while waiting for the disk subsystem to fill the requested area, and therefore the newly filled area will be "aged" somewhat by the time it finally gets used. Instruction continuation, utilized by the MC68010, MC68012, and MC68020, completely alleviates this problem because once an area has been successfully accessed, it is never needed again by that instruction.

Due to the virtual requirements and the need to accomplish this virtuality without massive operating system code, the MC68010, MC68012, and MC68020 have larger stack frames associated with the bus error exceptions (see figure 4). On the MC68000/008 processors, very little information must be saved for bus errors because the MPUs accommodate system faults rather than virtual faults. The MC68010/012/020 processors, on the other hand, save more internal information in support of instruction continuation. These variances in stack frames are buried in the exception handlers operating in the supervisory mode of an operating system. Only those exception handlers that deal with the maintenance of the supervisory stack or expect values at specific offsets on the supervisory stack are affected by the stack differences.

Thus, any exception handler code that is written to execute on one processor will require only minor or no changes to execute on another family member processor. These software changes are a normal part of upgrading a system, since memory management systems are typically upgraded from one system to the next—particularly when going from a nonvirtual memory environment to a virtual memory environment. However, the specific type of memory management implemented has no bearing on the compatibility, since the processor itself is not affected by the memory management scheme chosen.

The instruction continuation method protects the user from processor thrashing.

PHYSICAL BUS INTERFACE

All members of the MC68000 family use the same simple asynchronous

(continued)

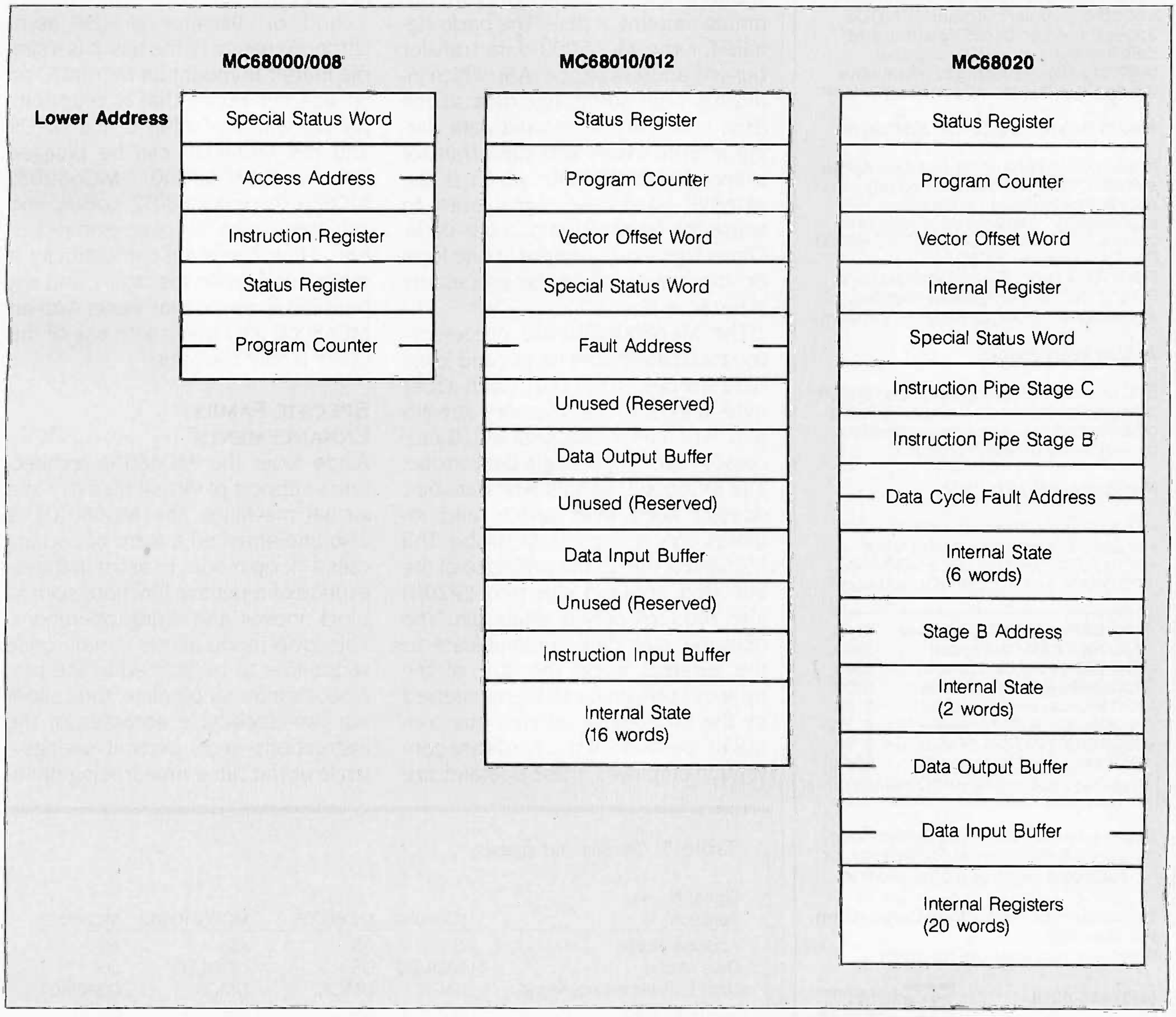


Figure 4: *Bus error stack frames.*

The MC68010/012 implemented the loop mode and support for program breakpoints.

bus interface to the outside world. On an asynchronous bus, the processor starts the bus cycle, and the external world controls the length of this cycle. Because of this, each portion of the memory subsystem (including memory-mapped peripherals) can respond to the bus cycle in its own optimum amount of time. The basic signals for the MC68000 data transfer bus are address strobe (AS), which indicates valid addresses; data strobe (DS), which indicates valid data during a write cycle; and data transfer acknowledge (DTACK), which is the external handshake signal used to cause the termination of a bus cycle. These signals are present in one form or another on all of the processors (see table 5).

The MC68000/010/012 processors use two data strobes (upper and lower data strobes, UDS/LDS), which act as byte selects to the memory subsystem, whereas the MC68008/020 processors use only a single data strobe. The MC68008, with its 8-bit data bus, doesn't need byte selects and requires only a single data strobe. The MC68020, due to the presence of the encoded operand size pins (SIZ0/1) also requires only a single pin. The operand size pins communicate to the external world the size of the operand remaining to be transferred by the MC68020's internal bus controller. Because of the hardware convention employed, these operand size pins may be combined with the low-order two address bits to generate the needed byte selects. The MC68020 dynamic bus sizing feature, which is enabled by encoding the data transfer acknowledge signals (DSACK0/1), allows the memory port size to change from 8 to 16 to 32 bits on a bus-cycle-by-bus-cycle basis (with one undefined-reserved encoding). Also, the MC68020 supports operand misalignment to the byte level.

The major difference in the external bus cycles is that the MC68000/008/010/012 execute a minimum bus cycle in four clock cycles, while the MC68020 executes its minimum cycle in only three clock cycles (see figures 5 and 6). Because of the asynchronous nature of the bus, it is a simple matter to mount an MC68020 on an adapter board that is plug-compatible with any other of the MPUs, and the MC68020 can be plugged into an MC68000, MC68008, MC68010, or MC68012 socket and can operate the bus of an existing system. Thus, hardware compatibility is maintained within the family, and any peripheral device that works with an MC68000 also works with any of the other family members.

SPECIFIC FAMILY ENHANCEMENTS

Aside from the MC68010 architecture's support of virtual memory and virtual machines, the MC68010/012 also implemented a form of caching called "loop mode" to assist in the execution of repetitive functions such as block moves and string operations. This loop mode allows certain code sequences to be latched in the processor's internal pipeline, thus allowing two-clock-cycle accesses of the instructions—a 50 percent savings—while at the same time freeing band-

Table 5: *Transfer bus signals.*

Signal Name Function	MC68000	MC68008	MC68010/012	MC68020
Address strobe	AS	AS	AS	AS
Data strobe	UDS/LDS	DS	UDS/LDS	DS
Data transfer acknowledge	DTACK	DTACK	DTACK	DSACK0/1
Operand size	n/a	n/a	n/a	SIZ0/1

width on the external data transfer bus. The sequences are composed of a 2-byte instruction, such as MOVE or ADD, which is followed immediately by a decrement and branch on condition (DBcc) instruction back to the 2-byte instruction. When the processor recognizes this sequence, it simply recycles the instructions and performs only data accesses to the outside world until the loop is terminated.

In addition to the loop mode, the MC68010/012 implemented special support for program breakpoints. Here, the recognition of a breakpoint *bit pattern* (one of eight specific illegal instruction encodings) causes the processor to execute a specific CPU space bus cycle during the exception processing for the illegal bit pattern to indicate that a breakpoint has been reached.

The MC68020 takes both of these features (loop mode and breakpoints) one step farther. The MC68020 has an on-chip 256-byte instruction cache, which increases overall processor performance from 40 percent to 80 percent, depending on the locality of reference exhibited by the code being executed. Code showing the greatest locality of reference (e.g., short loops) will show the greatest performance improvement by turning on the cache, while code that exhibits less (or no) locality of reference (long loops or in-line code) will show less (or no) performance increase. The cache is implemented on the MC68020 as a direct-mapped 64-entry by 32-bit cache. The supervisory programmer has control over this new resource by means of the cache control register.

The MC68020 enhancements to the MC68010 breakpoint function not only cause the processor to run the breakpoint acknowledge bus cycle just as before but also allow external hardware to supply a 16-bit instruction op code to be executed in place of taking the illegal instruction trap. This means that the MPU can execute the breakpoint a fixed number of times, substituting the replacement op code each time through the loop until the count expires and the breakpoint halts the loop.

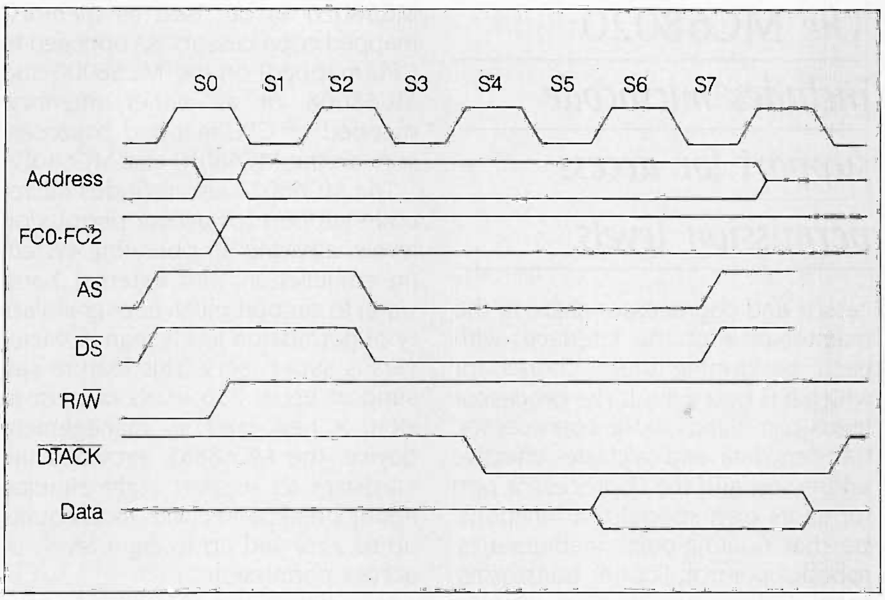


Figure 5: *The* READ *bus cycle for the* MC68000, MC68008, MC68010, *and* MC68012.

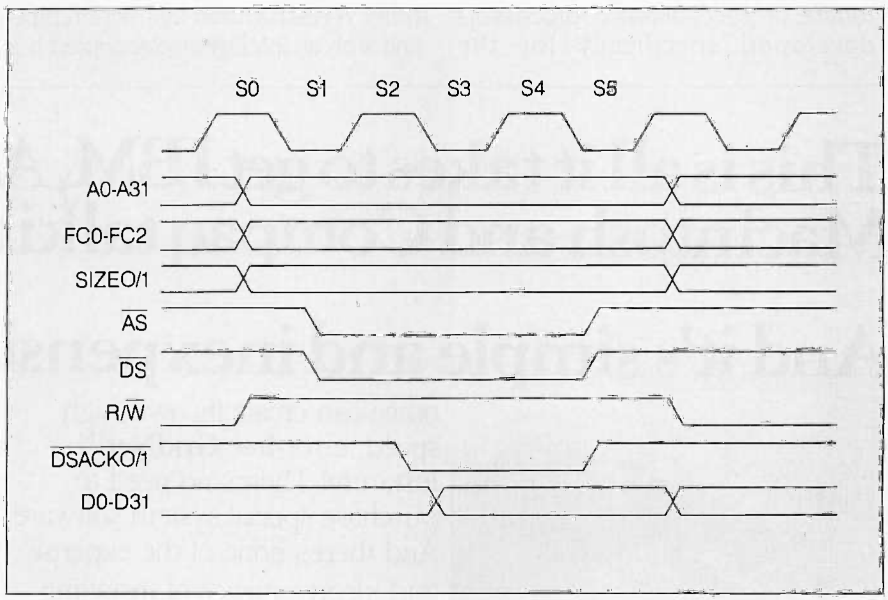


Figure 6: *The* READ *bus cycle for the* MC68020.

The MC68020 is the first processor in the family to offer inherent support for coprocessors. This coprocessor interface allows any coprocessor developed for the MC68020 also to be used on any other of the family members. This is accomplished by making the maintenance of the coprocessor interface reliant on standard read/write bus cycles. Because the interface is generic in nature, new processor designs will not require reworking existing coprocessors, and new coprocessor designs will not require reworking existing processors. In fact, the coprocessor interface gives users of the microprocessor an opportunity to develop their own custom coprocessors.

The extensibility offered by the coprocessor interface is one of the most powerful features of the MC68000 family architecture. Both the pro-

(continued)

The MC68020 includes microcode support for access permission levels.

cessor and coprocessor share in the maintenance of the interface, with each performing those chores for which it is best suited: The processor feeds commands to the coprocessor, transfers data, and calculates effective addresses, and the coprocessor performs its own specialized functions, be that floating-point mathematics, robotics control, Fourier transforms, graphics functions, or anything else. While the MC68020 offers implicit microcode support for the coprocessor interface, emulation of the interface protocol allows coprocessors developed specifically for the MC68020 to be used as memory-mapped coprocessors (as opposed to CPU-mapped) on the MC68000 and MC68008 or as either memory-mapped or CPU-mapped coprocessors on the MC68010 and MC68012.

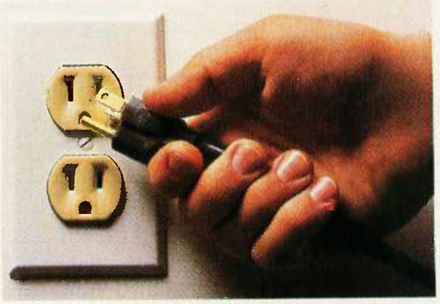
The MC68020 also includes microcode support for access permission levels, allowing an operating system (in conjunction with external hardware) to support much finer granularity of permission levels than just user versus supervisory. This feature can support up to 256 levels of permission. A new memory management device, the MC68851, provides the hardware to support eight simultaneous breakpoints (with loop counts up to 256) and up to eight levels of access permission.

In addition, the MC68020 has full 32-bit ALUs and a 32-bit barrel shifter for improved performance on arithmetic, logical, and bit-field instructions. A restructured instruction pipeline with an intelligent, decoupled bus controller allows a high degree of concurrency in instruction execution with external bus activity.

CONCLUSIONS

In the final analysis, the name of the game is compatibility. And the bottom line of compatibility between members of the MC68000 family shows that, for user code, all family members are 100 percent upwardly compatible for object code, while supervisory-level code only requires changes in supervisory-level exception handlers that use specific information on the supervisory stacks. Hardware compatibility is also good. In fact, an MC68010 can be directly inserted into an MC68000 socket, and an MC68020 could also be used with the appropriate adapter board.

The MC68000 family provides not only high performance in a commercial microprocessor, but also compatibility, protecting the user's software investment. ■



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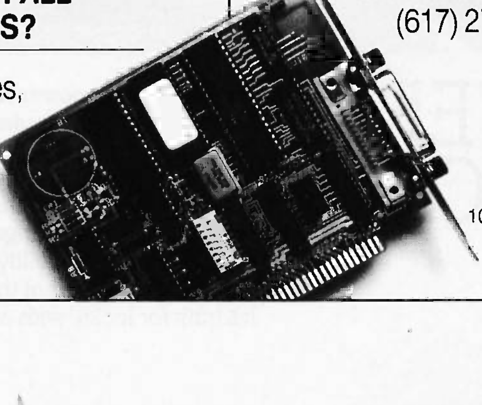

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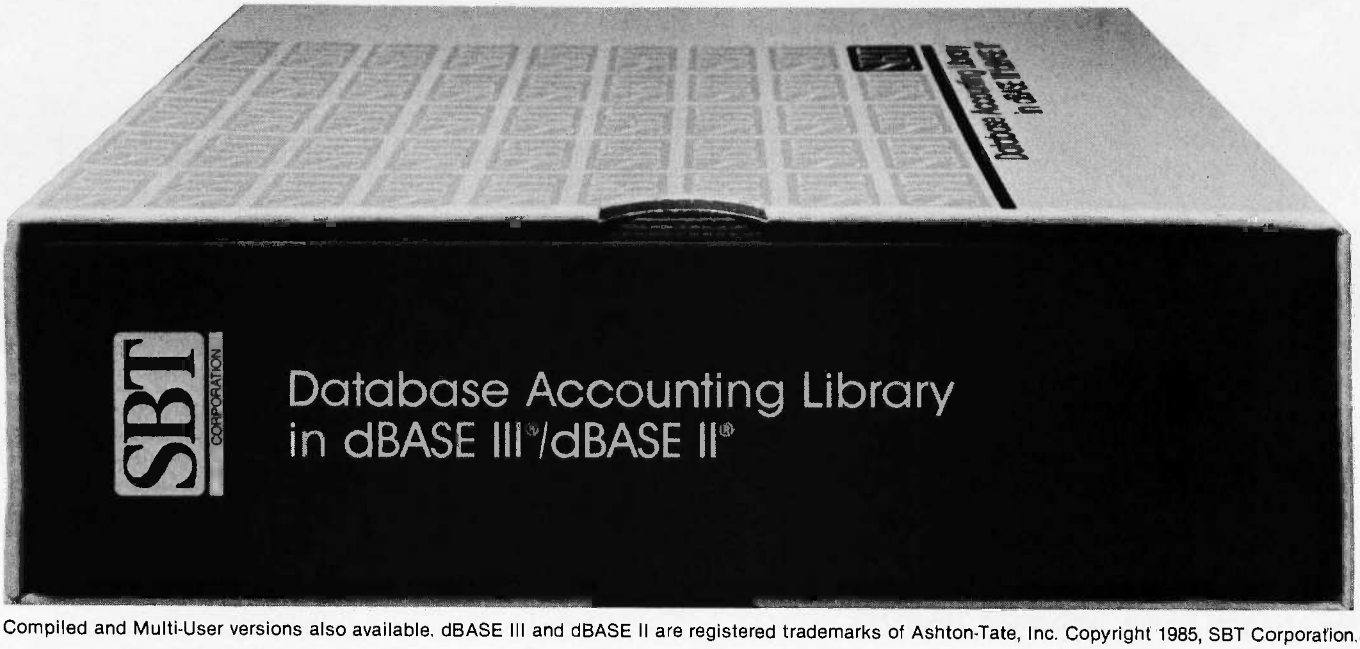

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ATARI ST SOFTWARE DEVELOPMENT

BY MICHAEL ROTHMAN

A survey of the TOS *operating system that comes with the* Atari ST

THE ATARI ST is one of several recently introduced microcomputers that use the Motorola MC68000 microprocessor. In this article I'll describe the organization of the ST's operating system, called TOS, and show some ways the 68000 influences it. TOS is approximately 200K bytes. Its organization is somewhat confusing because it has three parts that partially overlap in functionality. The two main parts, GEM (Graphics Environment Manager) and XBIOS (Extended BIOS), were originally designed independently and have somewhat different purposes. GEM, a complete operating system developed by Digital Research, is meant to support applications that are portable to other machines (at this writing, GEM has also been implemented on the IBM PC and compatibles).

The Atari-written XBIOS is meant to support ST-specific capabilities not accessible through GEM. For example, the ST's sound chip can be accessed only through the XBIOS. But in some cases, the differences between GEM functions and XBIOS functions are subtle. (For example, GEM and the XBIOS each have a function to read or write sectors to devices. The XBIOS function assumes the actual ST disk and is knowledgeable about its physical characteristics; the GEM function supports a number of devices that are logically but not physically similar.)

The third part of TOS, the Atari-written Line A Handler, overlaps almost entirely with the graphics routines of GEM—indeed, GEM graphics routines call the Line A Handler to do their work. The Line A Handler will let programmers write faster graphics routines than with GEM.

I've organized this article around the various parts of TOS, which means that you will sometimes encounter similar functionality discussed in two different places. (See figure 1.)

GEM

Most people probably identify GEM with the icons, menus, and windows of the GEM user interface, called the Desktop. The Desktop, however, is not technically part of the operating system. It is an application, automatically invoked by the operating system after the system boots.

GEM includes the GEM disk operating system (GEMDOS), the GEM Virtual Device Interface (the VDI—a powerful set of graphics routines), and the GEM Application Environment Services (the AES—a selection of special libraries designed to support the distinctive GEM user interface).

GEMDOS

GEMDOS contains the basic input/output system (BIOS), a disk file handler, and a number of functions to support peripheral devices, memory allocation, and the system clock. The BIOS handles low-level character I/O to five different devices: the printer, an auxiliary device (the RS-232C port), the console, a MIDI port for use with music synthesizers, and the keyboard. The routines read or write a single character to these devices or return status information.

(continued)

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The BIOS contains a single routine to read and write to appropriate devices on a sector basis (i.e., floppies, hard disks, networks). Two routines detect whether media in such devices have changed and return a map of the devices actually present.

Another routine returns a pointer to the BIOS parameter block (BPB) for a particular drive. The BPB is a block on the disk containing certain disk parameters, such as the number of bytes per sector or the number of directory entries. It is loaded into RAM when the disk is first accessed. The ST BPB is software-compatible with an MS-DOS BPB, right down to the 16-bit quantities in the BPB, which are written in low-byte, high-byte order—8086 style! (The 68000 orders quantities with the high byte in the lowest memory address.) Using the 8086's ordering of the 16-bit quantities in the BPB was presumably done to make porting GEMDOS from the 8086 to the 68000 easier.

Finally, the BIOS contains a routine to set the 68000's exception vectors in the low end of memory, a routine that returns the system timer value, and a routine to set or get the state of Shift and Control keys on the keyboard and the mouse buttons.

THE FILE HANDLER

GEMDOS supports a hierarchical file system similar to that of MS-DOS. The file-handling functions are

- Create, open, read, write, seek in, close file.
- Get, set file attributes.
- Create, delete, get, or set a subdirectory.
- Get disk free space.
- Directory search, file rename.

THE REST OF GEMDOS

The remaining GEMDOS functions let you

- Handle character I/O on the standard input and output.
- Check the status of a peripheral device.
- Get and set time and date.
- Terminate an application.
- Allocate or deallocate a memory block.

THE VIRTUAL DEVICE INTERFACE

GEM's graphics routines, known collectively as the VDI, provide a systematic way to handle a large number of graphics primitives in a device-independent fashion.

Graphics primitives are drawn by software that is tuned to the particular hardware at hand. The software does not simply move a prestored block of pixel data into memory; instead, it takes a mathematically described notion, like a circle with a diameter *x*, and calculates what pixels to change. Thus, if the lower-level software is properly written, closely equivalent results can be produced on different devices.

A wide variety of primitives have been defined in the VDI, and you can instruct the software to draw them with various attributes by using the portable VDI routines (the portable portion is sometimes called the Graphics Device Operating System, or GDOS). A number of device drivers have been written to support the primitives across several devices.

The VDI routines can "think" in either raster coordinates (RC) or normalized device coordinates (NDC). The raster coordinate system corresponds to the actual target's screen resolution. Thus, if you are working on the ST in its highest resolution, 640 by 400, you can call the VDI routines to place and size objects in terms of this resolution. Alternatively, you can use normalized device coordinates, which are always 0 to 32,767 in both directions, and the software will adjust for the particular device. The trade-off for the additional portability is that the software must do a transform on the object being drawn. The NDC space origin also differs from RC space in that it starts in the lower left corner rather than in the upper left corner of the device.

WRITING AN APPLICATION USING THE VDI

The first step in using the VDI is to specify the devices for graphics output. An application must always call the Open Workstation routine for each graphics device that the VDI routines will subsequently manipulate. This function takes an array containing the user's requested defaults for graphics characteristics such as line style, color, character size, fill color, and so on. It is here the developer also specifies the choice of NDC or RC coordinates.

In addition to a device identifier (handle), the routine passes back two large arrays (combined into one in the C language binding) that tell you the device's characteristics (e.g., the number of colors it supports and the size of its pixels in microns) and what VDI functions and attributes it supports.

For convenience, the VDI also provides the ability to open virtual screen workstations so that you can maintain several different sets of default characteristics for the screen device. Each of these workstations is attached to the real screen: Just change which one you specify in your subsequent VDI

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```
TOS consists of:
  GEM consists of:
    GEMDOS consists of:
      BIOS
      Disk File Handler
      Various System Functions
    Virtual Device Interface (VDI)
    Application Environment Services (AES)
  XBIOS
  Line A Handler
```

Figure 1: *Organization of TOS. GEM is an operating system in its own right, written by Digital Research and implemented across other machines such as IBM PCs and compatibles. The XBIOS and Line A Handler parts of TOS were written specifically for the Atari ST and provide faster and in some cases the only access to the capabilities of the ST.*

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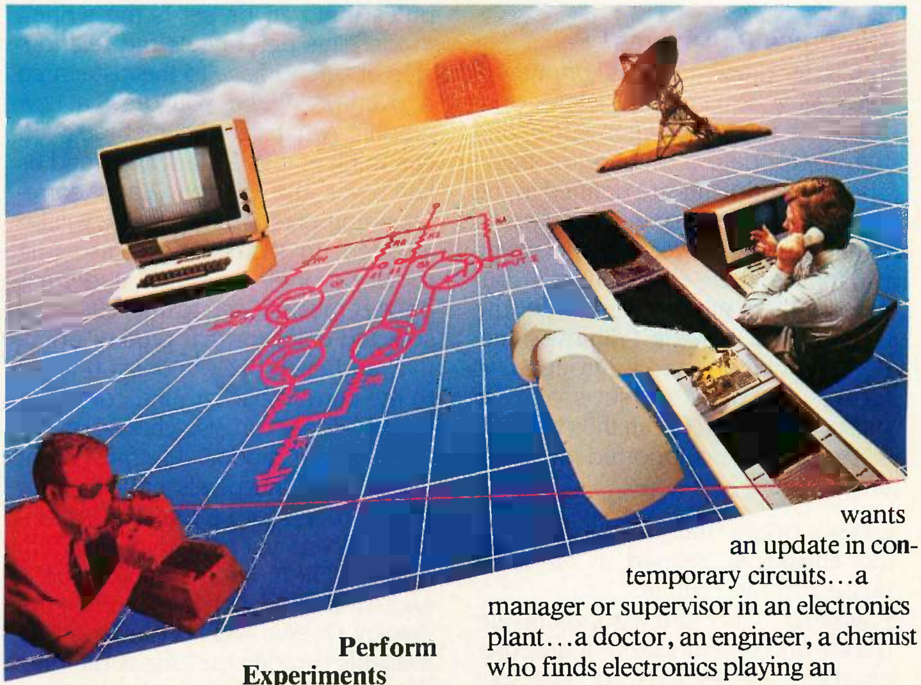

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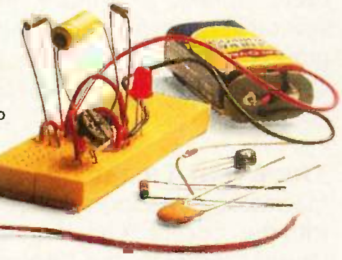

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routine, and the defaults will change appropriately.

The VDI functions themselves are too numerous to describe in detail, but most of them can be considered under three headings: graphics primitives, attribute functions, and text functions.

GRAPHICS PRIMITIVES

You can draw graphics primitives, such as a square, a polyline, or a rounded rectangle, after specifying the appropriate attributes for each. Size and endpoints are defined in the chosen coordinate system and passed to the routine. Several of the primitives have their own routines, but most of them are grouped under the Generalized Drawing Primitive function. Primitives can be grouped to form more complex objects, and sophisticated graphics can thus be built.

The primitives supported on the ST are

Polyline: Draws straight lines connecting endpoints defined in an array passed to the routine.
Polymarker: Only the endpoints are drawn, and several different graphics (markers) are available to represent those points.
Text: Note for novice programmers: isn't it nice to know you have been using a graphics primitive all along?
Filled area: The area is a complex polygon, again specified in an input array.
Contour fill: A seed fill.
Generalized Drawing Primitive: The GDP is a single entry point for the following primitives: bar, circle, arc, pie, ellipse, elliptical arc, elliptical pie, rounded rectangle, and filled rounded rectangle. If you are programming in C with the Atari-supplied developer's package, these are bound as separate functions.
Justified text: Can be justified left or right.

ATTRIBUTE FUNCTIONS

The attribute functions of the VDI manipulate characteristics of the graphics primitives. The developer can set color for both fills and lines. The polyline width is variable, as are the type of line (e.g., dashes or dots can be substituted for a solid line) and the end type (arrow, squared, or rounded). The polymarker function, which essentially lets you draw a connect-the-dots figure, is supported by an attribute function to change the type of "dot" or marker.

One of the most important attributes that can be set is the writing mode. This determines the relationship of a new image to the raster area it overlays. When you draw a new graphic, whatever the method, you can think of it as a mask of 1s and 0s laid over the display. Each corresponding pixel on the device will be affected. In the simplest case (the replace mode), each pixel under a 1 on the mask is set to the currently selected color for that type of primitive, and each pixel under a 0 is set to the current background color. But the developer can also choose one of three other modes. In transparent mode, only the pixels under 1s are changed. In reverse transparent, only the pixels under 0s are changed. And in XOR mode the mask value is exclusive-ORed with the value on the display. (Twelve additional modes are available through the Line A Handler, described below.)

All the attribute functions take effect for all subsequent relevant graphic operations, until the developer changes the attributes once again.

TEXT FUNCTIONS

The VDI provides two ways to handle text. One is an Alpha mode with its own set of functions, which on the ST implements an 80-column by 25-row text mode (in high and medium resolution). Alpha mode is not compatible with most of the other VDI functions; that is, you cannot display other graphics with text in this mode.

Much more interesting is text handling within the normal graphics mode, where text and graphics can be completely intermixed. The VDI supports two basic text output functions (regular and justified) and a sophisticated set of attributes, including multiple fonts (two are built into the ST, more have been developed by third parties). The developer can change the character height absolutely (in terms of the chosen graphics coordinate system) or in "points," the system used in print shops. The baseline of the character can be set at various angles (thus allowing rotated characters—on the ST, only multiples of 90-degree rotation are supported). And the characters can be thickened, skewed, underlined, outlined, or shadowed. In addition, text attributes include the standard VDI characteristics such as color and write mode.

THE GEM APPLICATION ENVIRONMENT SERVICES

The AES is an umbrella name for several libraries of routines, most of which implement various data abstractions for the developer. That is, some of these "services" gather together functionality available elsewhere in GEM to express useful concepts, such as windows or events.

But the AES also includes the part of GEM that manages the interaction between application and certain system capabilities that run concurrently. As a developer, you rarely need to think about this limited multitasking, precisely because it is limited and exists mainly to service system needs. Those needs are the desk accessories and the Screen Manager.

GEM supports several desk accessories: tasks that are selected by the user from drop-down menus, each of which occupies its own window. It also supports the Screen Manager, an application that runs concurrently with whatever else is going on and monitors user interaction with the menus and window borders.

The AES functions also comprise an event library, a window manager, several libraries for managing certain graphic data structures, a scrap library, a shell library, and a resource library.

THE EVENT LIBRARY

Macintosh developers will be familiar with the concept of an event manager. On that machine, the ideal program is seen as a loop. During each pass through the loop, the Mac waits for any one of several "events" specified by the developer, usually keyboard activity or mouse movement/selection, responds appropriately, and

(continued)

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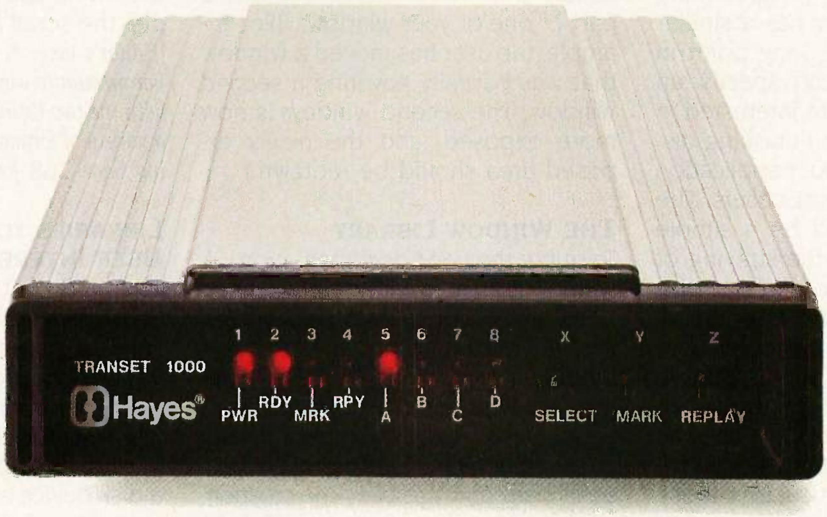

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then goes to the top of the loop.

Although GEM is much less radically tied to a particular programming style, the event library has a similar function on the ST. At any point in your program, you can specify an event or events you are interested in waiting for, and the multitasking dispatcher will suspend your application until one of those events occurs. The events included could be a simple keystroke or perhaps the straying of the mouse cursor into and out of a rectangle defined by your application.

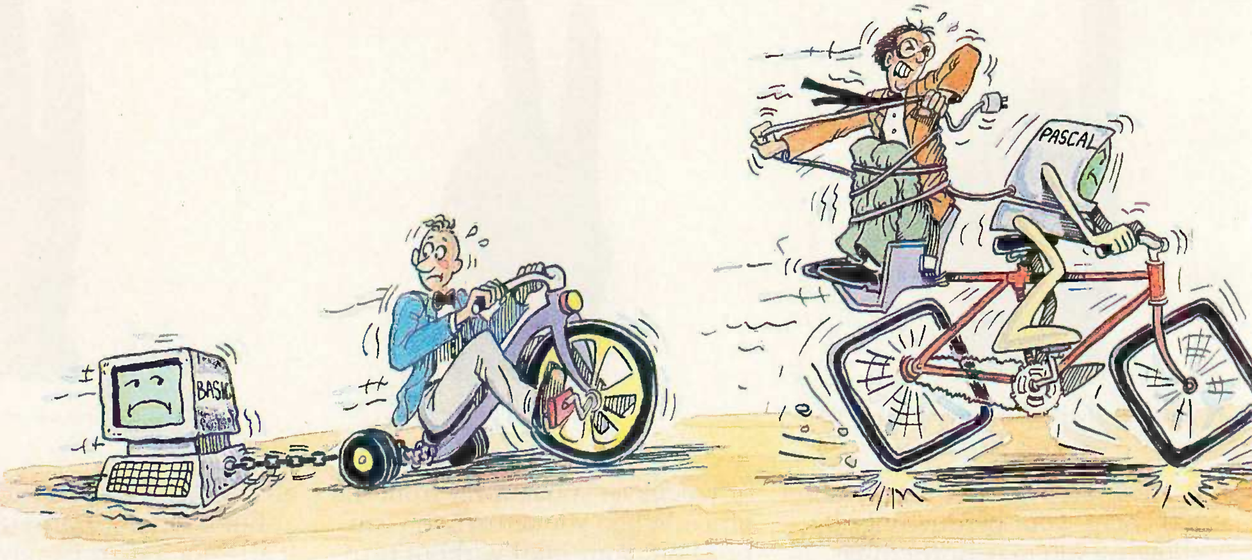
Giving your program the information it needs to do its part is the job of the message events. To wait for certain events, you call a routine specific to the event in question. For more complex events, particularly those concerning user interaction with screen windows, you call a routine that waits for a "message" from the AES. A message is a multibyte code that is placed in a buffer whose address you pass to the routine. Predefined system messages tell you, for example, that the user has taken an action that necessitates redrawing part of one of your windows. (For example, the user has moved a window that was partially covering a second window. The second window is now more exposed, and the newly exposed area should be redrawn.)

THE WINDOW LIBRARY

To quote the GEM documentation, "A window is an area with clearly defined boundaries." Anyone who has worked with the Macintosh or one of the user interfaces that mimic it will be comfortable with the GEM window concepts, which (as of this writing) included the familiar title bar, close box, scroll bars, and size box. The creation, care, and feeding of windows is handled by the routines in the window library. In general, the GEM division of responsibility for the user interface is that the developer is expected to handle and update the work area inside a window's frame while GEM handles the drawing and updating of the frame itself, including, for example, the scroll bars, the title bar, etc. [*Editor's note: A program that illustrates a fair amount of window work is available, along with the two listings printed in this article, in a variety of formats. See the insert card following page 368 for details.*]

LIBRARIES TO SUPPORT THE USER INTERFACE

The AES contains a number of routines concerned with manipulating various graphic data structures that your application can use for a standard user interface. For example, the File Selector Library provides a standard dialog box that lists the files on a disk device and allows you to select one. The Graphics Library is concerned mainly with drawing boxes on the screen. For example, it will draw an expanding box outline that your application can use to make a window or other rectangular object appear to



grow quickly out of some other object. This is what the Desktop does when you click on a disk icon and it "grows" into the disk's file window.

The Object Library is a macro facility that lets you create complicated graphic structures and link them in a single "object tree." For example, say you want to display a small rectangular box within a somewhat larger box on the screen and you also want to place text in the smaller box. You can do all this by calling the appropriate VDI graphics primitives. But alternatively, you can use the Object Library of the AES, which will let you define the whole thing in a well-documented tree structure. This has the advantage that the entire tree can be repeatedly drawn and reused in the application with only a single call each time. Furthermore, you can specify that only certain levels within the tree will be drawn.

The routines in the library support the construction of the tree and the reordering or deleting of its nodes. The library also offers various kinds of user interaction with on-screen objects, such as a routine that will tell you what object is currently under the mouse cursor and another one that lets you edit text in an object.

The Form Library uses object trees to implement more sophisticated user interactions. A form is an object tree designed for user input. A good predefined example of an object tree is the simple form that appears on the Desktop if the user decides to format a disk. The form is a box containing text that asks the user to confirm the format request and two small boxes containing the words O.K. and Cancel. (Boxes of this sort that contain mutually exclusive options are called "radio buttons.")

To use a form, the program calls the basic form routine, with an index of the desired object tree as argument. The AES takes over until the user selects an object that the developer has defined as an "exit object" (such as the O.K. or Cancel boxes in our example). Until that time, the AES handles the user's input, which can be of three types: the radio buttons, "check boxes"—boxes containing options that are not mutually exclusive, or text. On exit from the form routine, the application can examine the form to see what changes have taken place.

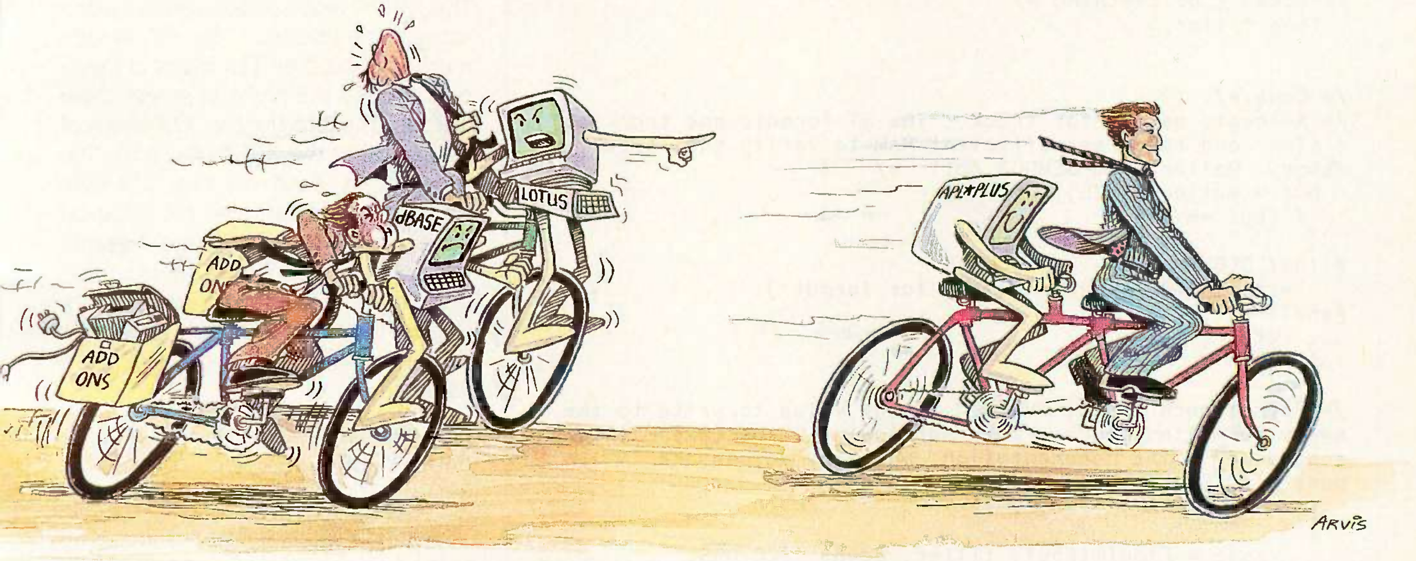
THE RESOURCE LIBRARY

Applications can share objects and object trees between applications or keep them conveniently modular through use of the Resource Library. For developers, Atari provides the Resource Construction Set, which allows on-screen construction of objects and other types of resources.

THE SCRAP LIBRARY

The Scrap Library allows developers to share certain kinds of data among applications. It supports the AES im-

(continued)



plementation of several standard data types. If you use these, your application can exchange information with other applications through a cut-and-paste mechanism.

THE SHELL LIBRARY

The Shell Library contains routines to allow the chaining of applications.

THE EXTENDED BIOS

The XBIOS provides more direct access to the ST's hardware than anything in GEM (which, after all, has to be portable). The XBIOS provides functions to read, write, verify, and format the floppy disks on a sector basis. Unlike the BIOS read/write function, these are not device-independent but are designed for the floppy disk drives only. They work for single- or double-sided drives. The format routine gives the caller specific information on bad sectors. Listing 1 is a routine to format an entire disk.

SCREEN PARAMETERS

The XBIOS also handles various video screen parameters. The ST screen memory occupies 32K bytes in memory. Initially, the physical screen base address is set to the top 32K bytes of memory, but the XBIOS has a routine to set that base on any 256-byte boundary. You can also set a logical base that the GEM and Line A graphics routines will use as their understanding of where the screen memory begins. Other routines let you set the screen resolution to one of three values:

640 by 400 pixels, monochrome
640 by 200 pixels, 4 colors
320 by 200 pixels, 16 colors

TOS knows what kind of monitor is attached to the system and will refuse to set the monochrome resolution if the color monitor is attached, or vice versa.

Two other XBIOS routines let you set the ST's palette. The palette has 16 entries. Three bits of information are stored for each entry for each of the three primary colors, red, green, and blue. Therefore, the lowest and highest values for each palette entry are (in octal) 0 and 777. In other

(continued)

Listing 1: *This is a routine to format a floppy disk on the ST. If the formatting is successful, the routine will return a 0.*

```
/* #define DEBUG 1 */
#include <osbind.h>        /* C bindings for OS routines  */

#define HITRACK 79         /* Highest numbered track      */
#define SECTORS 9          /* Sectors per track           */
#define MAGIC 0x87654321L  /* Required by Flopfmt()       */
#define VIRGIN 0xE5E5      /* Pattern to write to sectors */
#define ILEAVE 1           /* Interleave factor           */
#define DISKTYPE 2         /* Single side, 80 track       */
#define NOLOAD 0           /* No loader code              */
#define RANDOM 0x1000000L  /* Protobt makes a random      */
#define BOOTSECT 1         /* Side 0, sector 1            */
#define TRACK0 0           /* Track for boot sector       */
#define SIDE0 0            /* Format side 0               */


extern void errprint();  /* error notification routine */

format(devno)
int devno;              /* device holding media to format */
{
/* Automatic variables */
/* count tracks */
  register int i;
/* buffer for track, protoboot */
  register char *buf;
/* success in format? */
  register int succ, totsucc = 0;
/* doesn't do anything */
  long filler;


/* Code */
/* Allocate memory for track.  The ST formats one track at
a time  and requires sufficient RAM to verify that track in
memory. Malloc is a GEMDOS call. */
  buf = Malloc(8192L);
  if (buf == 0L)
  {
#ifdef DEBUG
    errprint(0, "insuff memory for format");
#endif
    return(-1);
  }

/* Format each track.  VIRGIN is the value to write to the
newly formatted track.  This particular value (0xE5E5) is
suggested in the documentation, but many values are
possible. Flopfmt is XBIOS. */
  for (i=HITRACK; i>=0; i--)
  {
      succ = Flopfmt(buf, filler, devno, SECTORS,
                i, SIDE0, ILEAVE, MAGIC, VIRGIN);
        totsucc += succ;
  }

/* Release memory.  GEMDOS */
  Mfree(buf);

/* For the purposes of this routine, I won't accept any bad
sectors. But, if there were any, their numbers would have
been left in the buffer after each track was formatted.
Alternatively, I could have retried or recorded the bad
sectors if I were developing my own file system. */
```

(continued)

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```
    if (totsucc != 0)
    {
#ifdef DEBUG
      errprint(totsucc, "format failed");
#endif
      return(-1);
    }
  /* Now we need to put a boot sector on the disk. */
  /* Allocate a 512-byte buffer */
     buf = Malloc(512L);
  /* Prototype a boot sector in that buffer.  The second
  parameter is a serial number for the disk.  The value I
  have chosen asks the XBIOS to generate a random number.
  XBIOS */
     Protobt(buf,RANDOM,DISKTYPE,NOLOAD);
  /* Write out the boot buffer to track 0, side 0.  Last
  parameter is how many sectors to write. */
     succ =
  Flopwr(buf,filler,SIDENO,BOOTSECT,TRACK0,SIDE0,1);
  /* Throw away memory */
     Mfree(buf);

  /* Return success or failure */
     return (succ);
  }
```

words, your 16 colors can be selected from a total of 512.

SOUND

Four routines in the XBIOS manipulate the ST's sound chip, which is the Yamaha Programmable Sound Generator (PSG) YM2149. The sound chip has two general-purpose I/O ports, which the BIOS uses for both floppy selection and some serial port functions; two of the routines are concerned solely with setting bits in one of these ports.

The chip has three sound channels and 16 registers. The third routine lets you set the registers to select

- The frequency for each channel.
- The volume for each channel.
- Either white noise or pure tone for each channel, or a combination.
- One of 16 envelope shapes.
- The frequency with which the envelope is applied to the basic sound waveform.

The last two points are of some interest: Although the PSG cannot manipulate the components of a sound envelope directly (i.e., the attack, decay, sustain, and release values), the ability to switch between different preset envelope shapes and manipulate their frequency gives you the ability to produce unusual sounds.

The final sound routine, dosound( ), gives you access to a mini control language for the sound chip that is implemented in the TOS software. By developing a list of commands, you can set any register on the chip, specify a sequence of tones, volume changes, envelopes, or any of the other parameters available through the chip. The dosound( ) routine sets a pointer to an area of RAM where you have placed such a list of sound commands. The software takes over and runs your commands at 50-Hz intervals (actually every fourth instance of a 200-Hz interrupt that is set up off the 68901 timer chip and used by TOS for a number of functions). One of the commands allows you to specify how many ticks should go by until the next command is executed.

THE LINE A ROUTINES

The Line A Handler is not part of GEM but the result of Atari's realization that it could provide faster access to some of the routines that support the GEM VDI. These routines are assumed to be used from the assembly language level. They are known collectively as the Line A Handler because access is through the 68000's unimplemented instruction exception handling. The 68000 recog-

(continued)

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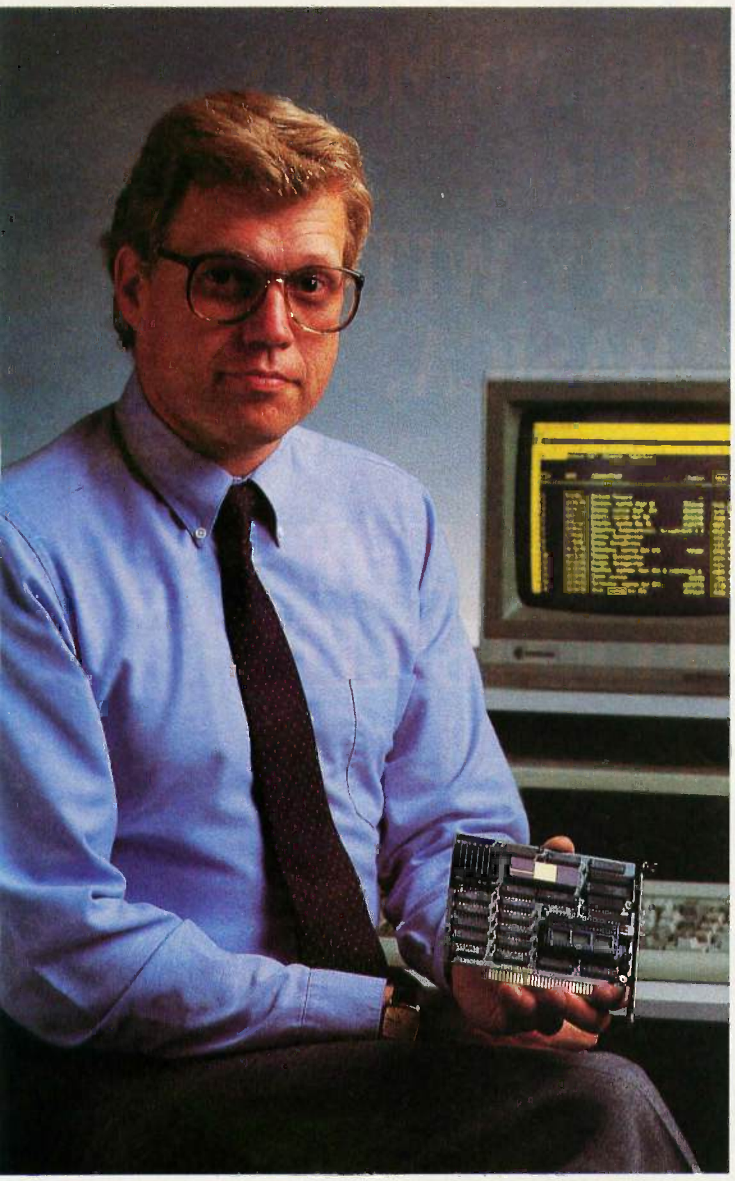

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nizes op codes beginning with the bits 1010 (hexadecimal A) as unimplemented instructions and jumps through a special exception vector, which in the ST points to these routines.

Because they were not originally intended for public access, use of these routines is not as easy or as consistent as is the case with the other entry points. Basic usage involves setting some of the values in a large data structure and then kicking off the Line A exception handler by defining a word op code whose first 4 bits are 1010 and whose last 4 bits specify which routine is desired.

The Line A routines give you faster access to graphics using the VDI and a few additional features, including a sprite facility and the ability to apply additional logical changes to raster objects while copying them from one place to another. You can mix and match Line A Handler and VDI routines, but this can be a little tricky, since your Line A variables may be affected by your VDI calls.

There are 16 Line A routines:

0	Initialization
1	Put Pixel
2	Get Pixel
3	Line
4	Horizontal Line
5	Filled Rectangle
6	Line-by-Line Filled Polygon
7	BitBlt
8	TextBlt
9	Show Mouse
10	Hide Mouse
11	Transform Mouse
12	Undraw Sprite
13	Draw Sprite
14	Copy Raster Form
15	Seedfill

About half of the Line A routines are concerned with graphics primitives similar to those in the VDI. The mouse manipulation functions are fairly boring and obvious. (Transform Mouse sounds neater than it is—it just changes the cursor representing the mouse position.) Let's take a closer look at the other routines.

BIT BLTING (ROUTINES 7 AND 14)

Raster operations involve a rectangular area of the raster, or video screen image. You often want to put a rectangular image (a bit-mapped object) on the screen and define the relationship it will have with the image that is already there "under" the rectangle being placed on the screen. For example, you may wish to say that certain pixels in the object are to be treated as transparent: Whatever is "below" them on the screen will not be changed and will therefore "show through" the new rectangle.

Additionally, you would like to be able to set the new rectangle down at an arbitrary coordinate on the screen. Unfortunately, many schemes for representing an image in memory are

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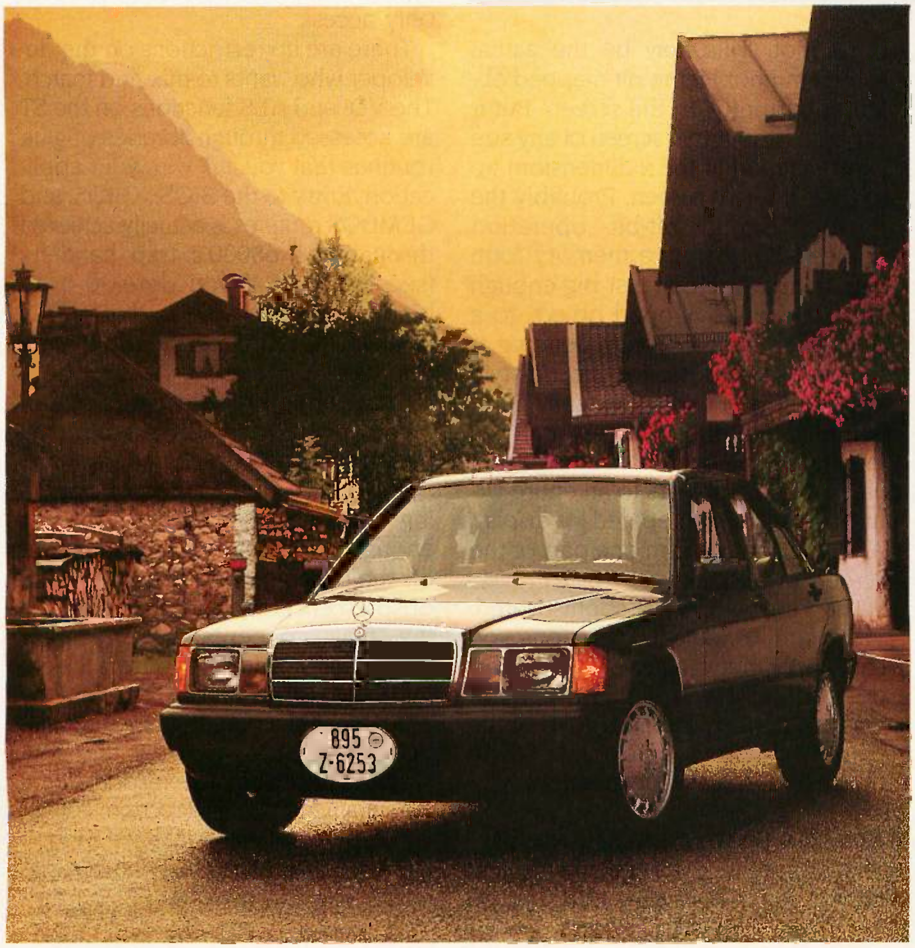

Listing 2: *This trap handler is the sort you might use if you were programming the ST in 68000 assembly language or were using a high-level language and needed to write a binding for access to a* BIOS, XBIOS, *or* GEMDOS *function. The functions assume the* C *calling conventions; that is, if there are any parameters, they are assumed to have been pushed onto the stack in reverse order and to be no smaller than a word. The number of the routine itself must be pushed last, just before the trap call. If you are developing using the* C *provided in* Atari's *developer's kit, this process will be transparent, since a set of bindings is available that makes* TOS *calls look just like ordinary* C *function calls.*

```
; At entry, any arguments for the function have been pushed
; on the stack in reverse order, C-style.  Then the
; function number was pushed.  Finally this routine was
; called, so as you enter, the return address of the caller
; is on top of the stack.

retsv:  ds.l                ; some memory for a long variable

traprtn:
  move.l (a7)+, retsv ; Save the return address,
                      ; because the OS functions don't
                      ; expect it.
  trap        #13     ; Trap to the BIOS function. (BIOS
                      ; is available through trap 13,
                      ; XBIOS through 14, GEMDOS through
                      ; trap 1.)
  move.l retsv, -(a7) ; Put the return address back on
                      ; stack.
  rts                 ; Return to caller.
```

often constructed for the hardware's convenience. The ST's screen memory, for example, consists of a word's worth of one plane of information, followed by a word of the next plane, and so forth, until 16 pixels for each plane have been defined. Then you start again with the first plane.

To simplify the job of manipulating the screen memory on the ST, a bit blter (bit-mapped block transfer) is provided. A bit blter can be software or firmware or both to support logical raster operations. On the ST, in the VDI and the Line A routines, a moderately complex data structure known as a memory form lets you define a raster and a rectangle within the raster so that the blter can manipulate it. One item in the form is a pointer to the actual image data. The rest of the fields specify things like the number of planes and the size of the rectangle. You need two of these memory forms for your bit-blting operations: one for the source raster and one for the destination.

An intriguing aspect of the memory form is the specification of the total raster representation that your object is part of. This may be the actual screen memory if the bit-mapped object is currently on the screen. But it can also be a virtual screen of any size (word-aligned in the *x* dimension) up to that of a real screen. Probably the most common bit-blt operation copies from a source memory form with a virtual screen just big enough to hold the bit-mapped object, to a destination memory form pointing at the real screen. But for arcade-style applications in particular, many more complicated arrangements can be imagined: for example, blting from various game objects to an entire virtual screen being prepared for display. And you can blt from one part of the screen to another.

The Line A BitBlt is sophisticated. There are 16 logical operations you can apply between the source and destination. If you define a pattern, you can perform a logical AND of the pattern with the source and combine the result with the destination.

SPRITES (ROUTINES 12 AND 13)

These sprites are not spectacular, and they're not in hardware. But they are convenient, and you can have as many as you want. The Line A sprites are two-color (foreground/background). They are 16 pixels wide and 16 lines high. A sprite can be plotted onto the screen relative to any one of its pixels. When you call Draw Sprite, you specify a buffer to save the screen area covered by the sprite; when you undraw, the routine can restore the screen. Nothing to write home about, but nice nonetheless.

WHAT DO YOU USE?

What is the place of the varied pieces of TOS in a typical application? Well, if you are willing to stick to GEM, you can access most of the ST's power. And you have the advantage of programming for a consistent virtual machine with a well-documented graphics model and a well-known user interface. Also, you will have an application that is portable to other systems supporting GEM. The non-GEM pieces give you more direct access to the ST hardware. And in some cases (such as sound), they give you the only access.

There are no restrictions on the developer who wants to mix and match. The VDI and AES functions on the ST are accessed through libraries of glue routines that you link with your application. Entry to the BIOS, XBIOS, and GEMDOS routines is actually achieved through the 68000's trap handlers (see listing 2). If you develop in C, bindings are available so that access to any TOS routine is simply a function call.

I have enjoyed software development on the Atari ST. I suspect my pleasure has something to do with the ST's peculiar combination of operating system routines. There are just enough traditional concepts to stave off the programmer's fear of coming obsolescence and just enough exciting new concepts to challenge creativity. Development has a clean, modular feel to it. The abstractions available in the operating system, particularly in GEM, are clear and consistent. These abstractions don't force you in any particular direction; if what you really want is to make the ST look like an old-fashioned, user-hostile machine, you can do it. ■

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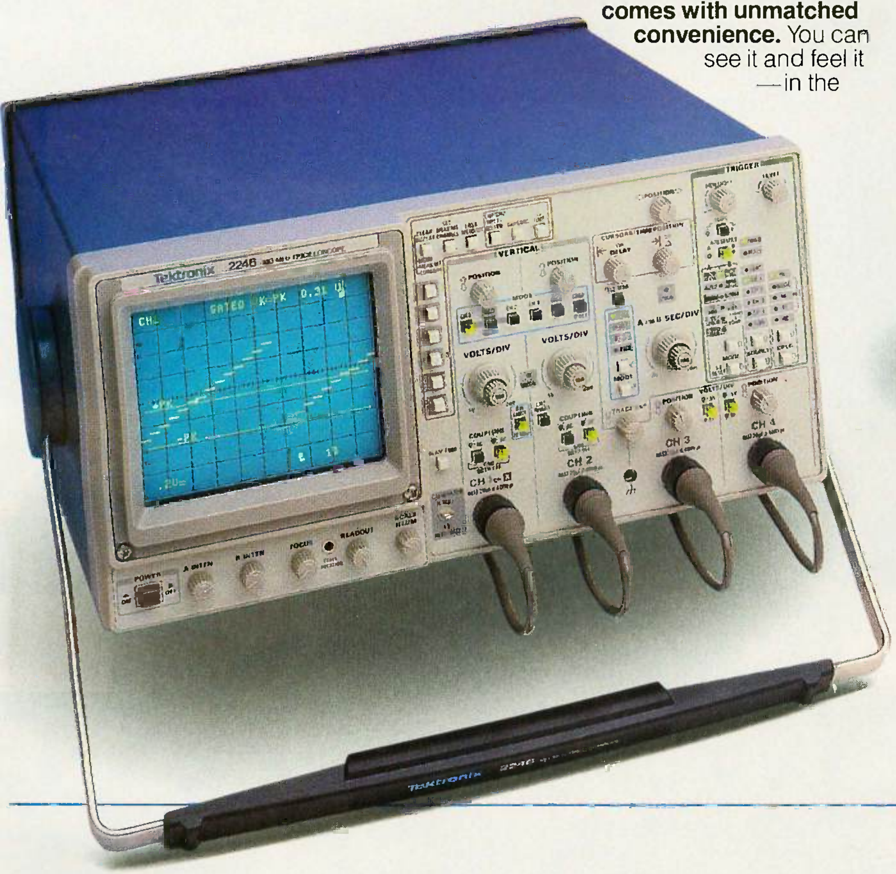

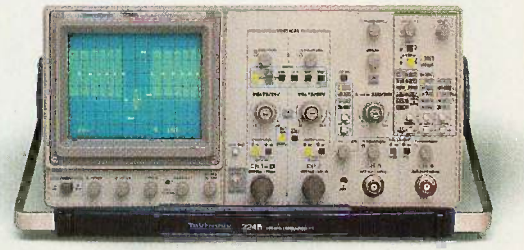

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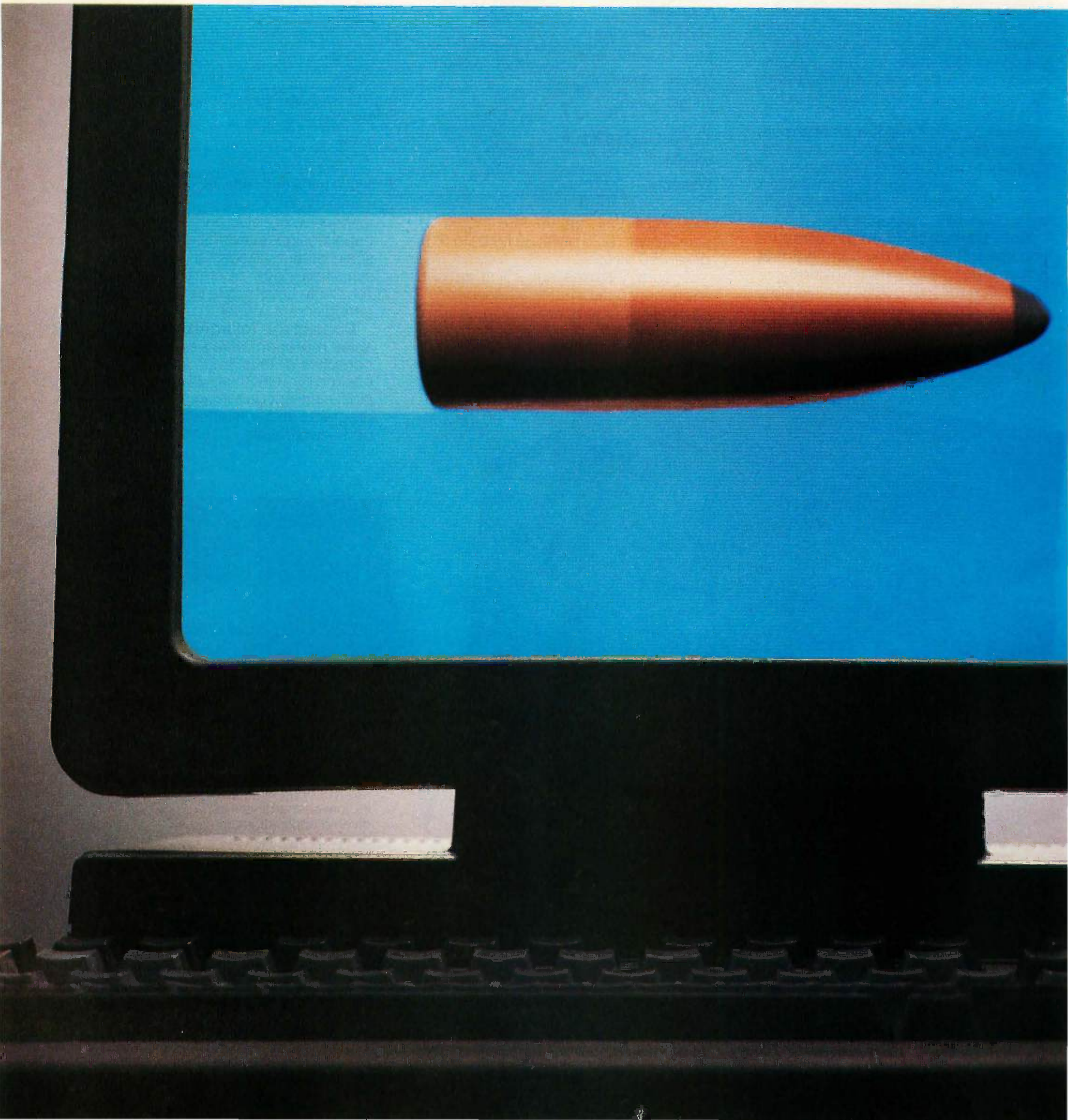

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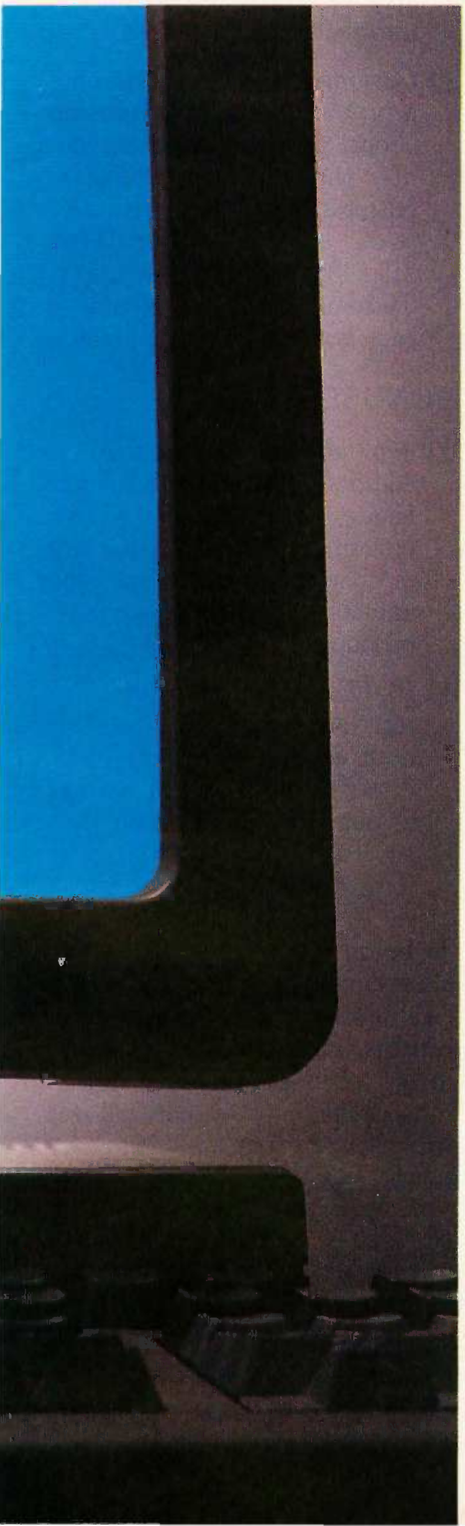

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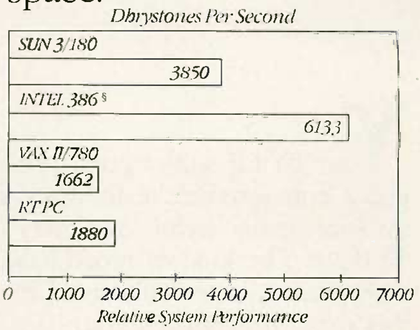

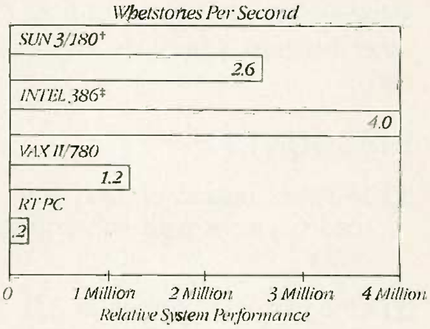

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THE SMALL SYSTEMS JOURNAL

AMIGA ANIMATION

BY ELAINE A. DITTON AND RICHARD A. DITTON

Bringing graphics to life on the Amiga

COMPUTER ANIMATION is the process of displaying a series of images on a video screen. The images can be displayed in the same spot on the screen for static animation or moved about the screen for dynamic animation. Animation in general consumes a large portion of a system's available processing power and memory space. Usually, though, trade-offs can be made between the amount of memory space and the amount of processing power required.

The Commodore Amiga has specific hardware that makes the task of animation consume less CPU processing. The sprite DMA (direct memory access) channels allow a relatively small image to be moved and altered by changing just a few locations in memory. The Blitter is a high-speed hardware device used for copying or merging image data and drawing lines. Because the colors in the Amiga are stored in registers, a special form of animation called color animation is possible.

In this article we will briefly discuss the various aspects of animation on the Amiga and the facilities provided in the Amiga ROM Kernel to generate graphic images. In conclusion, we will describe our methods of programming animation on the Amiga.

THE DISPLAY

The first thing that must be specified is the background on which the animation will take place. This is done by defining a View structure, which describes the characteristics of the display (see figure 1). The View consists of one or more ViewPorts, each with specified height, width, display mode, image data, colors, and position on the screen. ViewPorts must be vertically stacked and separated by at least one blank line. The width should be specified as either 320 or 640 pixels. Two or more ViewPorts of different horizontal resolution can exist on the screen at the same time. The ViewPort points via RasInfo to the BitMap structure, which in turn points to the actual bit planes of image data (figure 2). The number of bit planes determines the maximum number of colors. The ViewPort also points to the ColorMap, which is interpreted depending on the mode.

SPRITE ANIMATION

Sprites are hardware "objects" that are independent of the background display. The Amiga can have eight sprites, each 16 pixels wide and any number of lines high (figure 3). Even though there are only eight sprites, each one can be reused after its horizontal endpoint has been reached on the screen. Each sprite can have 3 colors plus transparent, or you can attach two sprites to have 15 colors plus transparent.

A sprite is displayed on the screen by specifying its *x,y* coordinates and a pointer to the memory area that describes the formed image. To animate a sprite you only have to change either of the coordinates or the pointer to the image data. Since you only have to change a few bytes to move or alter the image, sprite animation takes very little CPU processing.

The Amiga ROM Kernel provides several routines for manipulating the hardware sprites. GetSprite allocates a hardware sprite for exclusive use of the requesting task. ChangeSprite

(continued)

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changes the pointer to the image bit map of a reserved sprite. MoveSprite modifies the *x,y* coordinates of the sprite. FreeSprite returns a reserved sprite to the system.

To use the hardware sprites in the animation system, the Amiga ROM Kernel defines a structure known as the VSprite (for "virtual sprite"). Information about the sprite such as color data, collision detection, and double buffering is contained in the VSprite structure.

Sprites are extremely easy to animate but have limitations that you must consider. A limited number of sprites are available, and each sprite is of limited size. Therefore, if you have to animate a large area, sprites will not be appropriate. An individual sprite can have only 3 colors and attached sprites can have 15 colors, whereas the background display can have up to 32 colors. The SPRITES mode bit in the ViewPort structure must be set if you are using VSprites or hardware sprites.

BACKGROUND ANIMATION

The simplest type of background animation uses the XOR trick. For instance, if you XOR an area of the screen with a pattern, the pattern appears on the screen with a different color from the background (figure 4). The original background can be restored by XORing in the same position with the same pattern. This method is fast because no data is actually being moved. The Amiga drawing mode COMPLEMENT supports this idea. It is limited because all the bit planes are complemented so that the resulting color is always determined by the background color. You can obtain more color control if you selectively XOR bit planes. Unless you choose the colors in the registers carefully, the overlapped portion of XOR images will be a different color than either of the images.

The method most often used to animate complex background images is to move the actual blocks of data. This method takes up the most CPU time, but the Amiga assists with the hardware Blitter. The Blitter uses up to four DMA channels to move data 4 to 10 times faster than the 68000 microprocessor.

The routines BltBitMap and ClipBlit copy rectangular areas from one sec-

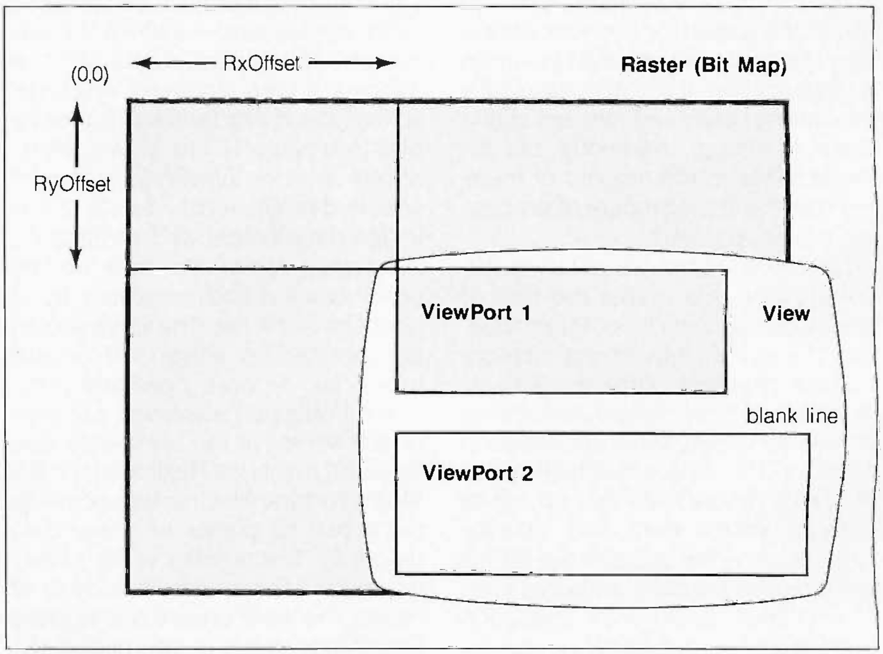

Figure 1: *The View structure, which defines the display characteristics of the Amiga, consists of one or more* ViewPorts, *which must be separated by at least one blank line. The values* RxOffset *and* RyOffset *determine which portion of the background bit map is displayed in a* ViewPort.

tion of chip memory to another. BltBitMap takes bit maps as arguments and will blit only specified bit planes. ClipBlit works with the RastPort structure and within the multitasking system. It will not destroy data of another task's overlapping window. Both routines use minterms, 8-bit values that determine how the source rectangle is moved into the destination area.

If you want the object to do more than just animate in a stationary position, you must save the background underneath the object so that it can be restored. If more than one object is moving across another, the data moves must be processed in last-in/

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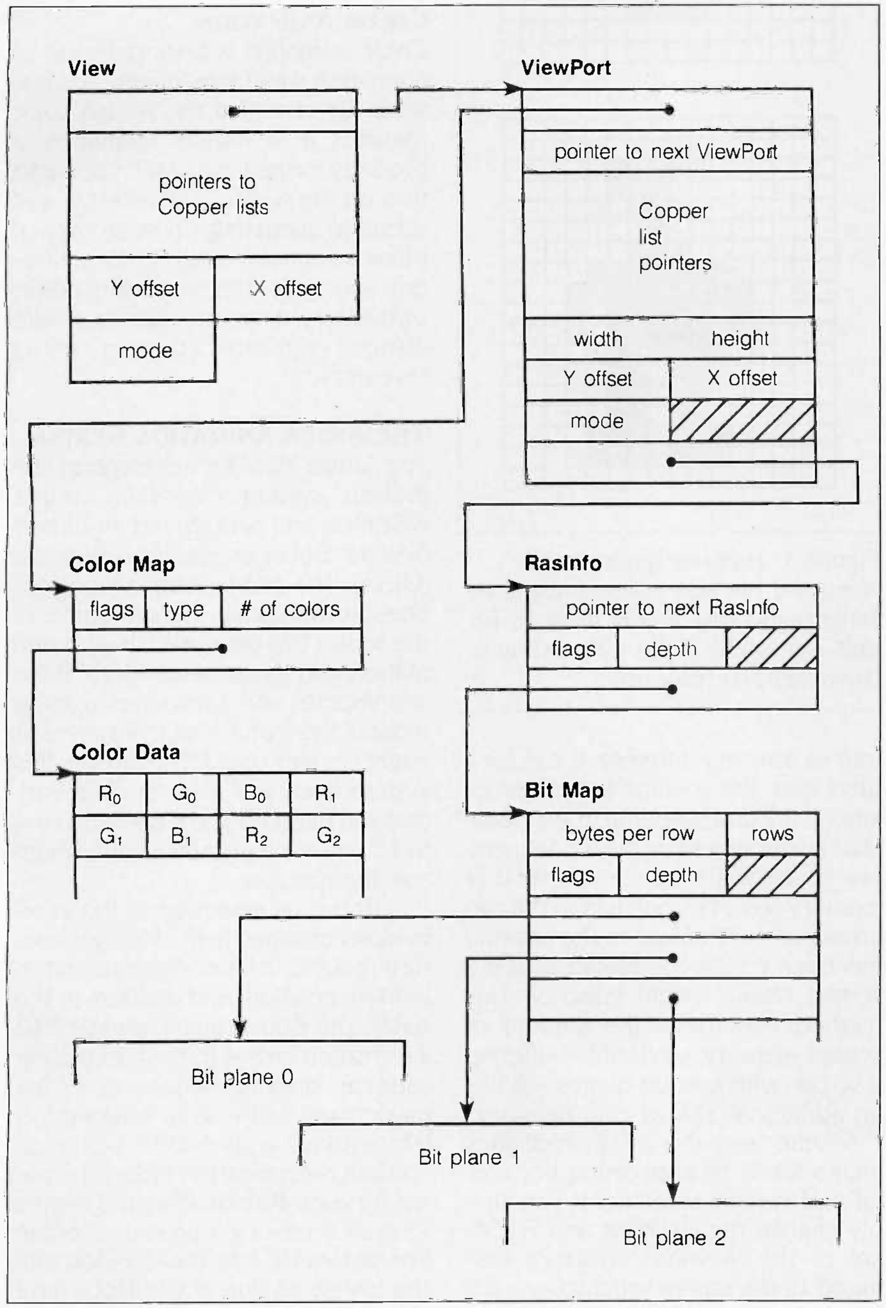

Figure 2: *The* ViewPort *structure contains pointers to the* ColorMap, *which tells the system which colors to use in the* ViewPort, *and to* RasInfo, *which tells the system where the* BitMap *is located. The* BitMap *structure contains pointers to from one to six bit planes representing from 2 to 64 colors, respectively.*

first-out order. Two moving and overlapping objects would be processed in this order: (a) save background 1, (b) place object 1, (c) save background 2, (d) place object 2, (e) restore background 2, (f) restore background 1.

If the animation object is not rectangular and you want the background to move behind the actual shape of the object, you can accomplish this by using the Blitter. First, the Blitter will OR all the bit planes of the object together to form a mask describing the shape of the object. Any of the colors can be chosen as the background color to be ignored in the mask. The Blitter will then AND the mask with each bit plane of the object to create an image of the object with a background of zero. It then inverts the mask and ANDs it with the background bit planes, creating an object-shaped hole. Now the Blitter will OR the object into the background in the hole. This procedure can be written as

$$D = AB + \bar{A}C$$

where A is the object mask, B is the object, C is the background, and D is the new animation frame. That is, the new frame is replaced with the object wherever the object mask is true, and with the background wherever the object mask is not true.

To implement this "cookie-cutter" operation, object and background data addresses are loaded into the Blitter source data registers BLTxDAT (where x equals A, B, or C, as above) and the minterm resulting from the above equation is placed in the BLTCON0 hardware register. The same thing can be accomplished by dividing the operation into two parts and using the BltBitMap function, which will take two sources at a time.

When the Amiga changes an image in memory, it does so by altering one bit plane at a time. Because of the finite period of time it takes to modify each bit plane, a moving object will tend to have its bit planes separate across the screen. Another problem occurs if the program starts drawing new information where the video beam is passing. This results in a screen consisting partly of old material and partly of new. If the two frames are very different, it can look quite bad. The solution to both problems is to double-buffer the screen. That is, the system displays one memory space while drawing in another memory area. The pointers to the two areas are switched when the drawing has been totally completed, and the screen retains visual integrity. This method uses twice the amount of screen memory, so double-buffering a screen with four bit planes will use an additional 32K of chip memory.

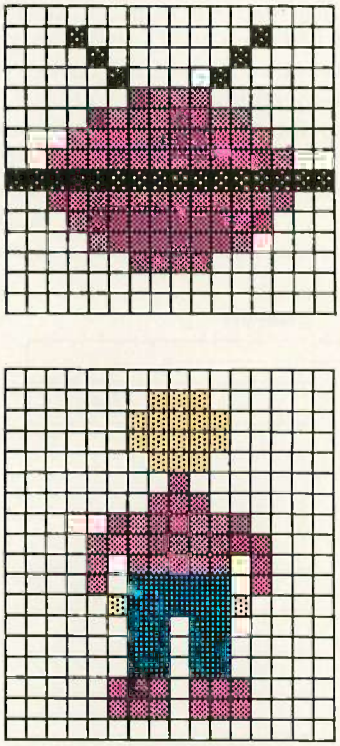

Figure 3: *Hardware sprites, graphic objects that can move independently of the background display, may be up to 16 bits wide, any number of bits high, and up to three colors plus transpartent.*

Another way the Amiga facilitates animation is by supporting horizontal and vertical scrolling. If you simply change the RxOffset and RyOffset of the ViewPort structure (see figure 1), the screen will display a different portion of the background data. No memory is moved, so the scrolling is fast and smooth. One quirk of the scrolling, however, is that it disables hardware sprites 6 and 7.

If you set the ViewPort to Dual-Playfield mode, you will have two independently controllable playfields, one with a higher priority than the other. Each playfield can have up to seven colors plus transparent. A moving background outside an airplane window is the type of effect possible with this technique.

COLOR ANIMATION

Color animation is a special form of animation with fairly limited applications. By changing the Amiga color registers in a regular sequence, a properly formed image will appear to flow on the screen. This effect is well suited to animating a flowing river or billowing smoke. Since color animation uses very little processing power or memory, it can provide for simple effects without utilizing many resources.

THE AMIGA ANIMATION SYSTEM

The Amiga ROM Kernel graphics animation system classifies sprites (VSprites) and background (or Blitter) objects (Bobs) as graphics elements (GELs). The graphics animation routines automatically handle some of the topics just discussed. If your animation sequence needs both Bobs and VSprites, and if you need to utilize most of the features of this system, it might simplify your job. However, this system does add a lot of overhead, and you may find you have more control if you write your own application-specific routines.

A Bob is an extension of the information contained in the VSprite structure (height, collision-handling information, position, and pointers to the data). The Bob structure handles the information unique to the background such as drawing sequence, image mask, save and restore background information, and double buffering. You can determine the order of drawing for each Bob or allow the system to draw them in *y*, *x* positional order. The system will first draw the Bob with the lowest *y* value. If two Bobs have the same *y* value, then the Bob with the lowest *x* value is drawn first. Objects drawn later overlap objects drawn earlier.

In order to have the system automatically save the background to be restored after moving the Bob to a new location, you must set the SAVEBACK bit in the variable sprFlag of the VSprite structure and set the variable SaveBuffer to the address of a memory location. To "cookie-cut" the Bob into the background, set the OVERLAY bit and define the ImageShadow mask. To double-buffer, a Bob pointer is set in the Bob structure to a structure called DBufPacket. This structure contains information that helps keep track of the background in the current drawing buffer for correct restoration. If any of the Bobs are double-buffered, all the Bobs must be double-buffered.

Four variables describe the boundaries of a rectangle that will clip the Bob. If the GEL has passed completely outside the clipping region, the GELGONE flag will be set. If this GEL is no longer needed, you may delete it from the GEL list to speed up the overall processing. The SAVEBOB bit can be set to tell the system not to erase the old image of the Bob, which gives a "paintbrush" effect as the Bob moves. Once all of the GELs are moved or changed, they must be sorted with the routine SortGList and finally displayed with the routine DrawGList. DrawGList makes up a Copper instruction list.

The Amiga supports a set of structures and routines that will animate Bobs. The AnimOb (animation object) is the top-level data structure that organizes the AnimComps (animation components) and contains the registration point in the display relative to which of its component Bobs are drawn. The AnimComp is a component of the animation that contains the actual imagery, such as an arm, leg, or other part of the complete object. The AnimOb structure contains the initial position of the object, its velocity and acceleration in the *x* and *y* directions, a pointer to the first of a linked list of AnimComps, and a pointer to a special animation routine. The AnimComp contains a pointer to the next AnimComp in the sequence and a timer to tell the system when to switch. After the two structures are set up, calling the Animate function sets the animation in motion.

The Amiga animation software supports sequenced drawing and motion control, which can be used separately and together. In sequenced drawing, each view is a modification of the preceding view. This is particularly useful with an animation that is cyclical in nature, like walking. One step in a walking sequence would be a sequenced drawing. To make the object look like it's moving, each new view is positioned farther from a common reference point. After the animation has completed one cycle, the AnimOb must be moved a certain

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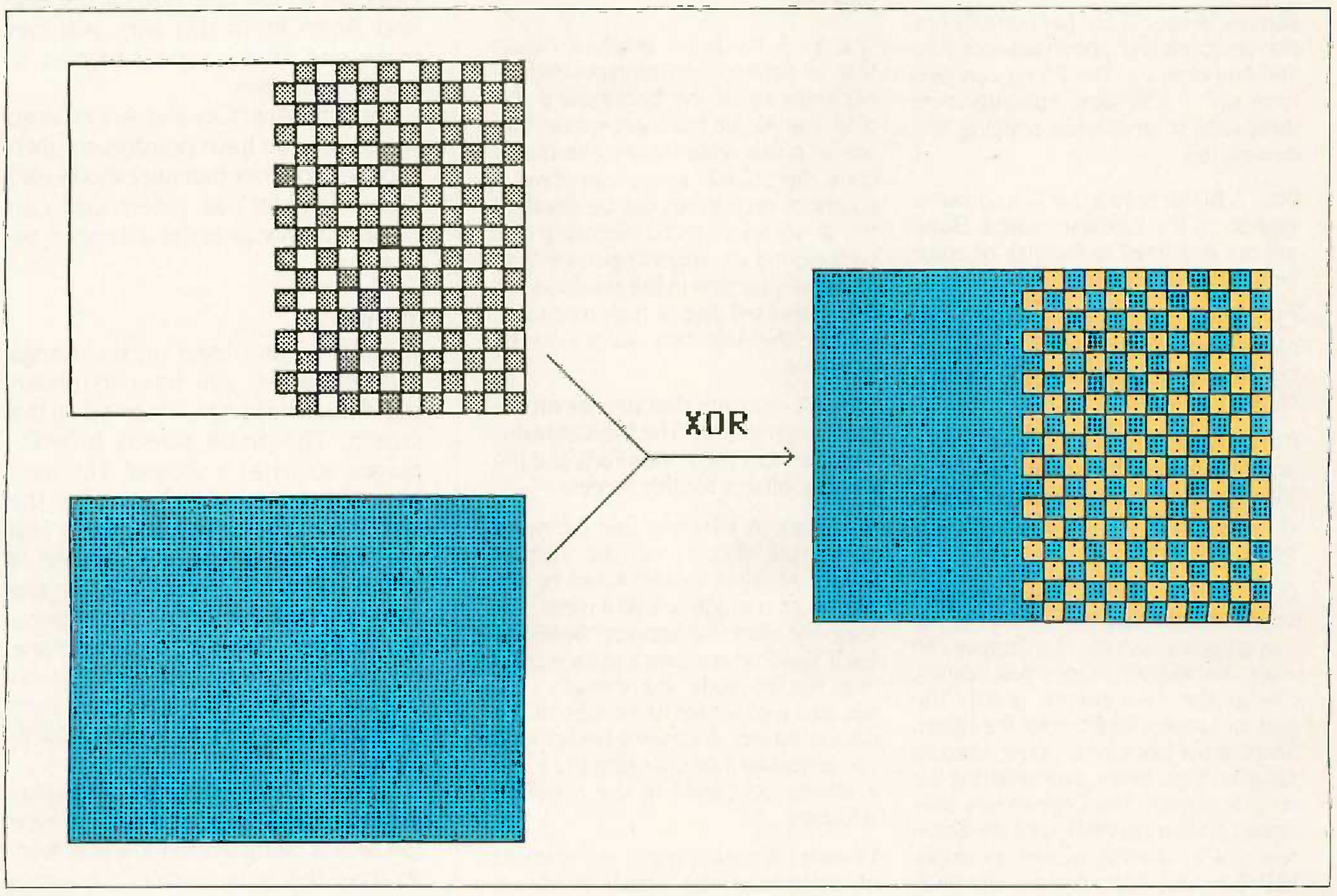

Figure 4: *One form of background animation on the Amiga involves using a pattern to* XOR *an area of the background. The pattern will appear on the screen with a different color than the background.*

distance to keep the apparent motion smooth. This distance is contained in the AnimOb structure.

Motion-control animation specifies objects that have independently controllable velocities and accelerations. The velocity and acceleration values are treated as 16-bit fixed-point binary fractions that have the form vvvvvvvvvv.ffffff. The slowest possible speed is one pixel every 64 frames. Each call to Animate causes the acceleration values to be added to the velocities.

The drawing precedence for AnimObs objects is determined by the precedence of the Bobs that make them up. The animation system automatically updates the precedence in the Bob structures for each frame to reflect the order of the first sequence. If more than one AnimOb is on the screen, one complete object can have precedence over another by linking the last Bob of the first AnimOb to the first Bob of the second AnimOb. In this way, you can make one object appear to pass in front of another.

Both the AnimOb and AnimComp structures can have pointers to user-supplied routines that are called every time Animate( ) is called and can cause any change in the animation sequence.

TIMING

To animate an object on the Amiga without flicker, you have to understand how the image is formed on the screen. The entire screen is redisplayed 60 times a second. The time period between the drawing of the last line of the previous screen and the first line of the next screen is called the vertical blank. During the vertical blank period on the Amiga, the sprites, Copper, and bit-plane pointers are initialized for the next display screen. The screen is then generated from top to bottom, left to right.

Flicker is caused when a display area is being altered at the same time the area is being written to the screen. To avoid this, your animation routines must complete all updates before the beam reaches the display area or after the beam has left the display

AMIGA ANIMATION GLOSSARY

AnimOb: A data structure that brings many AnimComps together in a whole object.

AnimComp: An expansion of a Bob to allow the Bob to function as part of an AnimOb.

Bit Map: A structure that contains pointers to bit planes and defines the width and depth of the bit-plane data.

Bit Plane: An area of memory that defines the color of the pixels displayed on the screen. Each bit plane multiplies the number of possible colors in the display by 2. If one bit plane is used for a display, only two colors are possible. If two bit planes are used, four colors are possible. A maximum of five bit planes can be used in a low-resolution display and four bit planes in a high-resolution display.

Blitter: A specialized hardware device that performs high-speed data copying and line drawing. The Blitter can perform up to 256 logic operations on three data sources while copying to a destination.

Bob: A Blitter object that is a software version of the hardware sprite. Bobs are not restricted to the size or color limitations of a sprite.

Chip Memory: The lower 512K bytes of memory on the Amiga, which can be directly accessed by the custom chips.

Color Map: A list of the red, green, and blue values that are attached to a ViewPort and loaded into the Amiga color registers when that ViewPort is being displayed.

Copper: One of the Amiga's custom coprocessor chips, it controls the entire graphics system. The Copper can alter the registers, reposition sprites, change the color palette, update the audio channels, and control the Blitter. The Copper frees the 68000 to execute program logic rather than updating the display screen. The Copper has only three commands: WAIT until the beam reaches a specific screen position, MOVE a value into a register, and SKIP the next instruction if the beam is past a specified screen position.

GEL: A graphic element that can be manipulated by the graphic animation routines in the Amiga ROM Kernel. VSprites, Bobs, AnimComps, and AnimObs are all GELs.

IFF: Interchange Format File, the standard format for data written to files on the Amiga. This standard allows for data to be easily exchanged among development tools and products.

Minterm: An 8-bit value that determines the logic operations to be performed by the Blitter during a data transfer operation.

RastPort: A data structure that contains information needed for manipulating the graphics display with the Amiga ROM Kernel routines. The drawing pen colors, drawing mode, area fill pattern, text attributes, font, pen position, and line pattern are stored in the RastPort.

Sprite: A hardware graphics object that is defined and manipulated independently of the background display. The Amiga has eight sprites that are 16 pixels wide by any number of lines high. Each sprite can have 4 colors, or two sprites can be attached for a 16-color sprite. Scrolling the background or displaying more than 320 pixels per line in low resolution or 640 pixels per line in high resolution causes the last two sprites to be unusable.

View: A structure that defines an entire screen display. The View contains a pointer to a list of ViewPorts and the *x* and *y* offsets for this screen.

ViewPort: A structure that defines a horizontal section of the display screen. Multiple ViewPorts can be displayed on a single screen if there is at least one blank line between ViewPorts. Each ViewPort contains a unique color map, display mode, width, height, *x* offset, and *y* offset for its portion of the display screen. A scrolling background can be created by changing the *x* and *y* offsets contained in the ViewPort structure.

VSprite: A virtual sprite, the method of describing the actual hardware sprites for use in the Amiga animation system.

area. The current beam position can be determined by calling the routine VBeamPos.

Under the multitasking system of the Amiga, each task is given 4/60 second to execute before the task is preempted to execute the next task of the same priority. This can play havoc with any attempt to perform smooth animation, since your animation routines may not be executed in a regular time frame. One method of getting around this problem is to increase the priority of your animation task to a high level or use the Forbid( ) function to defeat the multitasking system and allow the animation to execute exclusively in the Amiga.

Another method is to attach a subroutine onto the vertical blank interrupt chain. This increments a counter, which can then be checked to determine the number of frames that have been displayed since the last animation update. The animation routines can then use this value to correctly position the animation objects.

MEMORY USAGE

In one of our applications we have a scrolling background that is four screens wide and five bit planes deep, requiring a total of 160K bytes. We use six sprites to form one moving image. Each animation step uses approximately 1K byte. If the moving image has 40 steps, just the image and background data would consume 200K bytes of memory.

As you can see, it is practically imperative to add the additional 256K-byte memory expansion to the internal 256K on the Amiga to accommodate the operating system and any significant piece of animation. Currently, only the lower 512K bytes of memory are available to the custom chip hardware. If additional RAM is added via the 68000 bus, accessing image data from there will be slower than accessing data stored in the lower 512K bytes because all image and sound data must still be transferred to the lower 512K bytes to be used.

> *The mechanics of creating animated graphics are difficult, and good animation results only when artist and programmer take the system to its limits to produce visual effects.*

MATERIALS AND METHODS

We would like to briefly describe how we have developed animation on the Amiga. We are using the Lattice IBM-PC-to-Amiga cross-compiler and the Metacomco assembler and linker to develop our programs. We wrote our own PC-to-Amiga parallel transfer program because we found the one supplied with the Amiga developer's kit to be too slow. Developing large programs on the Amiga itself will be difficult until additional RAM and a good hard disk are available. Adequate debuggers for the Amiga are only now becoming commercially available.

The art for our animation was drawn using Deluxe Paint by Electronic Arts. Once again, we wrote our own routines to extract the data from the IFF file generated by Deluxe Paint and convert it directly into an assembly file. Then we used the structures and functions described earlier to program the animations.

CONCLUSION

The mechanics of creating animated graphics can be difficult enough, and the result is only as good as what you see in the end. If a car wheel in an animated sequence is rotating too fast for the speed of the background passing by, the animation will not reflect what you intended it to reflect. Good animation is created by both artist and programmer taking the system to its limits to produce visual effects. In this regard, the possibilities for animation on the Amiga are very exciting. ■

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AMIGA VS. MACINTOSH

BY ADAM BROOKS WEBBER

A programmer's comparison of the system calls on two 68000-based machines

I HELPED IMPLEMENT the True BASIC language system on the Macintosh. The project has been completed for some time now and we've all recovered our perspective and good humor, but at the time I felt that if I saw that smiling "Welcome to Macintosh" message one more time I would scream. It was in this frame of mind, on my way to see the Amiga for the first time, that I wrote out a list entitled "Why I Hate the Macintosh."

That incident led to this article. I have now completed the same project on the Amiga and have many gripes about that machine, too. In this article I compare the system software of the two machines.

Implementing a language system is a good way to get to know a machine. True BASIC is not just a compiler and interpreter, it's a screen editor, a graphics program, and a number cruncher. It makes sounds, it prints, it manipulates files—in short, it uses most of a system's software. My comparison of the Macintosh and the Amiga is necessarily limited, but I have tried to choose areas that are of general interest and that are representative of the differences between the two machines. These are the user interface, graphics primitives, printers and other devices, multitasking, and memory management.

THE USER INTERFACE

The user interface of a system is usually examined from the user's point of view. You ask, "Is it intuitive? Is it powerful? Is it forgiving of error?" as you consider how to communicate with a program. I am interested in another point of view: What does a program have to do to communicate with the user? For some machines, communicating with the user means reading characters from the keyboard and writing text to the screen. Adding windows, menus, and mouse operations makes things more complicated.

Just how complicated is shown by the Macintosh user interface software, which determines the structure of every Mac program more or less completely. The program must have a main loop that is executed as often as possible, usually 60 times a second. (One rule of thumb: The quality of system software is inversely proportional to the number of things a program must do "as often as possible.") The main loop checks for events like keystrokes, mouse clicks, and disk insertions and responds to them.

Responding to an event is usually a lot of work because the Mac's user interface software provides little assistance. Figure 1 shows, in pseudocode, a simple example of what a program must do to allow a window with a scroll bar to change in size—something that most Mac programs have to deal with. The system software does offer significant help in two areas of user interface: text editing and file access. TextEdit is a subsystem that provides a mechanism for displaying and editing text in a window. (True BASIC doesn't use TextEdit, but only because we have our own internal string-handling procedures.) For

(continued)

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file access, the system software provides the Standard File Dialog, which gives a graphic display of the contents of a disk and allows you to choose a file. It's an excellent tool and almost all Mac programs (including True BASIC) use it.

Intuition, the Amiga user-interface software, supports two different mechanisms for communicating with the user. The console device is the simpler of the two. From your point of view the console device looks like a no-frills window, but from the program's side it looks like a terminal. The program gets a sequence of characters as input and sends off a sequence of characters as output. Mouse clicks and other nontextual input come through the console device as special ANSI-defined character sequences. The console device is a very easy way for text-only applications to communicate with the user. It is especially useful for prompt-based applications like those typical of UNIX and the IBM PC.

The Amiga's other, more powerful user interface mechanism is the Intuition Direct Communication Port, or IDCMP. The Amiga Executive allows tasks to communicate with each other through message ports; an IDCMP is a message port that has a program at one end and Intuition at the other end. Events are communicated to the program through the port. This is a very flexible scheme: The program can poll the IDCMP, or it can arrange to run only when there is some event for it to work on, or it can spawn a separate task to handle events. And the events themselves are much more straightforward to handle—figure 1 shows in pseudocode what an Amiga program using an IDCMP must do to allow a window with a scroll bar to change in size. The program can get more control of the resizing process if it wants to, but for most programs (including True BASIC) it works almost automatically.

Amiga	**Macintosh**
Anything happen? *Yes, your window is a new size.*	Anything happen? *Yes, the mouse button was pressed.*
Fine.	Where was it pressed? *In the resizing box.*
	If the window isn't frontmost, make it frontmost. *OK.*
	Otherwise, what size does the user want? *This size.*
	Hide the scroll bar. *OK.*
	Change window sizes. *OK.*
	Change scroll bar to the location and size I've calculated. *OK.*
	Redraw the scroll bar. *OK.*
	Remember to redraw the part of the window whose size I've calculated. *OK.*

Figure 1: *Comparisons (in pseudocode) of a program's actions and the operating system's responses to a user event for both the Amiga and Macintosh. The user attempts to resize a window that contains a scroll bar.*

In future revisions of Intuition I'd like to see something like the Mac's TextEdit for displaying and editing text in a non-console-device window and some kind of file interface like the Standard File Dialog. But in spite of these deficiencies, I prefer the Amiga user interface. It is more flexible and usually requires less work on the part of the program.

GRAPHICS PRIMITIVES

The Amiga has more in the way of graphics special effects than the Macintosh. It has color, many different screen depths and resolutions, and special-purpose animation hardware. I suppose there's no comparison when it comes to games, simulations, art programs, and that crowd. But for a language system what I really want is a complete, logical set of basic graphics primitives. I want the system software to handle straightforward drawing on the screen. In this area the Macintosh system software excels.

The Mac knows how to draw rectangles, rounded rectangles, polygons, ellipses and arcs, and general closed figures. These basic objects can be outlined, filled in with any black-and-white pattern, or inverted (turning black pixels in the area to white and vice versa). The Mac can also draw lines and write text in software-definable fonts. The Macintosh graphics subsystem, called QuickDraw, supports a mechanism for recording graphics operations in a compact way and then playing them back.

The Macintosh doesn't support flood-fill. Flood-fill is what the "paint can" does in MacPaint: Starting at some point, the program colors in the screen, stopping at whatever boundary lines it comes across. True BASIC and several other programs accomplish this with custom software. (Note: The new 128K ROMs from Apple do support flood-fill.) Another weakness is the ellipse-drawing algorithm used by the Mac: An ellipse that is substantially longer on one axis than on the other is drawn unconnected, with frequent perforations. This means that such an ellipse cannot be flood-filled—it leaks! Plenty of published ellipse-drawing algorithms don't have this undesirable property.

The Amiga's graphics primitives are less well developed than the Mac's. The Amiga knows how to draw rectangles and polygons. Objects can be outlined, filled with any multicolored pattern, or inverted. Sometimes the machine can perform a combination of these operations, like outlining with one color and filling with another, in one pass. The Amiga does support flood-fill. It draws lines and supports software-definable fonts. However, it does not draw ellipses or any other curved figures at all.

Figure 2 summarizes the graphics primitives of the two systems. The Amiga graphics software strongly reflects the Amiga graphics hardware. The hardware helps the system draw lines and rectangles, so lines and rectangles are well represented; other figures are not.

Another example of this kind of hardware-oriented design is the software interface to the blitter. The Amiga's blitter is a custom chip that does bit-aligned data manipulation. One of its many duties is moving screen images around. The strictest hardware limitation is imposed on the blitter: It can access only the lowest 512K bytes of memory. That's fine, that's what hardware is all about; but the software that uses this hardware should relax that restriction. It doesn't. One of the things you might want to do with a lot of memory is to store lots of images in it. This is possible on the Amiga, but you have to copy those images down into the lowest 512K of memory before any of the graphics routines will touch them.

For these reasons I prefer the Macintosh graphics primitives. They're well chosen, and they have natural interfaces. The Amiga graphics software is very powerful, in its idiomatic way, and it cooperates well with the hardware. Is it too much to ask that it cooperate with the programmer too?

DEVICES

A printer is the programmer's bane. Printers are so similar on the outside that it seems ridiculous not to support a large variety of them—but they're all annoyingly different on the inside. Both the Amiga and the Macintosh try to get around the problem of printing by offering device independence. This means that the system software deals with the problem by offering a single device interface, regardless of what is connected to the computer.

To a program running on the Macintosh, the printer looks like a video screen. The program draws onto this screen just as if it were the video display, and the system software takes care of translating those operations into something the printer will understand. This makes good sense, but in practice it doesn't work out well at all.

The different Apple printers (and there are really only two) accept different subsets of the graphics primitives, so an operation that prints on the Imagewriter may produce no effect on the LaserWriter. The program is substantially involved in setting up, adjusting, paginating, and disposing of the special printer "screen." All this overhead is acceptable for a program that is printing complicated graphics, but for an ordinary text-only printing program like True BASIC, it's a lot of work.

An especially odd aspect of printing on the Macintosh is printing "in the background." Programs can allow you to do other things while the printer is busy. To do this, the program gives the Printing Manager (the software to handle printing operations) a procedure that it can call *as often as possible*. The program calls the Printing Manager, and the Printing Manager calls the program over and over to lend it processor time, and then when printing is done the Printing Manager returns to the program. This is ridiculous, but it's the Mac's lack of multitasking that is at fault, not the printing software—and multitasking is discussed in more detail below.

The Amiga offers several ways to use the printer. One is specifically designed for programs that print text only. Using this method, the program deals with the printer as if it were a file. The printer can be opened, written to, and closed just like a part of the file system. Special fonts and other features of the printer can be activated by the Amiga's printing software, which generates the required control sequences for the specified printer. Programs that need even more control over printing can access the printer driver directly. For printing graphics, the program passes the printer driver the same image used by the graphics primitives, rather like the Mac's scheme but a bit less automatic. [*Editor's note: The Amiga uses printer-specific drivers that perform the conversion from generic primitives to hardware-specific control sequences. You select the driver that fits your printer from a variety of printer drivers supplied with the system disk.*]

For other devices, like the serial port, the Amiga uses the same two-level scheme: The device can be

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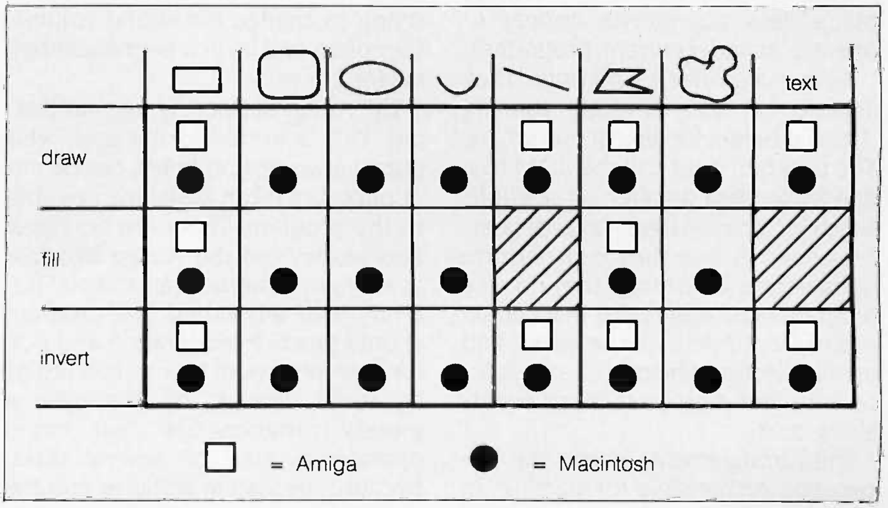

	▭	▢	⬭	◡	╲	▱	☁	text
draw	□ ●	●	●	●	□ ●	□ ●	●	□ ●
fill	□ ●	●	●	●	▨	□ ●	●	▨
invert	□ ●	●	●	●	□ ●	□ ●	●	□ ●

□ = Amiga ● = Macintosh

Figure 2: *A comparison of the graphics primitives supported by each machine.*

Consistent, high-level access to a variety of devices is a strong point of the Amiga that has almost no counterpart in the Macintosh.

opened as a file for simple access, or it can be manipulated directly for more complicated operations. The Amiga's parallel port and RAM disk device also use this method. Consistent, high-level access to a variety of devices is a strong point of the Amiga that has almost no counterpart in the Macintosh. For example, the Mac's serial port is accessed only through a low-level driver. (Actually, it's accessed through two low-level drivers, one in ROM and one in RAM; but the latter seems hardly more than a debugged version of the former.)

MULTITASKING

A multitasking system is one that runs several independent programs at once, giving each the impression that it is the one and only. The Macintosh system software does not support multitasking. Given this, how do the Mac's desk accessories appear to operate as independent programs?

Desk accessories are parasitic. They depend on the currently running "host" program for almost everything. The program must call the ROM routine SystemTask as often as possible, which in turn calls the various desk accessories so that they can perform whatever periodic things they do. The program must also notice that certain events (keystrokes, mouse clicks, and menu selections) belong to a desk accessory and must pass those events along to it.

This arrangement makes the application responsible for starting up desk accessories. A program that allows the use of desk accessories must find out which ones are available, create a menu listing them, and start up any desk accessory selected by the user. This means that desk accessories interact badly with the rest of the system and waste more programmer time than anything else I can think of on the Mac. Every program on the Mac becomes a frantic conspirator in the multitasking cover-up. Well, almost every program—some just give up on desk accessories, and others (like MacPaint) sharply restrict their use.

The only thing worse than supporting a desk accessory is being one. Desk accessories are hard to write because they're constructed so differently from the host programs they depend on. They're written as device drivers—which means, among other things, that they are table-driven, that they have to be small (about 8K bytes at the most), and that they have to be very careful not to alter the environment they work in.

One thing a multitasking system does is to mediate between programs that want to use the same device at the same time. If one program is using, say, the printer, another program will be told that the printer cannot be used right now. No such orderliness exists on the Macintosh. The Control Panel is a desk accessory that allows you to change (among other things) the volume of the Macintosh's sound. If a program is using the Sound Driver to make sound at the same time that the Control Panel is trying to change the sound volume, they often end up in a permanent battle for control.

The Amiga supports true multitasking. This is visible to the user, who sees that several programs can be run at once, but it can be nearly invisible to the program. There are no "desk accessories" on the Amiga because almost any program can run concurrently with any other. The program should practice moderation and not, for example, count to a million just to let some time go by. But even a greedy program like that could operate as one of several tasks, because the system software ensures that every task gets processor time. The system also mediates device access, so that problems cannot be caused by having two programs accidentally access a device at the same time. The only thing a program really needs to be polite about is memory usage, because any program could take up all available memory if it wanted to. A multitasking system really needs a more sophisticated plan for memory management than this, and, as you'll see, I have one in mind.

The Macintosh should have had multitasking. I can't stress enough what a big contribution it makes to the elegant design of system software. The Amiga has an excellent multitasking system, and I think it will have twice the product life of the Macintosh because of it.

MEMORY MANAGEMENT

The architecture of the 68000 processor requires a stack, which is an area of memory used for subroutine addresses and other last-in/first-out data. Since the Mac and the Amiga both use the 68000, both have stacks; but the multitasking Amiga needs a separate stack for each task, and this results in a memory arrangement very different from that of the Macintosh.

The Macintosh has one stack, which grows from the top of memory down to a preset limit. It has two *heaps*, the system heap and the application heap. (Heaps are areas of memory for blocks that, unlike stack blocks, need not be freed in any particular order.) The system heap is small and cannot grow; it is used mostly by system software and is preserved across runs of a program. The application heap can grow up to a preset limit (the same limit toward which the stack is growing, from the other side). The application heap is reinitialized each time a program is run, so programs need not remember to deallocate blocks when they are shutting down.

Many heap blocks on the Macintosh *float*; that is, the system software may decide to move a data block without consulting the program that allocated that block. Often it will move all allocated blocks to one end of the heap so that all free memory is in a

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continuous piece at the other. This helps reduce fragmentation and so conserves memory. Figure 3 shows a sample Macintosh memory layout.

One problem with the Mac's memory management scheme is the preset limit that divides the stack from the heap. The program has to decide where that limit is going to be—once set, it cannot easily be altered. For many programs it is difficult, if not unnatural, to set such a permanent fence. True BASIC can't tell what kind of memory demands the user is going to make: Running a BASIC program that uses big strings would use a lot of heap memory, but running one that's heavily recursive would use a lot of stack. Another problem is the complexity introduced by the floating blocks. Naturally, there's a way for programs to find the current location of a floating block, but the current location isn't current for very long and it's easy to make mistakes.

The most irritating problem with the Mac's memory management is that the stack can easily grow down past the limit and wipe out part of the heap. The system software uses some unspecified amount of stack space in addition to the amount used by the program. This makes it doubly difficult to determine when the stack is growing too low. There is virtually no way to guarantee that the stack won't overwrite the heap, and most programs merely try to make it as unlikely as possible.

The Amiga's memory management places everything at fixed locations in one heap: Data blocks do not float. Some memory is not accessible to the custom hardware, so programs need to explicitly request chip-accessible memory (that is, available to the graphics chips) if they want it. Each task has a stack, which is usually rather small (less than 8K bytes), and each task has to cope with the same problem of noticing when the stack is full. The operating system does not use the task's stack at interrupt time, which makes it somewhat easier to avoid stack disasters.

One drawback of the Amiga's memory management is that a program must remember exactly what heap blocks it allocated and must deallocate them before shutting down. If it doesn't, the memory cannot be reused until the system is reinitialized (as by turning the machine off and then back on). The small, fixed maximum size for task stacks is also a nuisance. Most annoying is that other tasks may have allocated immovable blocks at any location in the heap, so a program cannot count on finding large continuous pieces of memory free. This is part of the reason why task stacks are usually so small—they have to be small enough so the program can be pretty sure of being able to allocate one.

Considering the design constraints of the Amiga, I don't see how the memory management software could have been much better. It's simple and fast, unlike the Mac's memory

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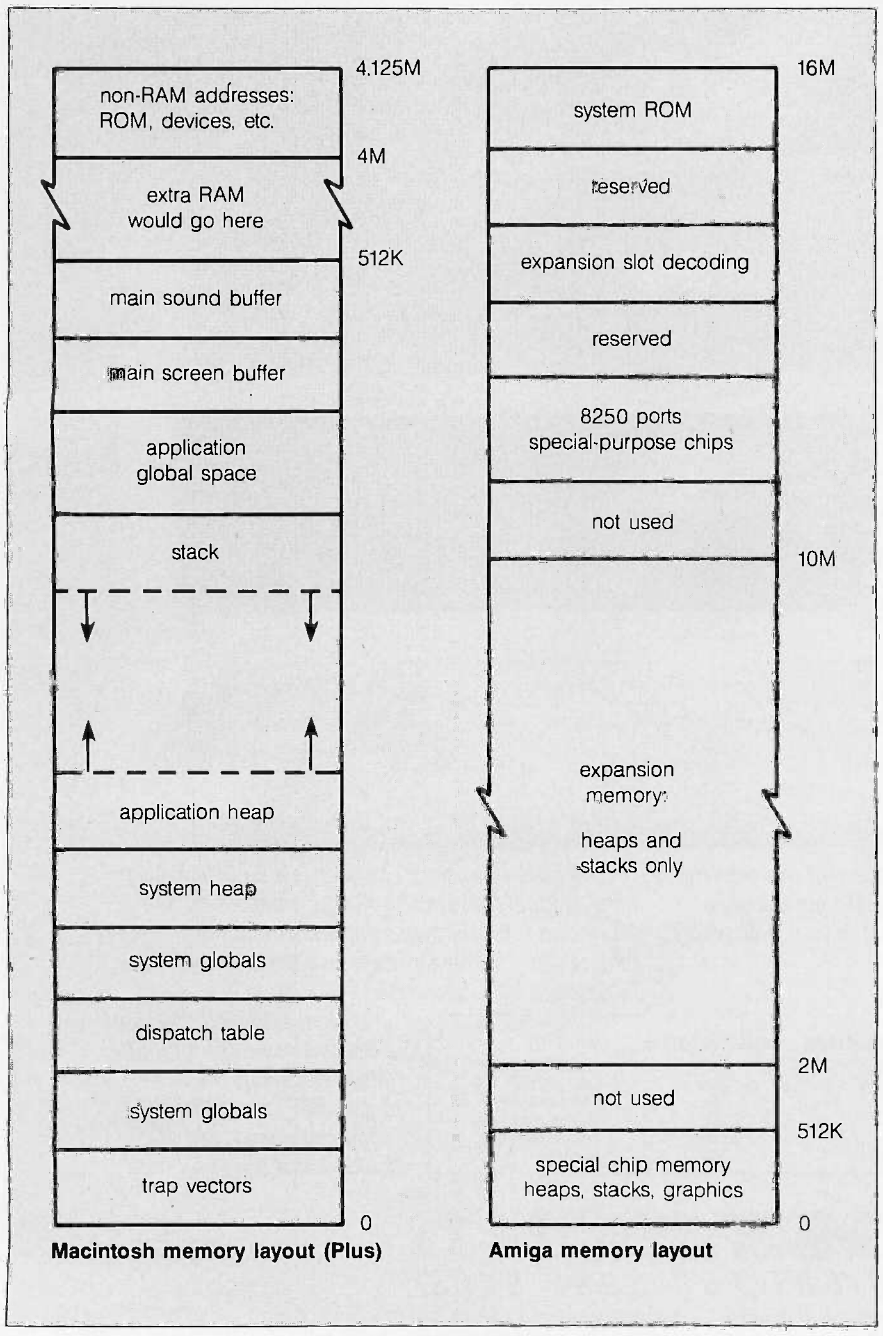

Figure 3: A *comparison of the Amiga and Macintosh memory maps.*

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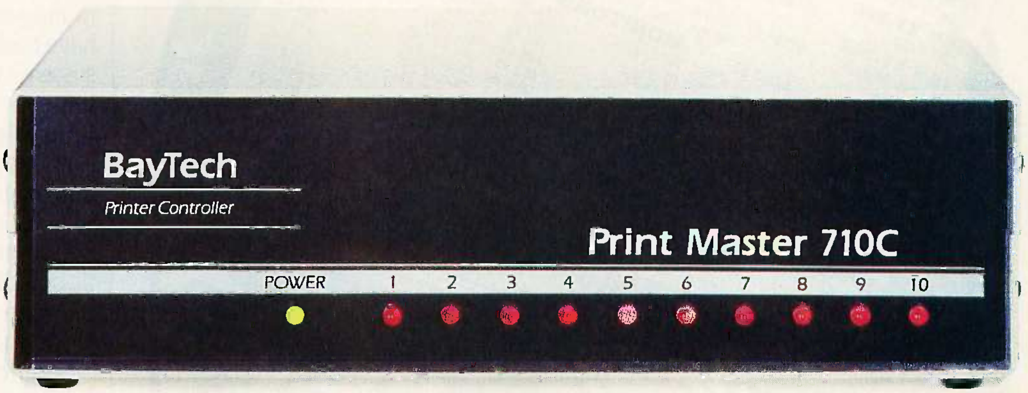

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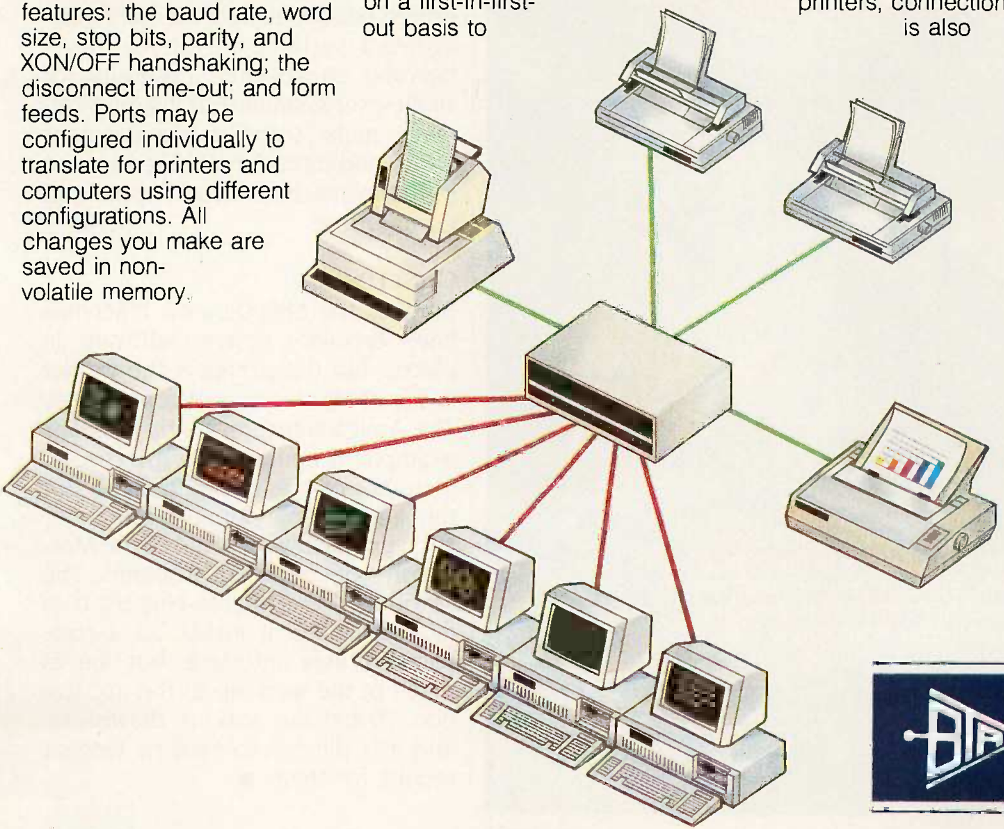

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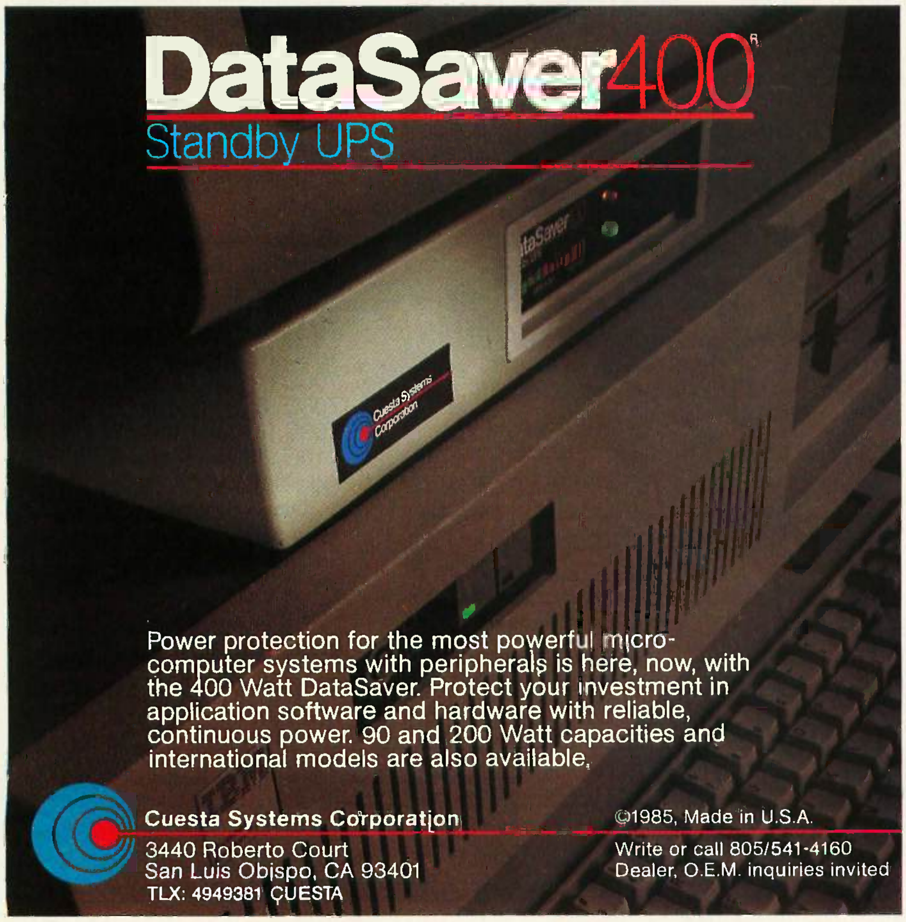

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Inquiry 95

management software, which, though it reduces memory fragmentation, is complex and slow. What I'd like to see in future machines is some memory management hardware. Mainframes have had the benefit of virtual memory systems for the last 20 years, and it's time this technology made it to micros. When people think of virtual memory systems they often think of *paging*, the automatic use of disk space as an extension of RAM. But with memory so inexpensive, who wants to page to a floppy disk? The real benefits of memory management hardware are *segmentation* and *access control*.

Segmentation means that memory is grouped into logical areas, not physical ones. There might be a segment for the stack and a segment for the heap. Hardware would take care of mapping these continuous logical areas into possibly noncontiguous pieces of RAM and would prevent them from ever running into each other. Access control means that the segments can be restricted for certain kinds of operations: A segment containing scratch space could be examined and altered but not executed, while a segment containing instructions could be examined and executed but not altered. Memory management hardware like this may never become an absolute necessity for single-user systems, but it would certainly make software development easier and more fun. I'd like to see it in future machines from Apple and Commodore.

CONCLUSION

Both of the 68000-based machines have excellent system software in places, but the Amiga is the winner in five of my six areas of comparison. The Amiga software is a bit thin: For example, it could use a more complete set of graphics primitives. But the Amiga's shortcomings are minor in comparison with some of the Macintosh's deep-rooted problems. The Macintosh lacks multitasking but tries to fake it, and it insists on a complicated user interface but leaves much of the work up to the application. These are serious drawbacks, and it is difficult to imagine elegant repairs for them. ■

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Lotus 1•2•3	✓					✓		✓					495^{00}
Symphony	✓	✓	✓			✓		✓		✓	✓		695^{00}
Framework	✓		✓	✓		✓		✓		✓	✓		695^{00}
Enable	✓		✓			✓	✓	✓		✓	✓		695^{00}
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Reviews

THE FRANKLIN ACE 2200 is an Apple IIe/IIc clone, but Albert S. Woodhull reports that the system differs from other members of the Apple family. The two disk drives are integrated and the keyboard is detached. He has found the system to be well built and highly compatible, but two expansion slots may not satisfy all users.

The Leading Edge Model D PC is an IBM PC clone with a long list of standard features. Stan Miastkowski reports that the computer is a very good value, with the lack of a higher processor speed being its main deficiency.

According to Wayne Rash Jr., the Xerox 6060 is virtually identical to the AT&T PC 6300. He was very pleased with the system's quiet and quick operation, although you should consider seriously his comments about obtaining affordable support.

Apart from a defective cover catch, Bob Swearengin enjoyed working with the C. Itoh TriPrinter. The price is not cheap, but the 9-wire print head can produce a variety of typefaces, the output is fast, and the overall print quality is very good.

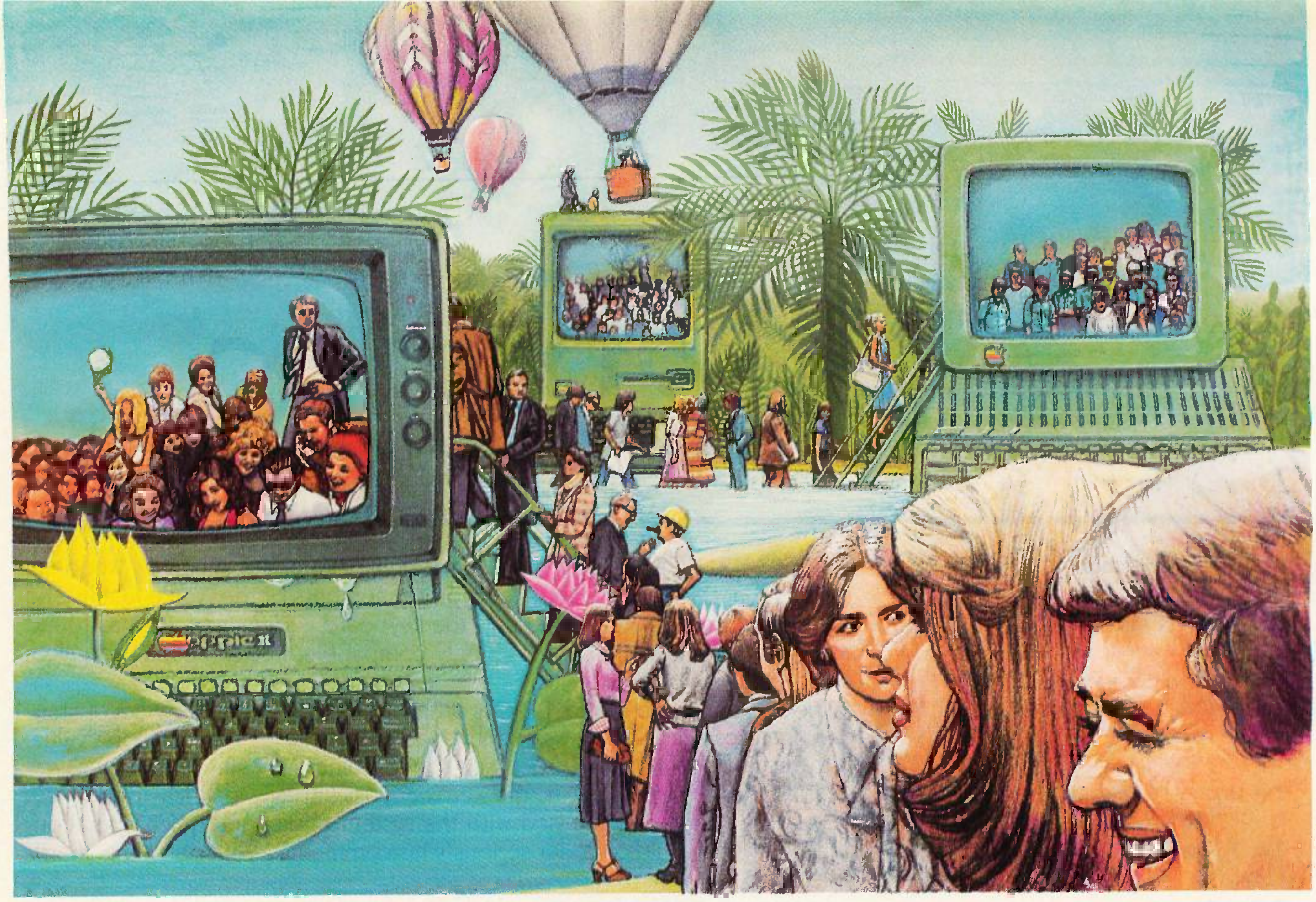
Jonathan Angel takes a brief look at one of many memory-expansion boards for IBM PC compatibles. The Turner Hall Card adds 256K bytes of memory, a clock/calendar, and software to let you set up a print spooler or a RAM disk. Even if you are considering a similar board, his discussion on installation should interest you.

Namir Clement Shammas reviews Turbo Prolog, a language that may do for Prolog what Borland's first language did for Pascal. He enjoyed the language's environment, its very fast compiler, and its support for screen and window management, but he has important reservations concerning its nonstandard implementation.

Software Carousel is a virtual memory manager that lets you load up to 10 applications at the same time. Mark Haas suggests that the $49.95 package has some minor limitations, but you might appreciate the fact that you can use any available main storage memory to hold inactive partitions.

Rusel DeMaria looks at Paradox 1.1, a relational database that combines a powerful script language, keystroke macros, and a complex relational data structure. The result is a powerful database well worth a look.

Finally, Ricardo Birmele examines the latest version of WordPerfect, which includes a wide variety of improvements and new features. Users of word processors will have little to criticize here.



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REVIEWER'S NOTEBOOK

This month I intended to provide a quick look at the best and brightest products from the 1986 National Computer Conference in Las Vegas, but the show was disappointing. Attendance was down, and very few new microcomputer products were shown. However, I vowed that I'd never return from a show cynically proclaiming that there was nothing there.

Therefore, I'm happy that Alloy (100 Pennsylvania Ave., Framingham, MA 01701, (617) 875-6100) showed its Bi-Turbo board, a dual-tasking accelerator for IBM PCs and compatibles. The plug-in card has an 8-MHz V20 processor, 1 megabyte of RAM, and a dedicated serial port. Bundled software allows you use the board to perform two separate tasks simultaneously. The software also provides disk caching.

Alloy recommends that you have 640K bytes of RAM in your system, although the board will operate with less memory. Note, however, that DOS 3.1 and the Bi-Turbo operating system take up approximately 142K bytes of your system's RAM, and you must have both a hard disk and DOS 3.0 or later. The software supports monochrome and CGA, but not EGA. A review of the board is now being written and should appear in BYTE this winter.

We hoped to find evidence of new products for the Amiga and the Atari ST at NCC, but the best source was the pile of packages waiting back at the office. For the Amiga, Byte by Byte Corporation (3736 Bee Cave Rd., Suite 3, Austin, TX 78746, (512) 328-2983) has just released Infominder, a powerful and innovative database manager. With it you can store, organize, and access text and graphic information. A display utility lets you view the content of files, including standard AmigaDOS text files and IFF format graphics. Byte by Byte claims that the database functions best with files that are prepared with it.

Byte by Byte has also just released its expansion chassis for the Amiga. For $1795, you obtain 1 megabyte of reserve memory (in addition to the 8 megabytes of RAM accessible through the expansion port), a battery-powered clock and calendar, and 5 DMA expansion slots. The chassis, which also will support up to three half-height devices including a hard disk, has a 200-watt power supply and will autoconfigure under Kickstart/Workbench 1.2. The unit, which includes a 20-megabyte hard disk, will sell for $3195.

For the Atari ST, Batteries Included (30 Mural St., Richmond Hill, Ontario, Canada L4B 1B5, (416) 881-9816) has released Time Link, a time management system, and Thunder, a Borland Lightning-like spelling checker. Time Link, which is also available for the Macintosh, lets you organize time-related information. The information you enter into the database is stamped with a time, allowing you to organize and structure your time or simply keep track of any time-based information. More advanced aspects of the utility allow you to compile information in separate categories over a period of time. You could, for example, use the tool to keep track of regular expenses.

We first saw Thunder at COMDEX in Atlanta, but it has now been released. Dubbed "The Writer's Assistant," Thunder provides a real-time spelling checker and a macro facility very much like PRD+ that uses abbreviations to speed up your typing. It also includes several writing tools for analyzing your prose and counting your words.

Finally, some reviews business. We are, as always, concerned with providing you with the best reviews in the business. And, of course, we want to provide as many reviews as possible. We have therefore organized a large number of comparative reviews of IBM PC and PC AT clones, PC AT multifunction boards, modems, printers, expansion boards, and, when possible, languages. You will begin seeing more of these comparative reviews in the next few issues, and I certainly want to hear what your reactions are.

We obviously have no desire to sacrifice our comprehensiveness or our user perspective, and I think that we have done well. We will be able to review far more products than ever before, and all of you who have walked the aisles at the larger computer shows know how important that can be.

However, our readers are the best judges. If you can, write me a quick note (c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458) to let me know how you feel about the direction of the Reviews section. After all, we are trying to serve you.

As for more immediate concerns, we are organizing a comparative review that will pit the new IBM PC Convertible against the Zenith Z-180, the Bondwell 8, and the Toshiba T1100 Plus. The review should be very exciting, especially since all of these machines are currently competing for government contracts. There will also be a Product Description of the IBM PC Convertible in our special IBM issue this fall. In addition, we are preparing comparative reviews of 18-pin dot-matrix printers, EGA boards, three new BASICs for the Macintosh, and much more.

—Jon Edwards
Senior Technical Editor, Reviews

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THE FRANKLIN ACE 2200

BY ALBERT S. WOODHULL

An inexpensive Apple II clone with a detachable keyboard and integrated disk drives

Although the Franklin ACE 2200 is an Apple IIe/IIc clone, its package is different from that of any member of the Apple II family. The two disk drives are integrated into the main unit, and the keyboard is detached. Franklin supplies its own disk operating system, and the internal firmware, including Franklin BASIC, is different from that of an Apple II. However, the ACE 2200 is designed to be a work-alike of an Apple IIe or IIc, with a 65SC02 microprocessor, built-in 128K-byte memory, graphics at low, high, and double-high resolution, expandability with standard Apple II peripheral cards, and the ability to run most programs written for the Apple II family.

PHYSICAL CHARACTERISTICS

The ACE 2200 is a well-built system. The two half-height 5¼-inch floppy disk drives have indicator lights to show activity and read/write status. The front panel has five indicator lights labeled Power, Diag, Disk Error, Dbl Hi Res, and CPU. I particularly like the Disk Error light; it flickers when disk errors are detected. This provides a useful early warning that a floppy disk is getting unreliable.

All the standard interfaces (keyboard, printer, game controller, and monitor) are attached by connectors to the backpanel, and there are cutouts for mounting additional connectors. From the rear panel, you can access a volume control for the built-in speaker. This is a nice idea, particularly for a family computer that might be used for playing games with sound effects. Also on the rear panel are four option switches for selecting an alternate character set and several other configuration options. The rear panel does not provide AC power outlets for the monitor or the printer.

You access the inside of the computer by removing two small screws from the rear panel and sliding the cover forward. The front panel and the disk drives remain attached to the cover, and several cables connect the drive assembly and front panel to the motherboard. This makes it difficult to open the machine. This problem may not bother many users, but for those who do a lot of work that requires switching interface cards, it may become annoying. Apple's easy access to the peripheral slots would have been a welcome feature in the ACE 2200.

When I opened the cabinet, I was surprised to see that there are over 110 integrated circuits on the main board. Recently the trend has been to rely on small numbers of specialized chips, but Franklin does not take this path with the ACE 2200. This means that if a malfunction can be identified, a long wait to obtain a part available only from the manufacturer is unlikely. On the other hand, however, most of the integrated circuits, except for RAM, ROM, the microprocessor, and a few other specialized chips, are soldered directly to the board. Thus, a local service person will not find it easy to locate a malfunction by systematically swapping chips.

THE KEYBOARD

Although I am not a skilled touch typist, the Franklin's keyboard seemed adequate to me. The two least-used punctuation keys, the backslash (\ ) and single left quote (`) keys, are located outside of their usual placement area, but otherwise the layout is standard, and the keys are full-size. The keyboard is connected to the main unit by a coiled cable that can easily be stretched out to five feet or more. It is very lightweight, and you can easily operate it with it resting on your lap.

At boot-up, the keyboard is in Caps

(continued)

Albert S. Woodhull (School of Natural Science, Hampshire College, Amherst, MA 01002) received his bachelor's degree from MIT and his Ph.D. from the University of Washington. He is currently an associate professor of computer studies and biology at Hampshire College.

Franklin ACE 2200

Company
Franklin Computer Corporation
Route 73 and Haddonfield Rd.
Pennsauken, NJ 08110
(609) 488-0600

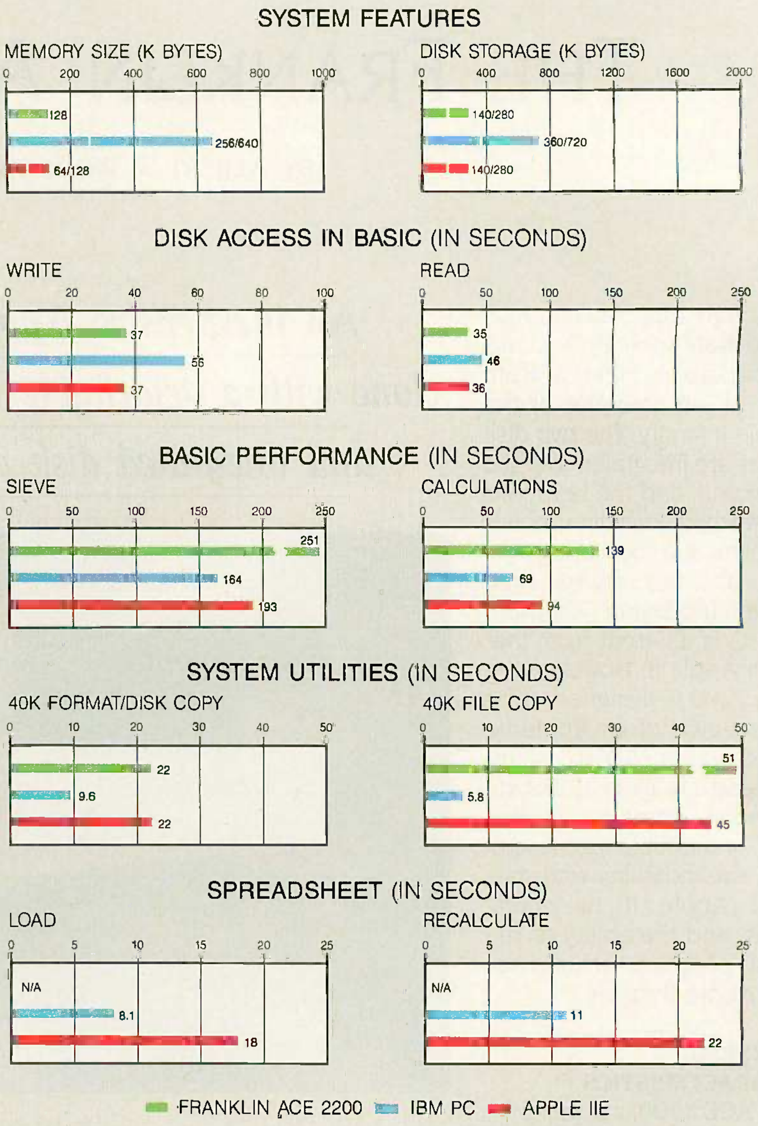
Size
Main unit: 15¾ by 13½ by 4 inches

Components
Processor: 65SC02 8-bit processor; 1.023 MHz clock speed
Memory: 128K bytes of RAM; 24K bytes of ROM
Display: Apple-compatible 40- or 80-column by 24-line text display; low-, high-, and double-high-resolution graphics; standard composite video output; provisions for RF modulator to allow use of standard television set
Keyboard: 90 keys, including full uppercase and lowercase alphabetic; numeric keypad; 12 function keys; open- and closed-F (equivalent to Apple's open- and closed-Apple keys)
Disk storage: Two 5¼-inch half-height floppy disks, format and capacity identical to Apple II; disks can be formatted for 40 tracks for about 15 percent more capacity, but Apple compatibility is lost
Expansion: Two internal connectors provided for standard Apple peripheral cards; expansion connector provided for an external expansion chassis, which has four additional slots
I/O interfaces: Composite video output, keyboard, game controller, serial printer interfaces standard; mounting holes for seven additional connectors provided

Software
Franklin BASIC in ROM, Franklin DOS 2 version 5.0, several utility programs

Documentation
User's reference manual, 150 pages
Technical reference manual (not supplied with the review model)

Price
$999



In the Disk Access in BASIC graph, a 64K-byte sequential text file was written to a blank floppy disk and then read. (For the program listings, see BYTE's *Inside the IBM PCs*, Fall 1985, page 195.) In the BASIC Performance graph, the Sieve column shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. [*Editor's note: This program had to be adjusted to run on the ACE 2200—see text.*] The Calculations column 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 disk (adjusted time for 40K bytes of disk data) and to transfer a 40K-byte file using the system utilities. [*Editor's note: The Disk Access and System Utilities benchmarks were performed using Apple's ProDOS. The ACE 2200 is supplied with Franklin's DOS 2 version 5.0, an Apple DOS 3.3 clone with improved disk I/O. As a sample comparison, an Apple IIe performing the Write benchmark in Apple DOS 3.3 required 180 seconds, while the ACE 2200 running Franklin DOS 2 ran the benchmark in 125 seconds.*] The IBM PC was tested with PC-DOS 2.0.

Lock mode, which is signaled by a status light. Initially, the numeric-mode light is off, indicating that the numeric keypad is functioning as a cursor control pad. In addition to the usual cursor movements, this keypad provides several other screen-oriented commands and single-keystroke execution of BASIC RUN and LIST commands. The closed-F and open-F keys duplicate the functions of the Apple's closed- and open-Apple keys. There are also 12 function keys, which will be examined later along with Franklin BASIC, since a special BASIC command is the only documented way to set them up.

THE MONITOR

The ACE 2200 that I reviewed came equipped with a green-phosphor Franklin monitor. The computer generates a standard composite video signal, so any other composite input monitor or a standard television with an RF modulator would work with the system. The ACE 2200 monitor's housing matches the main cabinet, and it tilts and swivels over a wide range. The resolution is excellent—the specifications indicate that it has a 22-MHz video bandwidth. I did have some trouble adjusting the contrast and brightness. After I adjusted the vertical size so that Apple Logo graphics produced a true circle, the dots making up the characters fused horizontally but not vertically, giving them an unpleasant beaded appearance. I decided to decrease the vertical size when I used text.

The extremely short cable supplied with the monitor was a nuisance because of my frequent need to open the cabinet. The monitor cable, like all the cables supplied, has large ferrite cores on each end to suppress RF interference, but I decided to risk using another longer cable I had. Since I have cable television, I had no problems with interference.

EXPANDABILITY

The ACE 2200's expansion capabilities lie somewhere between those of its two Apple competitors. The Apple IIe has an internal bus with seven connectors available for various peripherals, and it requires interface cards for the disk drive, printer, and serial communications. The Apple IIc has no peripheral card slots, but the interfaces for the disk drives, printer, and serial communications are built in. In the ACE 2200, the disk controller and the parallel printer interfaces are built in, and two additional peripheral card slots are available. One of these slots functions as slot 2 and is intended for use with a serial communications interface. The other slot can be jumpered to be addressed as either slot 4 or slot 7.

The ACE 2200 also allows an expansion chassis to be attached by a connector, which is accessible by removing a small cover on the right-hand side of the cabinet. This provides slots for four additional peripheral cards. (My review machine was not provided with an expansion chassis.)

I tested the ACE 2200 with several of the peripheral cards I normally use in my Apple. I used an Advanced Logic Systems CP/M Card and a Synetix Flashcard RAM disk extensively with no trouble. I wrote most of this review on the ACE 2200 with MINCE, a CP/M word-processing program.

While testing a Microsoft Softcard, I noticed an unusual flickering of some of the dots on the video display. This effect disappeared after the system had been running for a while. It also vanished during disk accesses, when the 6502 microprocessor is handling I/O and the Z80 is inactive. The Taurus 8 large-format floppy disk controller I normally use with my Apple also worked well with the ACE 2200 under CP/M with either of the Z80 coprocessors.

I had one major hardware compatibility problem: An Apple Co-op Big Board (a 1-megabyte RAM disk) would not work properly in the ACE 2200. The system would not boot properly when the Big Board was in place, and the screen display was torn, as if there was a serious disruption of the video sync timing.

The problems with the Big Board and the Softcard indicate that the ACE 2200's internal timing and video signal generation are significantly different from that of the Apple II+, which works well with both cards. Purchasers of the ACE 2200 who intend to use a coprocessor or an extended memory card should make sure that they have chosen compatible cards.

FIRMWARE AND SOFTWARE

From my observations of the cabinet's insides, I found that the ACE 2200 has a total of 24K bytes of firmware in ROM. This includes a machine language monitor that is called in the same way as the Apple's machine language monitor (by a CALL-151 from BASIC). There is absolutely no mention of the monitor commands in the user's reference manual. The commands to examine, alter, and move memory contents seem to work exactly as they do in the Apple II series, but other commands, including the one used to disassemble 6502 code, are missing.

One aspect of the firmware that didn't work properly was the graphics screen dump. I have a Star Micronics Gemini-10 printer, which is one of four printers for which a screen dump command is supplied. However, trying to dump the screen pattern generated by Franklin's diagnostics program did not work.

FRANKLIN BASIC

Franklin BASIC is also supplied as part of the firmware. Franklin claims that its BASIC is compatible with Applesoft BASIC, but it has one documented extension and one documented omission. I found a few other differences, two of which may be serious problems.

The extension is the FKEY command, which allows you to set each of the 12 function keys to generate a unique string when pressed. The only limitation is that the total number of characters in the strings for all the function keys must be less than 233. A program containing FKEY statements will hang up on an Apple, but portability of this function is not really a necessity, since you would use it primarily in the Hello program that executes at boot-up.

The documented omission of Franklin BASIC is that it does not recognize commands related to cassette tape storage (the ACE 2200 has no tape interface). Since the days of cassette

(continued)

storage are now long gone, I don't think these commands will be missed.

One feature that the manual doesn't describe is that you can enter BASIC programs using either uppercase or lowercase keys. When you list the program, you see the BASIC keywords in lowercase, and the other parts of your program are displayed as they are entered. I particularly like this feature because it adds clarity to the listings. BASIC programs originally written on an Apple are also listed in this manner. There is a potential pitfall, however, if you want to write a program on the ACE 2200 that will also run on an Apple. In Franklin BASIC, variable names are saved in the form in which they are entered; thus, a and A are distinct variables. The Apple cannot recognize lowercase variable names, however. A program with lowercase variables can be listed and edited on an Apple, but it won't run. For Apple compatibility, you must enter variable names in uppercase.

A more serious problem occurred when I attempted to run a program I had written that lists text files to the console or printer. The program refused to run on the ACE 2200 when the 80-column display was active. As the screen scrolled, the text near the top became blanked out, and eventually the program crashed. ASCII blanks seem to be written into the Franklin BASIC program memory. I was able to list only the first line of the BASIC program, and many commands would not work until I rebooted. This problem did not occur when I used the ACE 2200's 40-column display mode, however.

This program uses no undocumented tricks of Applesoft BASIC, but it does output dummy characters to the display to get around the Apple quirk in which the first character sent to the output following a get command is not displayed. This bug is well known and likely to be encountered in commercially available Apple programs, and a good Apple clone should be able to handle it.

I ran into a problem with Franklin BASIC while testing it with the Sieve of Eratosthenes benchmark. The standard BYTE Sieve program uses a 7000-element array. On the Apple II+ with Apple DOS 3.3, this uses almost all available memory. On the ACE 2200, the problem isn't just that the machine has less memory available for the array; Franklin BASIC incorrectly executed the DIM statement without issuing an "Out of Memory" error message. Editing the program to decrease the array size to 6000 elements resulted in a correct run. Running with the array size at 8000 was, of course, not possible, but in this case, the machine properly reported "Out of Memory."

Clearly, there are two serious problems here. Since ACE 2200 owners will depend on software written for the Apple, they may be disappointed by programs that use all available memory. Moreover, it is unacceptable for a machine to fail to detect overallocation of storage when running a high-level language.

DISK OPERATING SYSTEM

Franklin Corporation supplies its Franklin DOS 2 version 5.0 with the ACE 2200, along with several utility programs for disk and file copying, hardware diagnosis, and disk verification. I didn't find any problems with the DOS, and it seems to be able to read and write text files considerably faster than Apple DOS. The Franklin DOS recognizes the hyphen (-) as a smart run command (as in Apple's ProDOS), which allows you to run an executable file by typing a dash before its name. This will work whether the file is a machine language or BASIC program, or an EXEC file.

Franklin DOS 2 also supports formatting and using 40-track disks, which provides about 15 percent more storage capacity on a disk than the Apple standard. Several DOS utility programs also provide a menu option, which implies that double-sided disks are supported. However, this isn't mentioned in the documentation, and I'm not sure whether Franklin plans to sell machines with double-sided drives in the future.

The problems with memory allocation that I observed while running the Sieve of Eratosthenes benchmark are apparently not in the DOS but in BASIC itself, since the problems occurred whether I booted with Franklin DOS 2 or with Apple DOS 3.3 (see page 264 for details). This means, of course, that a ROM update will be needed to correct the problem.

SOFTWARE COMPATIBILITY

I was able to successfully boot and run five different Apple operating systems: Apple DOS 3.3, ProDOS, Pascal, and two versions of CP/M. In addition, I tested some Apple games on the ACE 2200. Many of these are copy-protected, which usually involves some kind of nonstandard disk interface. In every case, I found that a disk that would boot on my Apple II+ would also boot satisfactorily on the ACE 2200.

I had one failure running a commercial program, however. Spinnaker's Snooper Troops booted properly, but crashed early with an "Out of Memory" error message. This seems to be an example of a program that needs all the memory an Apple can provide.

The ACE 2200 documentation says that Apple Integer BASIC is not supported, but I found that an Apple DOS disk, which loads Integer BASIC into RAM at boot time, worked properly, and some Integer BASIC programs also ran properly. An exception was the public domain TED II+ 6502 editor/assembler program, which is an Integer BASIC program that contains an embedded machine language portion. The program did not list or assemble files correctly.

DOCUMENTATION

A 150-page user's reference manual was supplied with the review machine. I found this manual useful and accurate, but I wanted much more detail. Everything I needed to know to set up and configure the ACE 2200 was there, and many of the machine's advanced features were covered. However, there were major gaps, including the complete lack of mention of the machine language monitor commands. No mention is made of how to configure the programmable function keys to work under CP/M. It is an exaggeration to call this book a reference manual.

The manual does suggest that Apple reference manuals should be consulted for additional information.

This is valid advice, but it raises some questions about what one should expect from a manufacturer.

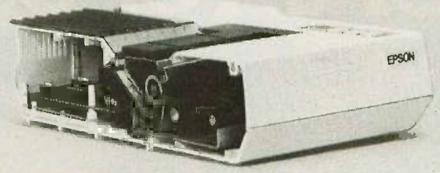
The user's reference manual refers to a companion technical reference manual, but the latter was not supplied with my machine. Even though every user may not need the technical details that such a manual would contain, most users will end up with some problems that they need to ask an expert about. My experience has been that when technical information is not part of the package that the purchaser receives, it is often not available to the dealers or service people either.

CONCLUSIONS

Although there is a definable niche for the Franklin ACE 2200 between Apple's IIc and IIe, it is a narrow one. Even though the IIc is not supposed to be expandable, additional memory and Z80 coprocessors are available as piggyback boards that plug into an existing chip socket on the main circuit board. Experienced users will surely advise those who are attracted by the ACE 2200's cost advantages over the Apple IIe that two expansion slots may not be adequate.

The Franklin ACE 2200 does have some appeal. Physically, it is a nice package. I like the detachable keyboard and the single cabinet with integrated disk drives. Franklin's DOS is a significant improvement over Apple's painfully slow DOS 3.3 for reading and writing text files. Standard operating systems, such as Apple's ProDOS and Pascal and (with a coprocessor) Digital Research's CP/M, are all usable as well.

On balance, however, I don't think I would buy an ACE 2200 for myself. Problems that could affect every user are burned into ROM—the flawed Franklin BASIC cannot be replaced simply by booting a different disk. I also find the Franklin Monitor program inadequate. In addition, I found that the RAM disk that I use to increase the performance of my Apple would not work in the ACE 2200. Users who could carefully define their software and hardware needs might find a combination including the ACE 2200 and selected peripherals suitable for their work, however. ■



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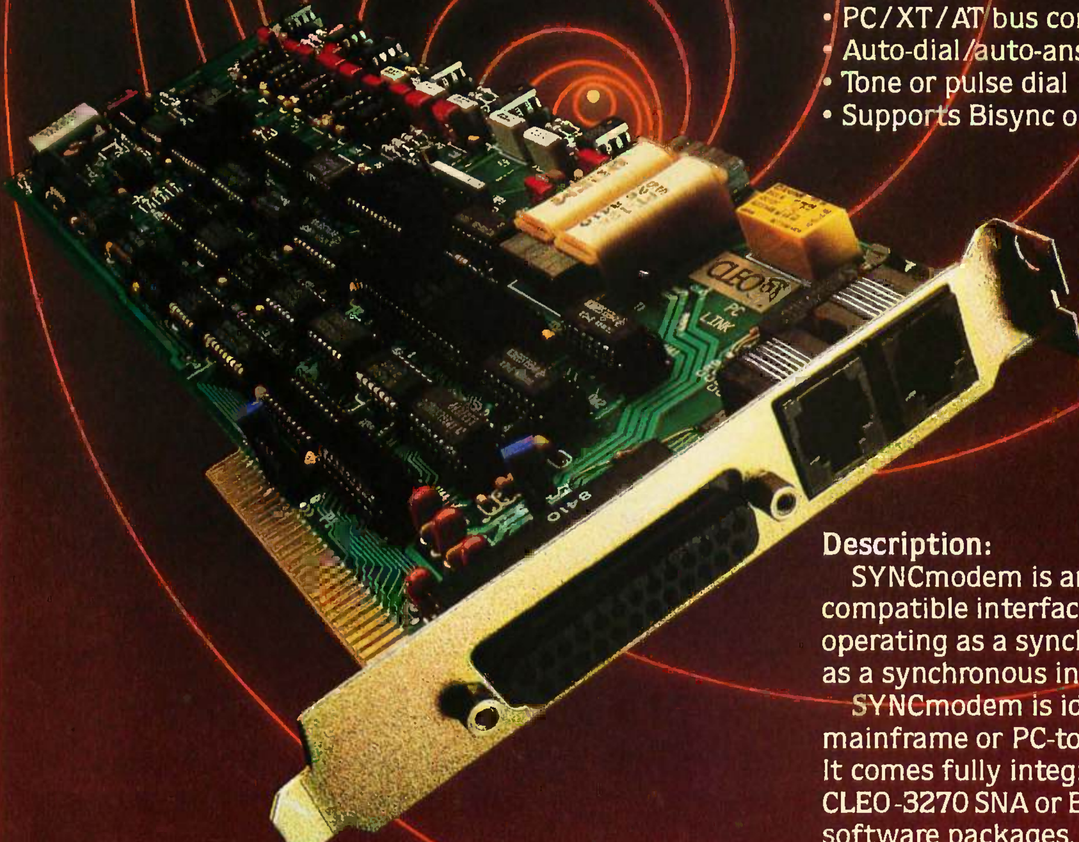

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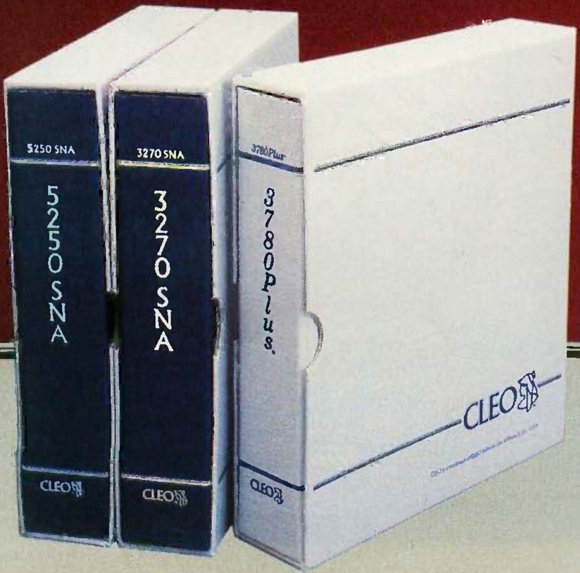

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THE LEADING EDGE MODEL D PC

BY STAN MIASTKOWSKI

An inexpensive, well-built IBM PC *clone with a long list of standard features*

The Leading Edge Model D PC is the closest thing to a "plug in and run" IBM PC clone that I have seen. Standard features include a monochrome (amber or green) monitor, two 5¼-inch floppy disk drives, 256K bytes of RAM, serial and parallel ports, monochrome and RGB display adapters, and a clock/calendar. The basic Model D retails for $1495 and comes with an impressive 15-month warranty. A printer is the only addition you will need to make the Model D into a complete system, although you can also add a RAM upgrade to 640K bytes, an 8087 arithmetic coprocessor, and a 20-megabyte hard disk drive. You can also purchase the Model D with a 14-inch 640- by 200-pixel RGB monitor in place of the monochrome monitor.

The Model D has many useful features. The system unit and the monitor both come with extra-long (10-foot) AC power cables. The power supply's fan is extremely quiet. The power and reset switches are on the front of the system unit, and the monitor's power, brightness, and contrast controls are on the front of the monitor. The system unit even has a depression in which the monitor sits comfortably.

INSIDE THE SYSTEM UNIT

Despite the small footprint of the Model D (a full five inches narrower than the IBM PC), you still have plenty of room for expansion, because the parallel and serial ports and display adapters are built into the motherboard. The Model D power supply is rated at 130 watts, which is enough power for the system and most additional boards. There are four full-length expansion slots available, enough for most environments. As you might expect in a system this compact, the components on the motherboard are closely packed.

The system unit cover slides forward off the machine after you remove five screws. The motherboard, which contains all memory and circuitry for ports, completely covers the bottom of the case. The disk drives and power supply sit on a shelf mounted above the board. To gain access to the entire motherboard, you must unplug the disk drive cables and power supply connectors, remove four screws from the front of the shelf and five from the back, and then lift out the power supply and disk drive assembly. The entire process takes about three minutes. The only potential problem is that you must keep track of three differently sized screws.

The position of the 4.77-MHz 8088 processor (in the middle of the motherboard just in front of the four expansion slot connectors) made it impossible for me to use an 80286 expansion card. The connector that replaces the 8088 just wouldn't reach, no matter which slot I used. The motherboard also has an empty ROM socket next to the BIOS ROM. You can install up to 32K bytes of ROM.

In addition to a 6-pin connector for a light pen, there are several configuration jumpers on the motherboard. They enable and disable the monitor controller, set the interrupt level of the clock, enable and disable the I/O controllers, and set the installed RAM and ROM size.

The standard 256K bytes of RAM comes on easily accessible memory chips on the front of the mother-

(continued)

Stan Miastkowski (P.O. Box 548, *Peterborough*, NH 03458) *is a freelance writer, northeast bureau chief for* Newsbytes, *and editor in chief of the* McGraw-Hill Microcomputer Handbook.

Leading Edge Model D PC

Company
Leading Edge Hardware Products Inc.
225 Turnpike St.
Canton, MA 02021
(800) 343-6833

Size
5½ by 14 by 15½ inches; 43 pounds

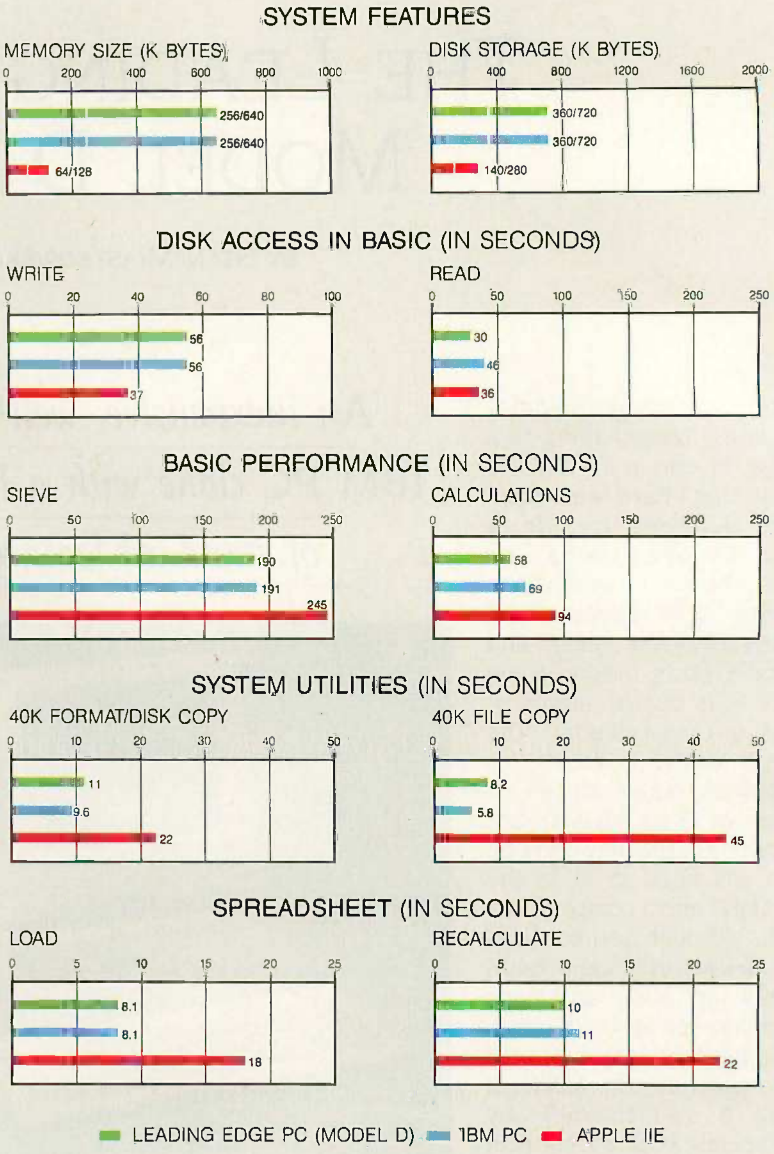
Components
Processor: 4.77-MHz 8088
Memory: 256K bytes, expandable to 640K bytes
Mass storage: Two double-sided 360K-byte 5¼-inch floppy disk drives
Display: 12-inch green- or amber-phosphor monochrome display standard; dual-mode display adapter
Keyboard: IBM PC compatible; 83-key layout
Expansion: Four 62-pin, full-length IBM PC-compatible slots
I/O interfaces: Parallel printer; RS-232C; clock/calendar

Software
MS-DOS 3.1; GW-BASIC; diagnostics disk; demonstration disk; Leading Edge word processor

Options
20-megabyte hard disk drive; 14-inch RGB monitor; 384K-byte memory upgrade; 8087 numeric coprocessor

Documentation
Operator's guide
Guide to MS-DOS
Guide to GW-BASIC

Price
Basic configuration: $1495
With RGB color monitor: $1895
With 20-megabyte hard disk and monochrome monitor: $1895
With 20-megabyte hard disk and RGB color monitor: $2295



The Memory Size graph shows the standard and optional memory available for the computers under comparison. The Disk Storage graph shows the highest capacity for a single floppy disk drive and the maximum standard capacity for each system. 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 spreadsheet used was Microsoft's Multiplan.

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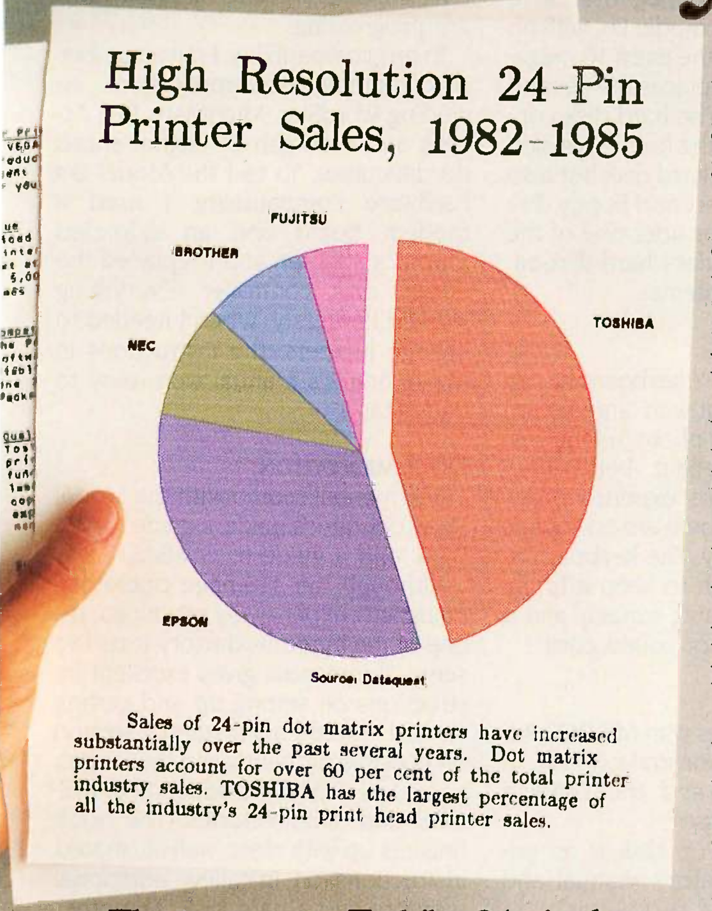

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Source: Dataquest

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The P351

The P351C

In Touch with Tomorrow

TOSHIBA

Toshiba America, Inc., Information Systems Division board. There are four rows of 64K-bit chips, two rows of which are in sockets. To upgrade the system to 640K bytes, you need only remove the 64K-bit chips from the sockets, replace them with 256K-bit RAM chips, and change a jumper. The operator's guide includes complete and clear instructions for the change.

DISPLAY OPTIONS

The connectors for the monochrome monitor, color monitor, RS-232C serial port, and parallel ports are clearly marked on the rear panel of the Model D. Between the monochrome and color jacks is a single-throw switch used to select either port, eliminating setup problems. You can circumvent the switch in software by using the familiar MODE command or the Model D MS-DOS's COLOR or MONO commands.

The monochrome adapter is Hercules-compatible; you can therefore display graphics on the monitor in varying shades of green or amber. Resolution is 720 by 348 pixels. The display has a nonglare surface and can tilt up and down. Both text and graphics characters are crisp and of high quality.

DISK DRIVES

The standard Model D comes with two double-sided 360K-byte 5¼-inch floppy disk drives, mounted one over the other. A mechanical switch on the front of each drive locks the drive door closed after you insert a disk. The switches are not absolutely necessary, especially since you don't have to throw the switches to use the drives, but they do keep a disk from being inadvertently removed at an inopportune time.

The optional 20-megabyte hard disk drive replaces the 10-megabyte drive available with early model Ds, with no additional cost for the extra 10 megabytes. This drive replaces the second floppy disk drive. The hard disk controller uses one of the four expansion slots. If you want a hard disk but also want to keep your second floppy disk drive, you might consider one of the increasingly popular hard-disk-on-expansion-card systems.

KEYBOARD

The 83-key QWERTY keyboard has an IBM Selectric layout with large Return and Shift keys (see photo 1). The keyboard feel is excellent, better than many of the more expensive keyboards. However, there are no sounds when you hit a key. The keyboard itself weighs enough to keep it firmly planted on the typing surface, and it comes with a 6-foot coiled cord.

SOFTWARE

The Model D comes with MS-DOS 3.1, GW-BASIC, a demonstration disk, a diagnostics disk, and the Leading Edge word processor.

The demonstration disk is an adjunct to the operator's manual and uses the monochrome card's graphics to walk beginners through the features and capabilities of the Model D.

The diagnostics disk has twelve standard tests that you can run individually or all together. The tests are well designed and include copious status messages that tell you how long the tests will take and how they are progressing.

To test compatibility, I ran a number of commonly used applications, including WordStar, MultiMate, PFS:Access, and a few games. I experienced no difficulties. To test the Model D's hardware compatibility, I used a modem board and an extended graphics adapter, and I replaced the floppy disk controller. Everything worked flawlessly. When I needed to change jumpers, the instructions in the operator's manual were easy to understand.

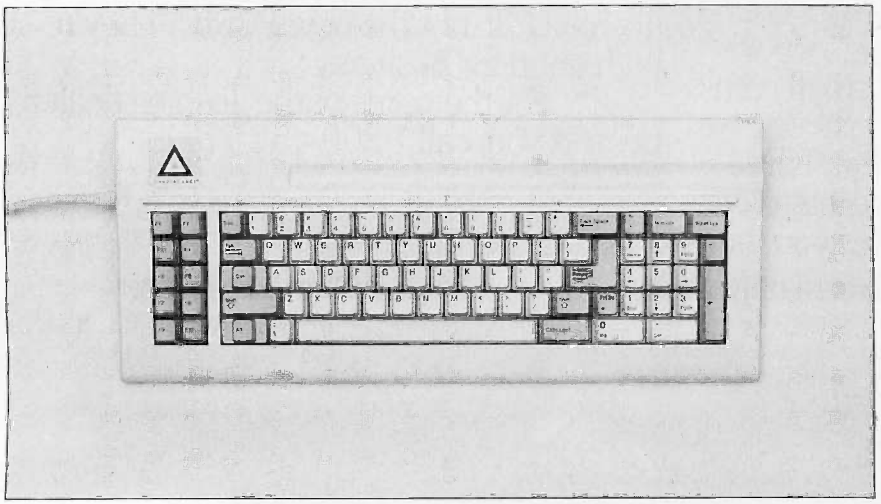

Photo 1: *The Model D's 83-key* QWERTY *keyboard.*

DOCUMENTATION

Three manuals come with the Model D: an operator's guide, a guide to MS-DOS, and a guide to GW-BASIC.

Although the 110-page operator's guide isn't expensively produced, it's one of the best introductory texts I've seen. The manual gives excellent instructions on setting up and getting started. There's a substantial section on possible problems and their cures, as well as a short introduction to MS-DOS and subdirectories. The book finishes up with clear, well-illustrated instructions on installing additional memory and a hard disk. The other manuals are also of high quality.

Although there is no technical manual for the Model D, more detailed information is easy to obtain. There is a toll-free support number, and the technical support people are knowledgeable and helpful.

SUMMARY

The Leading Edge Model D PC is a thoughtfully designed and well-built IBM PC clone. Its long list of standard features makes it stand out from the pack. The lack of a higher processor speed (see page 270) is perhaps its greatest shortcoming. However, at nearly half the cost of a comparably equipped IBM PC, the Model D is a superb value. ■

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THE XEROX 6060

BY WAYNE RASH JR.

A fast-running machine with an Intel 8086 microprocessor and a 16-bit data path

The Xerox 6060, which is virtually identical to the AT&T PC 6300 (see the review by Bob Troiano in the December 1985 BYTE), provides quiet, unobtrusive, and very fast operation. The machine is based on an Intel 8086 microprocessor running at 8 MHz. The 8086 uses a 16-bit data path, allowing faster operation than the 8-bit data path in the IBM PC. For some applications, the Xerox 6060 is nearly three times as fast as the IBM PC. The 6060's main problem is its very costly support.

Besides the exterior color, the biggest difference between the 6060 and the AT&T PC 6300 is the monitor. Like other Xerox computers, the 6060's monochrome screen is black and white. Green and amber apparently are not available. There is also a noticeable difference in the software supplied with the Xerox 6060. Along with MS-DOS, you get a menu-oriented user interface that performs most MS-DOS functions.

THE SYSTEM UNIT

The Xerox 6060 system unit is about two-thirds the size of the IBM PC. My review unit contained a half-height 10-megabyte hard disk drive and a 360K-byte floppy disk drive. Both drives are very quiet. My floppy disk drive had a strong ejection spring. In many cases it ejected the floppy disk to the keyboard and sometimes to the floor.

A pilot light and a reset switch are directly beneath the disk drives. If you have one of those programs that turns your screen off after a few minutes, it's nice to be able to tell at a glance whether the machine is really off or if the screen is just blank.

The rear of the Xerox 6060 contains the power switch, the communications ports, the keyboard connector, and the monitor connector. The housing for the cooling fan protrudes slightly over the main unit. The parallel and serial connectors are next to each other near the bottom. Both connectors are DB-25s. The monitor connects to a third DB-25 located on the rear of an expansion board. Four screws allow you to remove both the top and bottom of the machine.

Like the AT&T PC 6300, the Xerox 6060 has its motherboard beneath the bottom panel. You must remove the bottom of the computer to change switch settings or to add a math coprocessor. As unlikely as it seems, this is more convenient than the access to the inside of many other machines. Once the bottom is off, you have clear, unobstructed access to the entire motherboard. Most of the circuitry is soldered in place rather than socketed, so you won't be able to do much with the motherboard other than change the switch settings.

The backplane contains seven expansion slots that will accept most IBM PC–compatible expansion boards. Two slots also have an additional connector that allows use of the full 16-bit data path from the 8086 microprocessor. The additional connectors are arranged and located differently from those on the IBM PC AT, eliminating any chance of using PC AT expansion cards in the 6060.

The disk controller and an optional memory-expansion card each take one of the seven slots. At the far left edge of the case is the graphics card, into which the monitor is plugged.

THE KEYBOARD

The Xerox 6060 keyboard is identical to that of the AT&T PC 6300. The rear of the keyboard can be raised and lowered to three different angles. The keys are arranged like those on the IBM PC, although the Caps Lock and Num Lock keys have LEDs to indicate when they are active. The touch of the

(continued)

Wayne Rash Jr. is a member of the professional staff of American Management Systems Inc. (1777 North Kent St., Arlington, VA 22209), where he consults with the federal government on microcomputers.

Xerox has extensively modified some MS-DOS system utilities.

keys is quite light. At the rear of the keyboard is a connector for the mouse.

THE MOUSE

The two-button optical mouse works with Screenmate, the MS-DOS shell (see description below). The left button indicates a selection; the right button confirms acceptance. You slide the mouse on a piece of gray cardboard that comes supplied with it. An optical sensor on the mouse's underside determines direction using the dots created by the cardboard's halftone. The mouse is very sensitive to movement, and I obtained better results by using *Washington Post* want ads instead of the gray cardboard.

THE MONITOR

I found the screen of the Xerox 6060, which is black with white letters, tiring to use for long periods. I talked to people who had used this screen all day, and they complained of headaches. I would recommend that you consider buying the color monitor from Xerox or the monochrome monitor and card from AT&T.

Because the monitor receives its power through the same DB-25 connector that provides the video signal, you will probably have difficulty using a third-party monitor. The characters are not the same as the IBM character set, but they do not seem as strikingly clear as those used by AT&T. A monitor stand allows you to tilt and swivel the screen.

USING THE XEROX 6060

The complete installation process for the hard disk–equipped review machine took about 20 minutes. It takes almost no training to start and run the computer. I was able to use the system before I looked at the documentation. When you turn on the system, it performs a number of self-diagnostic tests and reports on their outcome. The Xerox logo then appears for a few seconds, followed by the Screenmate main menu. You can use function keys or the mouse to control the menu functions.

The Xerox 6060 is so fast that you may change some of the ways you use your software. For example, you may want to slow down Framework menus so you won't miss the animation of the windows.

I used all my IBM PC application software in the 6060 without incident, although many programs ran faster than they do on other machines. In some cases there are special installation programs for the AT&T PC 6300. If this is the case, use these special programs, since the PC 6300 is essentially identical to the 6060.

Despite software compatibility, the Xerox 6060 is not totally compatible with the IBM PC. Since the 6060 has a 16-bit data path, it requires special memory-expansion boards. Thus, third-party memory and multifunction boards may not run properly, or they may not have the use of all their functions. A Tall Tree JRAM-2 board, for example, functions properly except that it does not recognize the extra memory, and the memory-related software for the board will not function.

THE SCREENMATE SHELL

With MS-DOS, Xerox includes Screenmate (which is called XMATE on the disk), a command-processing shell that provides all the functions from a menu. The Screenmate menu will respond to input from the keyboard or from the mouse.

Nearly any MS-DOS command or program can be run from within Screenmate, but at times, such as when copying files, it is more difficult than simply typing the command at the command level. The only way that I was able to copy files while using Screenmate was to copy one file at a time. I was also unable to set the system clock from within Screenmate, despite following the directions exactly.

Xerox has modified a few of the MS-DOS system utilities extensively. The MODE command, for example, refers you to the Xerox program Configur, which allows you to set up the communications ports by using a menu. You can even convert from codes designed for one type of printer to those of another. While you gain some additional functions, you lose the control that the original commands give you. I think it would have been preferable to retain the utilities in their original form so that advanced users would have access to them.

Eliminated are two MS-DOS commands: the ASSIGN command, which lets you reassign disk drives, and the GRAPHICS command, which lets you print graphics screens using the Prt Sc key. This last function is replaced to some extent by the Xerox device drivers, which translate a program's codes to those of another printer.

Whatever the trade-offs from the changes to the system utilities may be, one definitely useful change is Xerox's on-line help files. Most of the programs Xerox modified will let you get more information about the command by pressing a key for help.

DOCUMENTATION

Xerox has rewritten the standard MS-DOS documentation. The result is a set of manuals that should be understandable to most beginners but is insufficient for more advanced users.

The Screenmate manual serves more as a tutorial than as a reference manual. The manual has an index, but it is limited to a cross-reference of Screenmate operations. Less-used operations, such as partitioning the hard disk, are in the appendixes.

The Screenmate manual is well written, and all operations are clearly explained. New users should have no trouble following its procedures.

Like the Screenmate manual, the MS-DOS manual presents explanations in the form of a tutorial, a small disadvantage when you only need to locate a discussion on a single command. Of course, the use of menus to control operations lessens the need to understand command syntax. The index of the MS-DOS manual is somewhat more complete.

The hardware and setup manual is excellent. It explains each step clearly and completely with fine illustra-

(continued)

Xerox 6060

Company
Xerox Corporation
1301 Ridgeview Dr.
Lewisville, TX 75067
(214) 420-7200

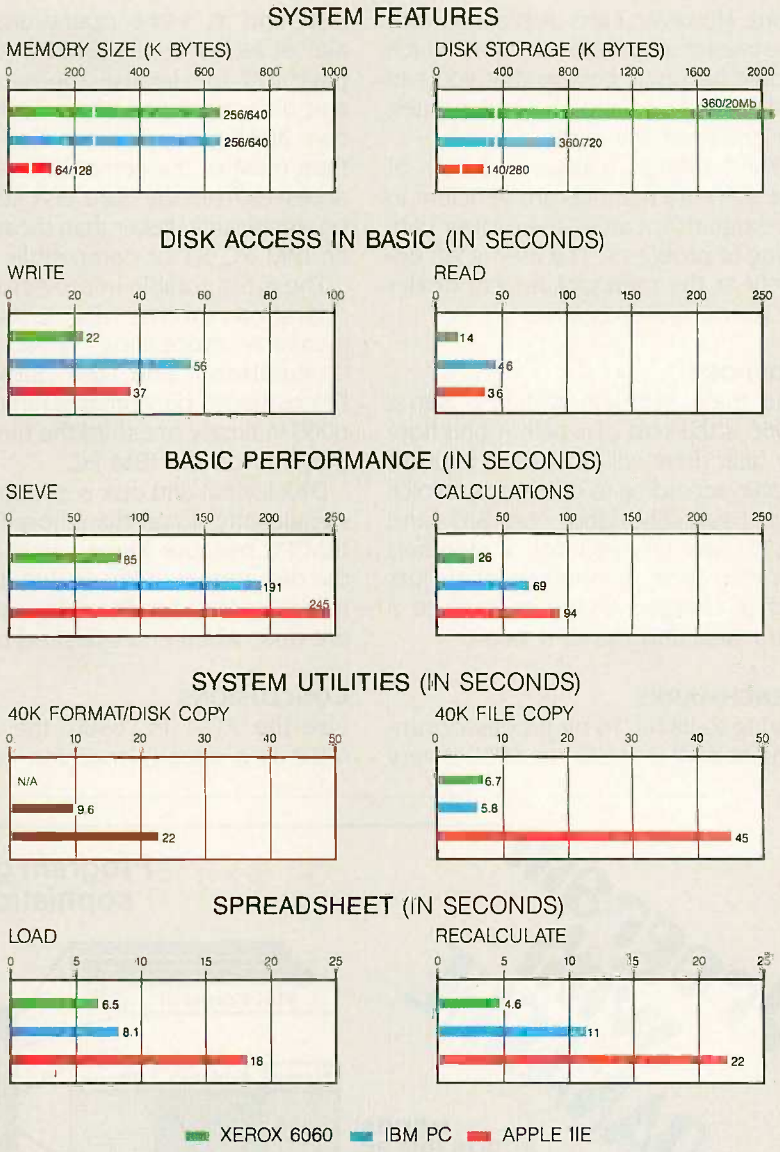
Size
15 by 15½ by 15¼ inches

Components
Processor: Intel 8086
Memory: 256K bytes, expandable to 640K bytes
Mass storage: Two half-height 360K-byte 5¼-inch floppy disk drives, or one floppy disk drive and a 10-megabyte hard disk drive
Display: 12-inch white phosphor, 80 characters by 25 lines; color is optional
Keyboard: 83 keys, 10 function keys; indicator lights on Caps Lock and Num Lock keys
Expansion: Seven slots, two of which are 16-bit
I/O interfaces: One serial and one parallel port

Software
MS-DOS 2.11; Screenmate shell (XMATE)

Documentation
MS-DOS manual, Screenmate manual, hardware and setup manual

Price
Basic system with two floppy disk drives and 256K bytes of memory: $2605
Basic system with one floppy disk drive, a 10-megabyte hard disk drive, and 256K bytes of memory: $2810
Basic system with one floppy disk drive, a 20-megabyte hard disk drive, and 512K bytes of memory: $3505



The Memory Size graph shows the standard and optional memory available for the computers under comparison. The Disk Storage graph shows the highest capacity for a single floppy disk drive and the maximum standard capacity for each system. 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 graph shows 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 spreadsheet used was Microsoft's Multiplan. The Xerox 6060 did not come with a copy of GW-BASIC; the tests were done with AT&T's version of BASIC.

tions. However, I was displeased with the printer installation section, which would have you believe that you can only install a Diablo or Xerox printer, which is not the case.

The hardware manual and both of the software manuals are deficient in one significant area—the proper handling of problems. The user is left entirely at the mercy of a local dealer or Xerox representative.

SUPPORT

The main problem with the Xerox 6060 is the cost of repair. A bad floppy disk drive will cost over $900 to repair, according to one Xerox invoice that I saw. The labor cost $85, and $855 was charged for a standard 5¼-inch drive. In another repair job, Xerox charged $5339 to replace a hard disk and the CPU board.

BENCHMARKS

Owing to its full 16-bit processor running at 8 MHz, the Xerox 6060 is very fast, and in some operations it is almost as fast as the IBM PC AT (see page 277 for details). The hard disk and disk controller, which have their own 8085 processor, are also faster than most of the competition's. Disk accesses from the hard disk seem to be significantly faster than those from an IBM PC XT or compatible.

The most notable improvements in operation involve the tests that measure processing speed. The Calculations and the Sieve of Eratosthenes benchmarks ran on the 6060 in nearly one-third the time that they ran on the IBM PC.

Disk format and disk copy times are significantly slower than those for the IBM PC because Xerox has changed the disk format utility so that it automatically does a verification of the entire disk, whether it's desired or not.

CONCLUSIONS

Like the AT&T PC 6300, the Xerox 6060 is a speedy machine. It runs well, operates with most IBM software, and is generally unobtrusive.

You will have to decide if you like the Screenmate shell, the optical mouse, and the black-and-white screen. Note that you can never get away from Screenmate entirely, since many of the system utilities retain their menu-driven front ends. You may be forced to work your way through several layers of menus when all you really want to do is issue a simple command, such as to change the data rate on the serial port. It's just too bad that Xerox eliminated some of the standard system utilities from MS-DOS.

Overall, I was pleased with the capability and speed of the Xerox 6060. It takes the needs of the infrequent or unskilled user into account, and it serves this type of user better than nearly any other machine. The biggest question mark is service, and you should consider this before buying the system. ■

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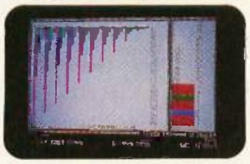
Multiple windows allow quick movement between tasks.



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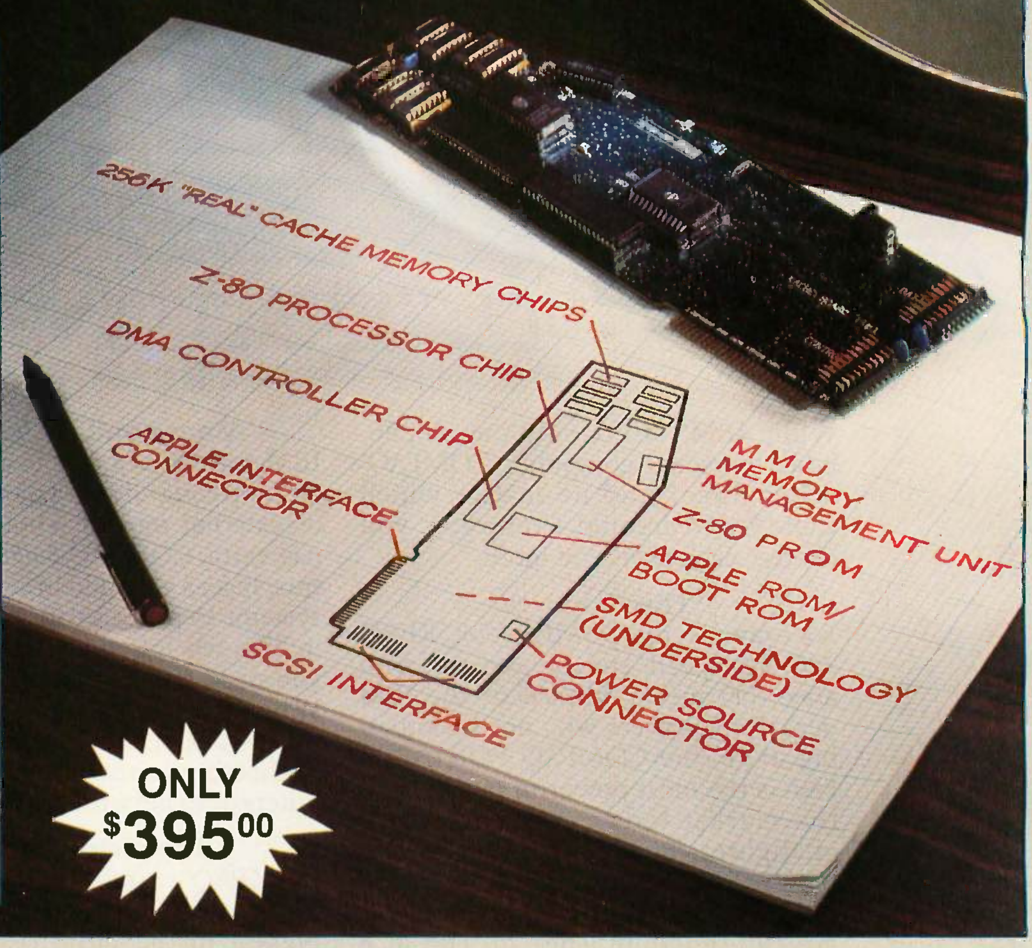

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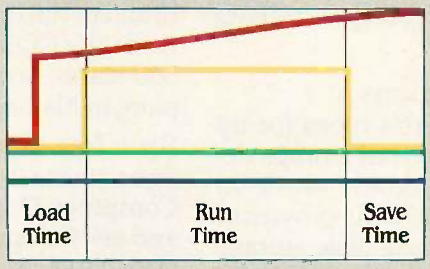
KACHE BOARD PERFORMANCE



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Inquiry 255

THE C. ITOH TRIPRINTER

BY ROBERT D. SWEARENGIN

A hefty printer that produces speedy drafts and high-quality graphics

The TriPrinter by C. Itoh is a hefty printer that produces pica, elite, condensed, italic, double-wide, double-high, bold, underlined, superscript, and subscript typefaces. It can also produce combinations of these typefaces (see the box on page 284). The printer lets you program dozens of functions such as print quality, pitch, and lines per inch using 11 membrane buttons on the flat front panel. You read the printer's current status on a three-digit LED display. If anything goes wrong, you'll know immediately; the machine has several alarms, including one that signals overheating.

All these features come with a considerable price tag: $1895. The TriPrinter is not for the casual user.

SETTING UP

Getting the TriPrinter out of the box and onto a sturdy stand is the hardest part of setting up; the unit is 22 inches wide, 16½ inches deep, and 4½ inches high. It weighs almost 39 pounds. After setting up, you simply lift the lid and plug in the matching interface and font cartridges.

The interface cartridge for the Model 20 TriPrinter (the IBM and Epson graphics–compatible version, which I reviewed) has the standard Centronics parallel interface. Serial interfaces come with the Model 10, which is for DEC computers, and the Model 40, designed for the Apple Macintosh. The Model 30, which emulates CIE and Printronix 300- and 600-line-per-minute printers, uses both parallel and serial interfaces. The font cartridges for all models are in Courier, a clean and readable typeface. No other typefaces are available. The cartridge interface sets sell for $75, or $245 with the optional 16K-byte buffer.

The TriPrinter's ribbon cartridges snap in easily. The cartridges cost $35 each, or $210 for six. This sounds expensive, but the bidirectional nylon ribbons each provide 15 million impressions.

The printer's built-in tractor feed is the best design I've encountered, although it makes paper a bit more difficult to load. The rear-fed paper snaps into the bottom of the tractor feed, goes around the platen, and snaps again into the top. The double grip may be an example of over-engineering, but this printer will probably be feeding paper long after other printers have jammed or worn out.

The mechanism works smoothly and can accommodate paper up to 16 inches wide. You can also feed paper from a slot on the bottom of the printer. In this case, the paper goes around the platen and attaches to only the top side of the tractor feed.

The printer performs five self-diagnostic tests. One initializes the EEPROM to factory-specified default values for all functions. Another test prints a menu of current default values. A standard sliding-character test, in which each line begins one character over from the line above it, includes graphics. A single-character test repeats the letter or number you select, and a mixed-character test includes all the type variations: bold, underline, italics, etc.

The front panel is well designed but takes considerable time to get accustomed to because of its numerous programming options. Each button represents a function and a numeric value. For example, the Reset (0) button returns the printer to its previous state. The Mode (1) button readies the printer for function changes, and the Test (2) button activates the test mode. Additional buttons change commonly used functions without requiring you to change the Mode (1) switch: Forms (3) changes form length, Font (4) changes draft and letter quality, CPI (5) changes pitch, LPI (6) changes lines per inch, TOF (7) controls top of form,

(continued)

Robert D. Swearengin (P.O. Box 1743, North Adams, MA 01247) *is a professor of English and journalism and a freelance author.*

C. Itoh TriPrinter (Model 20)

Type
Dot-matrix impact printer

Company
CIE Terminals
2505 McCabe Way
Irvine, CA 92714
(714) 660-1421

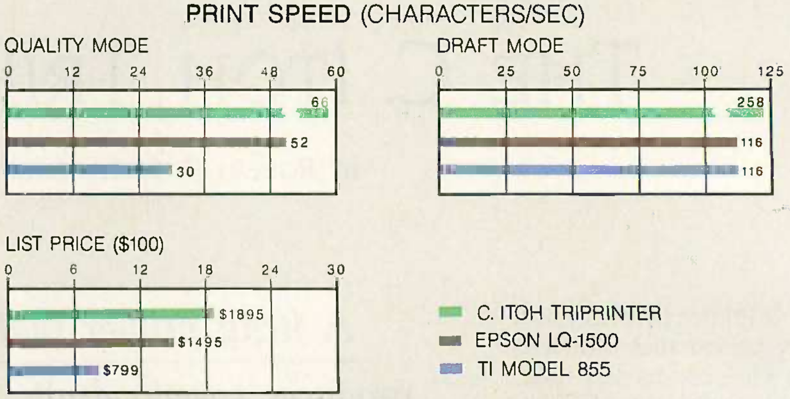
Size
22 by 16½ by 4½ inches
39 pounds

Features
Draft and letter-quality text
IBM and Epson graphics-compatible
Highest speed: 258 cps (BYTE benchmark)
2K-byte buffer; additional 16K bytes optional

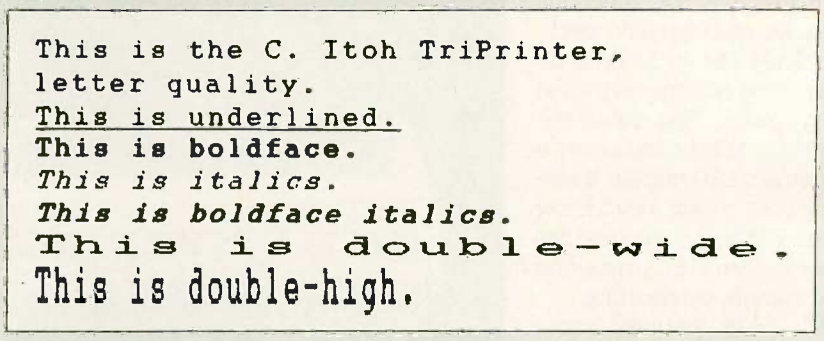
I/O Interfaces
Parallel or serial

Documentation
90-page spiral-bound user's manual

Price
$1895



A comparison of the C. Itoh TriPrinter with the Epson LQ-1500 printer (see the review in the December 1984 BYTE) and the TI Omni 800/Model 855 printer (see the review in the January 1985 BYTE). Each printer has a fast-draft mode and a slower high-quality mode, among others. The Print Speed benchmark involves printing 50 rows of 80 *A*s each at a pitch of 10 characters per inch in draft and quality modes. The prices shown include a tractor-feed mechanism.



This is the C. Itoh TriPrinter,
letter quality.
This is underlined.
This is boldface.
This is italics.
This is boldface italics.
This is double-wide.
This is double-high.

and LF (8) controls line feed.

This process sounds complicated but is actually fairly simple. The printer EEPROM stores 49 fields, each representing a function with a menu of options. For example, field 34 is the print-direction function. Options on this field menu are number 1 for bidirectional (the factory default) and number 2 for unidirectional printing. To change from bidirectional to unidirectional printing, you simply punch the Mode (1) button and enter 34. The LED always displays the default, which in this case is 1. You then enter 2, and the display changes accordingly. The printer sends the change to the nonvolatile EEPROM, and unidirectional printing becomes the new default. This ability to change makes the printer extremely flexible; you can tailor any number of defaults for a specific application. The new settings you choose remain until you initialize the EEPROM to return to the original factory defaults.

All function changes from the control panel go to the EEPROM. You can also change functions with control codes from your computer; these changes go only to the printer's 8K bytes of RAM and remain in effect until you turn the power off. The printer reverts to EEPROM defaults at the next power-up.

SPEED AND QUALITY

The TriPrinter is fast, although its throughput was considerably less than the rated maximum instantaneous speed of 350 cps (characters per second) in draft mode and 87.5 cps in letter-quality mode. On the standard BYTE 4000-character benchmark test, which involves printing 50 lines of 80 *A*s, the TriPrinter's throughput at 10 pitch was 258 cps in draft mode and 66 cps in letter-quality mode. The speed was about the same on a 60-column one-page American English first-order random approximation (see "The Art of Benchmarking Printers" by Sergio Mello-Grand, February 1984 BYTE).

I found the overall printing quality to be good. The 9-wire print head can produce a 9- by 8-pin matrix in draft mode, a 17- by 16-pin matrix in letter-quality mode, and 144 by 144 dots per inch on graphics. Keeping in mind that such judgments are always somewhat subjective, I'd rate the draft quality as standard. The letter quality is quite acceptable, but not as dense as daisy-wheel printing. I was pleased with the graphic reproduction of both large black designs and smaller intricate figures with fine lines.

DOCUMENTATION

The TriPrinter's step-by-step installation instructions are clear and easy to understand, and the user's manual is packed with technical information. The chapters on operation and programming are thorough and detailed.

However, the manual is not written for novices, and more detailed explanations would have been helpful in several places. Also, the organization of the manual could be improved. For example, when you've finished installing the printer, you must flip over some 20 pages to find the information about the printer's self-diagnostic tests. Furthermore, there's no index—a serious omission.

PROBLEMS

A sliding aluminum catch on the left side of the TriPrinter locks the cover open for loading paper and making other adjustments. The catch on my printer got stuck several times, preventing the cover from closing properly and triggering the "cover open" alarm. I tried to do some gentle adjustments with no success. Finally the catch fell off. I had no problem closing the lid after this, but I had to prop it open to change the paper. The company says it is aware of the problem and is replacing the catches with improved ones.

The printer's noise level is acceptable; it's rated at less than 58 decibels. However, the noise itself is somewhat harsh. I'd recommend using an acoustic cover for operating the printer in quiet environments.

CONCLUSIONS

Aside from the defective catch on the cover, the TriPrinter is well constructed. Once you spend the time to learn how to operate the control panel, you can easily exercise the printer's many options. It's hard to think of any necessary features that aren't already built in. I liked the TriPrinter and enjoyed using it.

The price tag, however, raises a very serious question about the TriPrinter, particularly with its 9-wire print head. A number of printers with denser matrices sell for considerably less money, although the specified printhead life of one billion dots per wire should provide longtime, high-volume data-processing and graphics use, with the letter quality as an added bonus. If its features fit your needs, the TriPrinter is certainly worth comparing with other high-end printers. ■

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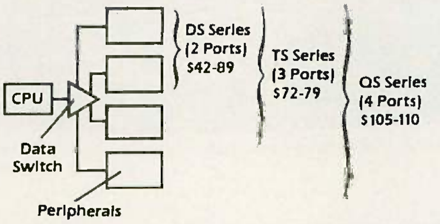

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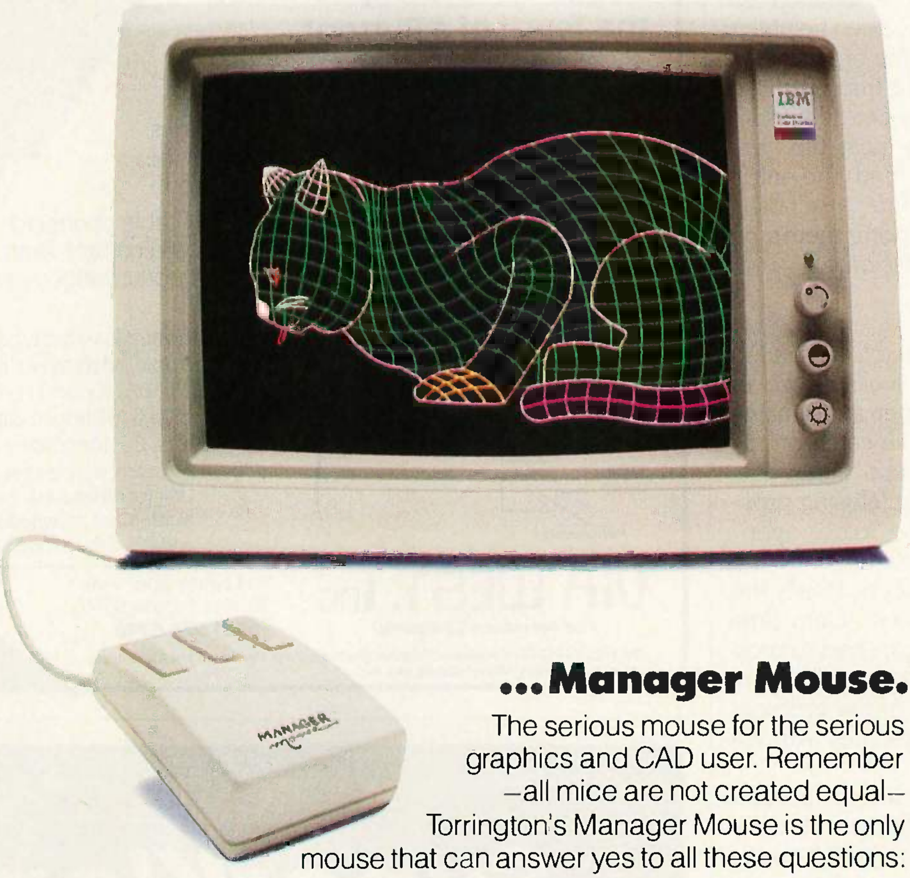

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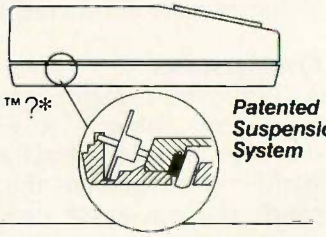

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THE TURNER HALL CARD

BY JONATHAN ANGEL

Simple-to-install and inexpensive memory expansion for IBM PCs *and compatibles*

The IBM PC and many compatibles were designed when 256K bytes was considered an ample amount of memory. Adding more memory to these machines requires installing an expansion card. Most expansion cards are already loaded with optional parallel and serial ports. However, the typical IBM PC user already has a parallel and a serial port. Adding a typical multifunction card could be expensive overkill.

One solution to this problem is the Turner Hall Card, which expands the IBM PC's memory by 256K bytes without adding any unwanted extras. The card also includes a clock/calendar and software to let you use the extra memory for print spooling or as a RAM disk.

INSTALLATION

To keep the price down, Turner Hall has kept the circuitry on this card simple. This makes installation relatively easy for most users. If you have a 256K-byte IBM PC XT, the Turner Hall Card is the simplest expansion card you could possibly install. All you have to do is remove the PC XT's cover, fit the Turner Hall Card into the short expansion slot, and put the cover back on. Your PC XT will now have 512K bytes of memory, a clock, plenty of room for expansion, and you won't have had to change any switch settings or move any jumpers.

The only mistake you could make during installation is to put the card in its expansion slot backward. This is possible because the card is so short and doesn't have a backplane connector. The owner's manual cautions against this potential problem.

If your computer is not an IBM PC XT you will, at the very least, have to alter DIP switches on the motherboard to let your computer know about the new memory you have installed. This is no more than you would have to do with any other card.

However, some aspects of the Turner Hall Card make installation complicated if your IBM PC is not fitted with 256K bytes of memory. Most memory-expansion boards have a bank of DIP switches that let you select a variety of load addresses; the Turner Hall Card has only a jumper that sets its load address at either 256K or 512K bytes.

Thus, if your IBM PC does not already have 256K bytes of memory, you must add either chips or another expansion card to bring the machine's memory up to the first address. If your IBM PC already has 512K bytes of memory, adding the Turner Hall Card will bring the memory up only to the DOS limit of 640K bytes.

For machines that already have memory between 256K and 512K bytes, there are three options. First, you can disable some of your existing memory to bring it down to 256K bytes. Second, you can add RAM with another expansion card to bring it up to 512K bytes and then install the Turner Hall Card. You would then have 768K bytes of RAM, of which only 640K bytes could ordinarily be used. Third, you can add the Turner Hall Card memory between 256K and 512K bytes and set switches, if available, on your other expansion card to make sure its memory address starts at above 512K bytes.

Turner Hall's documentation takes you through all these steps with good tables and illustrations. It also shows you how to disable the clock on the card if your IBM PC already has one.

SOFTWARE

The Turner Hall Card comes with software for activating the clock, which is a device driver (CLOCK.SYS). You do not have to slow booting by cluttering your AUTOEXEC.BAT file with another program name. You can simply add the line

```
DEVICE = CLOCK.SYS
```

(continued)

Jonathan Angel (678 Tennyson Ave., Palo Alto, CA 94301) is a freelance writer and columnist.

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to your CONFIG.SYS file, and the onboard clock will be automatically activated when you turn your computer on. Furthermore, the clock can be permanently reset simply by using the date and time functions in DOS; many competing boards require their own software to do this.

The RAM disk and print spooler programs (RAMDISK.SYS and SPOOL.COM) do not come with the board. Instead, Turner Hall sends them to you after you register your purchase. The documentation for these programs comes as a disk file that you must print.

RAMDISK.SYS gives you a RAM disk that is variable in size from 64K to 360K bytes but limited to holding a maximum of 32 files. SPOOL.COM gives you a print spooler that can be as small as 1K or as large as 64K bytes. Unlike some spoolers, you can vary its size or delete it from memory without rerunning the program. You can also pause it to change paper. I found that it worked with SideKick and SmartKey II without conflict.

CONCLUSIONS

The Turner Hall Card is reasonably priced and supported by superior documentation and software. The workmanship is good, but the 256K-byte RAM chips are soldered in place. However, Turner Hall will give you a new card if anything fails during your first year of ownership.

The only major flaw is that the card's starting memory addresses are set only at 256K or 512K bytes. This is too limiting; other expansion cards offer much more flexibility.

I would recommend the Turner Hall Card particularly to computer users who don't want to study manuals and flip switches. For users of 256K-byte IBM PCs, XTs, ATs, and compatibles, it is a simple and economical way to upgrade memory. The card would also be useful in any machine that lacks full-length expansion slots. ■

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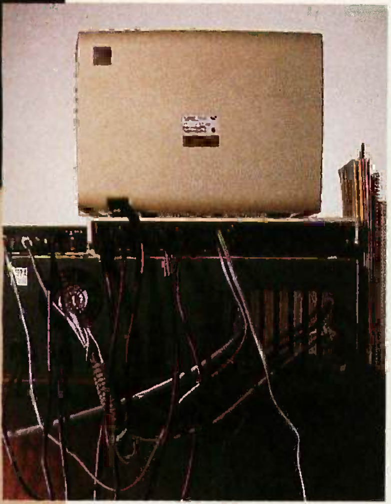
The Toshiba T3100.



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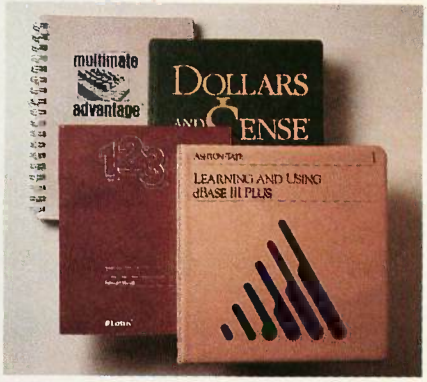

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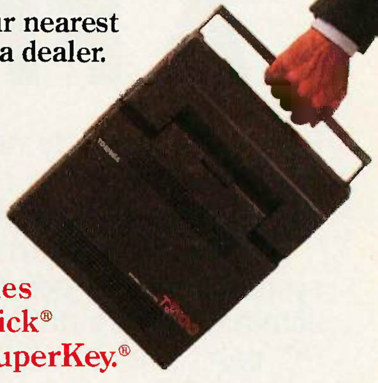

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TURBO PROLOG

BY NAMIR CLEMENT SHAMMAS

An easy-to-use nonstandard implementation of Prolog for the IBM PC

In March, Borland International entered the arena of artificial intelligence languages by launching its Turbo Prolog compiler. This review looks at version 1.0.

ENVIRONMENT

Turbo Prolog provides an excellent interactive environment in five windows. The top window is a one-line horizontal main menu that offers options that let you edit, compile, and run a program; set up the compile options; perform file-related operations; alter the window setups; and quit.

A message window informs you of current activities. These include messages related to file I/O and compilation progress. The dialog window is active when you run a program. It accepts input from the user and displays results. The trace window is active only when a program (or portions of it) turns on the trace option. This window lets you follow the Prolog program in execution step by step. Turbo Prolog does not make a more advanced debugger available.

You can adjust the color, size, and location of the windows and save the updated configuration in a special file for a permanent setup.

The built-in Turbo Prolog editor is very similar to that of Turbo Pascal or WordStar in nondocument edit mode. Turbo Prolog also provides a pop-up auxiliary edit window that lets you view or edit another Turbo Prolog source file. You can make nested calls to the auxiliary edit window, and the environment correctly recalls previous files once you have finished editing the current file.

COMPILER

The Turbo Prolog compiler lets you compile and run programs in memory or create external program files. Compilation in memory is very fast and attempts to approach the immediate interaction of a Prolog interpreter.

If the compiler detects an error, Turbo Prolog activates the editor window, points out the location of the offending syntax, and displays an accompanying compiler message that is highlighted at the bottom of the window. One problem with this is that the error message is truncated if it is longer than the width of the editor window (although you can adjust the size of the window, as mentioned above). The Turbo Prolog manual lists the error messages but offers no additional explanation or remedies, and some of the compiler error messages are unclear.

When you create compiled program files, Turbo Prolog offers two alternatives. If the program you are compiling is relatively small, you can create an EXE file (executable at the DOS prompt) from within Turbo Prolog. This makes the compiler create an object file and then call for the Microsoft linker, LINK.EXE, to produce the EXE file. Following the linking phase, you are prompted to either run the new Prolog program or go back to the Turbo Prolog environment. I found that it is best to go back to Turbo Prolog, exit from it, and then run the compiled program. I discovered that attempting to run programs using extensive recursion while having Turbo Prolog resident in memory invariably resulted in an "insufficient memory" run-time error. For large programs, you should select the option to create object files, exit from Turbo Prolog, and resume linking under DOS.

The Turbo Prolog compiler has 10 directives to fine-tune its operation. Among these directives are ones that allow you to set the size of the internal code array, include source code from another text file, display an analysis of your program as it is being compiled, suppress the Control-Break or Control-C options for program interruption, suppress compiler warnings, set up a modular software project, and trace the program flow.

Turbo Prolog programs can interface with programs compiled in Pascal, C, FORTRAN, and assembly language. This allows you to write routines more efficiently in any of the above languages and then call them from a Turbo Prolog program.

LANGUAGE

The syntax of Turbo Prolog differs significantly from that of standard Prolog. Being a Pascal/Modula-2 programmer, my initial reaction was one of delight. Turbo Prolog is more structured and enforces data type checking, which makes the source listings much more readable that those of standard Prolog.

A Turbo Prolog program is divided into declaration sections, some of which are optional. The first program declaration section is the domains, where local user-defined types and lists are declared. The global domains section makes data types accessible by other program modules. The predicates section defines local predicate names and the number and type of arguments for each predicate.

(continued)

Namir Clement Shammas (4814 Mill Park Court, Glen Allen, VA 23060) *is a freelance writer and programmer.*

Turbo Prolog

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The global predicates section declares predicates accessible by other program modules. The optional goal section allows you to specify a consistent goal. If you want to try a variety of goals one at a time, this section is omitted and you are prompted for a goal at run time. Programs compiled into files must have a goal section. The database section specifies the predicates to which facts are added during run time.

The clauses section is the last program declaration section and contains all the facts and rules. All the clauses in this section must be consistent with the declaration in the predicates section. Turbo Prolog does not allow you to define predicates that have the same names as built-in predicates, even if the numbers and types of arguments are different.

Turbo Prolog supports the following basic data types: characters, integers, real numbers, strings, symbols (also known in Prolog as atoms), and files. Symbols and strings can be used interchangeably, but internally they are handled differently. There are two additional special types: regdom, which is used with BIOS-related predicates to access the 8088 microprocessor registers, and dbasedom, which is used in conjunction with the limited dynamic database.

Turbo Prolog provides predicates for data type conversion and simple string manipulation. Standard Prolog uses symbols or instantiated variables for I/O redirection, making it more flexible than Turbo Prolog. Turbo Prolog supports the list structures, which are declared by using the syntax list name = data type *

BUILT-IN PREDICATES

Turbo Prolog contains a wealth of built-in predicates, many of which come from Turbo Pascal. These predicates perform math operations, reading, writing, screen handling, string handling, and type conversion. There are also file system, system-level, and language predicates.

Turbo Prolog supports the absolute value, square root, random-number generator, logarithmic, and trigonometric functions. It provides the MOD and DIV operators, as well as bit manipulation predicates to perform AND, OR, NOT, XOR, and shifting (left and right) operations.

The reading predicates allow the input of different data types, something not needed in standard Prolog. The write predicate is "overloaded," allowing the output of multiple arguments of different types and a formatted output. Redirecting I/O is achieved by using the readdevice and writedevice predicates.

The file system predicates enable a program to open a file for reading, writing, and adding data. Sequential and random access files are also supported. The file position pointer in random access files can be taken in reference to the beginning or the end of a file.

Turbo Prolog's screen- and window-handling predicates for text and high-resolution graphics allow you to control the screen cursor and create, remove, select, and clear windows. High-resolution graphics come with basic plotting and line-drawing predicates as well as turtle graphics commands.

Since Turbo Prolog is a data-typed implementation, a number of predicates are provided for type conversion. These predicates perform conversions between characters, strings, integers, real numbers, and uppercase and lowercase characters.

The implementers of Turbo Prolog paid attention to low-level access. The predicates included in this category allow a variety of tasks, such as setting and reading the system time and date, calling the IBM PC BIOS, invoking the Turbo Prolog editor, executing a DOS command from within a Turbo Prolog program, performing port I/O, and POKEing and PEEKing bytes or words in the memory.

DYNAMIC DATABASE

Artificial intelligence languages, applications, and expert systems rely heavily on databases to store and retrieve accumulated information. Standard Prolog is characterized by its ability to incorporate a wide variety of user input (clauses, rules, and facts) into its database at run time. The absence of strict type checking and predicate checking in standard Prolog implementations offers superior flexibility over Turbo Prolog in this regard.

Turbo Prolog's attempt to offer such a dynamic database is hampered by both data type and predicate checking. The Turbo Prolog predicates that are involved in the dynamic database must be specified in the database section before program run time. This severely limits the flexibility that Prolog was meant to offer. The implementation deviates from the spirit of Prolog by its lack of a genuine database. Moreover, Turbo Prolog has no garbage collection routine to reclaim memory left vacant by retracted, or deleted, facts.

Turbo Prolog does not implement a number of standard Prolog predicates. These omissions are important because they have done away with some powerful Prolog features. For example, list equality test has been rendered very limited by Turbo Prolog, and complex data (such as mixed integers) is more difficult, and sometimes impossible, to define.

MODULAR PROGRAMMING

Turbo Prolog allows you to build modular programs. For these programs you need to use the compiler's project directive and include to include a file containing the global domains and predicates. You create a

Table 1: *Benchmark tests for Turbo Prolog. Tests reflect the speed of Turbo Prolog in compiling programs and the run-time speed of the compiled programs. Turbo Prolog seems to assign a good stack size to allow deeply nested recursion. Floating-point operations and mathematical functions use the 8087 chip.*

Test	Source File	EXE File	Memory Compile	Compile and Link	Run Time	
	(bytes)		(seconds)	(minutes:seconds)		(minutes:seconds)
List Reversal	844	46,637	2	1:22		0:11
Floating Point	610	46,478	2	1:23		0:42
Sieve	955	46,541	3	1:22		0:03
Math Functions	1469	49,321	4	1:23	sqrt	0:06
					ln	0:16
					exp	0:28
					atan	0:19
					sin	0:18
Factorial	634	46,313	2	1:20		0:24
Tower of Hanoi	598	46,229	2	1:21	Height 5	0:03
					7	0:16
					10	2:14
Disk Write	585	46,184	2	1:21		0:54
Disk Read	448	47,915	2	1:23		0:29

librarian file for each modular program project. This is a simple text file that lists all the names of the modules involved. The compiler generates a file containing the symbols table for each module involved.

BENCHMARKS

I carried out a number of benchmarks on Turbo Prolog using an IBM PC XT with 512K bytes of memory, an 8087 math coprocessor chip, and a 20-megabyte hard disk drive running PC-DOS 3.1.

The List Reversal test reverses a list of 50 integers 30 times. The Floating Point test, which is similar to the standard BYTE benchmark, repeats a series of four basic operations 5000 times. The Sieve test extracts the prime numbers from the range of numbers from 1 to 100. The process is repeated 10 times. The Math Functions test clocks the speed of the square root, natural logarithm, exponential, arctangent, and sine functions. Each function is evaluated 1000 times using a fixed argument. The Factorial test evaluates the factorial of ten 1000 times. This tests the speed of a simple type of recursion. The Tower of Hanoi program tests recursion and the speed of screen output. The program accepts a variable tower height.

The Disk Write test is the Prolog version of the standard BYTE test. It writes 512 blocks of 128 characters to a text file on an empty disk. The Disk Read test is the Prolog version of the standard BYTE test. It reads 512 blocks of 128 characters from a text file stored on a floppy disk that contains no other files.

Table 1 shows the results of the benchmark tests. The Floating Point and Math Functions tests, by virtue of their speed, seem to automatically use the 8087 coprocessor, although the Turbo Prolog manual does not mention 8087 chip support. (The manual also incorrectly lists the arctangent function as arctan instead of atan.)

Turbo Prolog programs running as compiled EXE files seem to have access to a larger recursion stack than programs running within the Turbo Prolog environment. Turbo Prolog programs enjoy fast execution speed and larger stack size (relative to other Prolog interpreters), which permits deeper recursion levels.

CONCLUSION

Turbo Prolog is an implementation with many good features: a very good interactive environment, a fast compiler and compiled programs, support for screen and window management, high-resolution graphics, low-level access, and mathematical functions.

However, Turbo Prolog has a Turbo Pascal flavor in its compiler and strong data typing that create an identity problem for the language. Turbo Prolog's lack of a genuine dynamic and flexible database is its main weak point. Strict data type checking weakens Turbo Prolog's ability to perform more advanced symbolic processing. The lack of many important Prolog predicates deprives you of enjoying the unique features of standard Prolog language. Some programs written in the standard language syntax must be "hacked" before running with Turbo Prolog, while others may prove to be unportable.

Borland International claims that Turbo Prolog is a large superset of the W. F. Clocksin and C. S. Mellish definition of the language (*Programming in Prolog*, 2nd edition, Springer-Verlag, 1984). A glance through the language reference book disproves this claim. Turbo Prolog has enough changes from standard Prolog to earn it the name of "Turbo Paslog." As such, I do not recommend it if you are seriously considering becoming a Prolog programmer.

Editor's note: The programs used in the benchmark tests of Turbo Prolog are available for downloading from BYTE*net Listings (see the insert card following page 368). To run them you will need an* IBM PC *with 384K bytes of memory,* PC-DOS 2.0 *or later, and Turbo Prolog. The programs have been grouped together in a single file called* TBPROLOG.TST. ■

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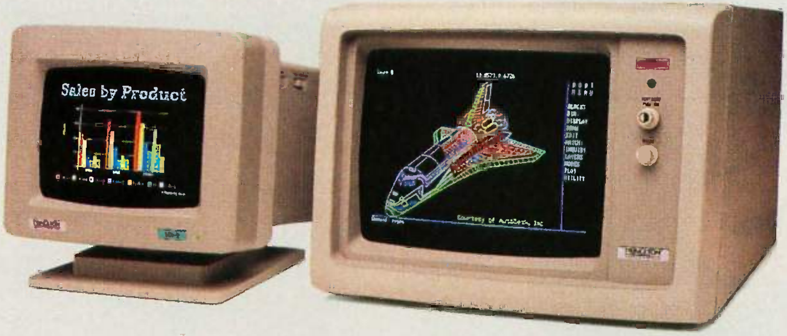

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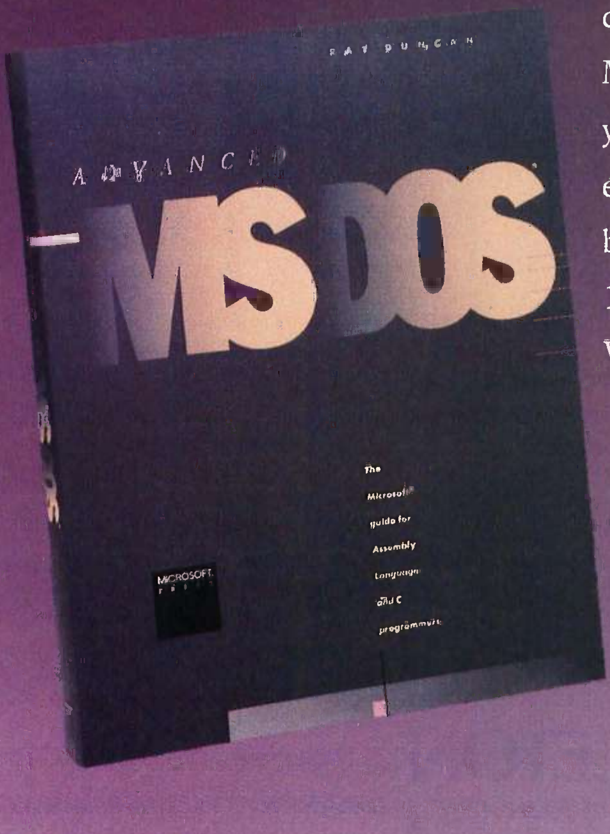

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PRESS

SOFTWARE CAROUSEL

BY MARK HAAS

A *virtual memory manager that allows you to shift between programs instantly*

Software Carousel, by SoftLogic Solutions, is a virtual memory manager that allows you to have up to 10 applications loaded and available for use. Only one program at a time can actually run, however. Unlike multitasking environments such as Quarterdeck's Desqview, Software Carousel programs that are not on-screen are in a state of suspended animation. For instance, you can start recalculating a large spreadsheet, switch to another program, and then return to find the recalculation continuing from the point where you left it. Nothing happens to your spreadsheet while you are away from it.

USE OF MEMORY

Unlike many multitasking systems, Software Carousel allows each program, when it is running, to use all the available memory in your system. Thus, you could load your spreadsheet program six times to work on six different worksheets requiring 512K bytes of memory (assuming you have sufficient memory to store inactive partitions) and still be able to load and use four more programs with equal memory requirements. Software Carousel does this by setting up to 10 virtual compartments, called partitions, in memory to be used by the applications. This functionally turns your computer into 10 computers. Each time you switch between applications, it's like turning to another machine that is already running that application. There is no connection between the partitions, however. You cannot, for example, move data from one program to another as you can with systems like Microsoft Windows.

The active partition is loaded into what SoftLogic Solutions calls lower memory. This is the main RAM addressed by DOS, which can be up to 640K bytes. Several smaller partitions can coexist in lower memory, making switching between them faster. Larger partitions need to be swapped in and out of lower memory from some other storage area.

Software Carousel can utilize any available main storage memory for holding inactive partitions. On any machine you can access up to 640K bytes of RAM, the normal DOS limit. With an IBM PC AT compatible, you can have Software Carousel use up to 16 megabytes of extended memory to hold inactive partitions. With an IBM PC XT compatible, you can have the software use up to 8 megabytes of expanded memory using the Lotus/Intel/Microsoft (LIM) standard. Any machine can use up to 6.4 megabytes of available hard disk space to hold inactive partitions.

You can determine how much memory, up to the limit of available RAM, each application will have access to. You wouldn't want to assign 512K bytes of memory to a BASIC partition, for example, since anything above 64K bytes would never be used. However, you may want to have 512K bytes of memory assigned to a partition to run a program like Lotus 1-2-3. Other programs may have different memory requirements. In general, it is best to use as little memory as possible for any given application. This will improve Software Carousel's overall performance.

The user's manual might lead you to believe that you can set up a partition to hold 640K bytes of memory. However, it will actually be less. DOS itself usually takes up between 25K and 35K bytes. Software Carousel uses about 75K bytes, and resident software, like SideKick, can take up much more. What remains is the maximum memory that you can assign to any partition. Software Carousel gives you some flexibility with this. For example, you can load memory-resident programs like SideKick and Keyworks selectively into individual partitions, freeing up memory for other partitions. You can also make these programs available from all partitions.

SETTING UP

Before you can use Software Carousel, you must first install and initialize it. Because of SoftLogic Solutions' copy-protection method, you can install Software Carousel only three times. However, the company will provide purchasers with a non-copy-protected disk at no charge. Installing Software Carousel onto my hard disk was easily handled by a batch file provided on the master disk. After installation, I noticed in my root directory several additional "hidden" files that were associated with the copy protection.

After installation you must determine how much memory you want in each partition and where the inactive partitions will be stored. You can assign any amount of memory for each partition, in 16K-byte chunks, for up to 10 partitions. Some partitions

(continued)

Mark Haas (55 Franciscan Way, Kensington, CA 94707) is an editor and computer consultant. He is a former managing editor for BYTE.

Software Carousel

Type
Virtual memory manager

Company
SoftLogic Solutions Inc.
530 Chestnut St.
Manchester, NH 03101
(603) 627-9900

Computer
IBM PC or close compatible with 192K bytes of RAM, one disk drive, and PC-DOS or MS-DOS 2.0 or later. A hard disk is recommended.

Price
$49.95

can be left empty. This, in turn, determines the total system memory requirement. If, for example, you chose to have five partitions with 512K bytes, three partitions with 384K bytes, and two partitions with 64K bytes, your total system memory requirement would be 3840K bytes.

You also have to decide where you are going to get that much memory. If you are using an IBM PC XT compatible, you have at most only 640K bytes of RAM, and you must get the rest of the required memory elsewhere. You can use an AST RAMpage card or a similar expanded memory card. If you have another card that does not use the LIM standard, you can turn it into a RAM disk and use that. Or you can use a hard disk, although this results in the poorest overall system performance. If you have an IBM PC AT compatible, you can also use the machine's extended RAM, which is up to 16 megabytes. You can assign the memory requirements to your resources in any combination.

Finally, you can name each memory partition, if you find this useful. You can give the partitions any names you like, and the names will appear as part of the DOS prompt to remind you where you are. Otherwise, they will simply be numbered.

The partition sizes, the resource allocation, and the optional partition names can all be saved for subsequent use in an ASCII file, which can be modified at any time using most text editors. You can also add commands to this file to customize other functions of Software Carousel, such as reassignment of command keys (to avoid conflicts with other applications) and to automatically load applications into each partition, including multiple command lines. This is similar to having an AUTOEXEC.BAT file for each partition. Once you have Software Carousel running, you can change partition sizes and names.

USING SOFTWARE CAROUSEL

After Software Carousel has been set up on your computer, you can call it up manually by entering CAROUSEL or automatically by including it in your AUTOEXEC.BAT file. The software takes about one minute to load, initialize, and load an application into the first memory partition. By pressing a two-key combination (which you can define), you can switch to another partition. If you are in a partition for the first time, you will see DOS load again. Then, if the partition is set up for it, the appropriate application will load and run.

The speed at which you can move from one partition to another depends on how much lower memory you have, how large the partitions are, and what type of backup memory you are using to hold the unused partitions. Large partitions will move more slowly than small ones; only one 512K-byte partition can exist in lower memory at once, while several 64K-byte partitions will fit at once and eliminate the need to swap partitions. A hard disk is the slowest device for holding unused partitions, while extended and expanded memory are the fastest. The slowest time that I experienced was about 15 seconds to swap a large (448K-byte) partition from a hard disk. However, when I was using a 256K-byte partition together with two 64K-byte partitions, no swapping was needed, and the change took about 2 seconds.

SoftLogic Solutions says that Software Carousel will run with most resident software, including SideKick and ProKey. I had no problems using Software Carousel with a variety of commercial and public domain resident software. If you load these programs before running Software Carousel, they will be available in all partitions. On the other hand, if you load them from a particular partition, they will be available only in that partition.

CONCLUSIONS

Software Carousel has some limitations. It will not work with programs that boot directly without DOS (like Flight Simulator) or that use another DOS (like CP/M-86 or the p-System). Some software has limited compatibility with Software Carousel. For instance, programs that grab the keyboard like WordVision and Smartcom II will run in a partition, but since Software Carousel cannot receive the required key sequence to change partitions, you must first exit the program to do so. Communications software can be a problem, too. While you may be able to switch partitions from within your communications software, you probably won't be able to change while you are on-line without fouling up the communications link. I was able to do this only while the system I was connected to was at a prompt. If I changed partitions while data was moving in either direction on the communications link, or if line noise caused data to move, I could not resume communications when I returned to that partition.

Some other types of software can change graphic controller video modes without informing DOS. These programs will cause problems, too. Finally, Software Carousel does not work well with dual-display systems. If you change displays while going from one partition to another, you may have a problem when you return to the first display.

These limitations are minor, especially when compared to Software Carousel's benefits. Being able to, for instance, write in one partition, switch to another partition to run a BASIC benchmark, do some more writing, switch to a third partition to use a Lotus 1-2-3 spreadsheet, change again to go on-line with BIX to get some information, and return to my word processor is a marvelous timesaver. ■

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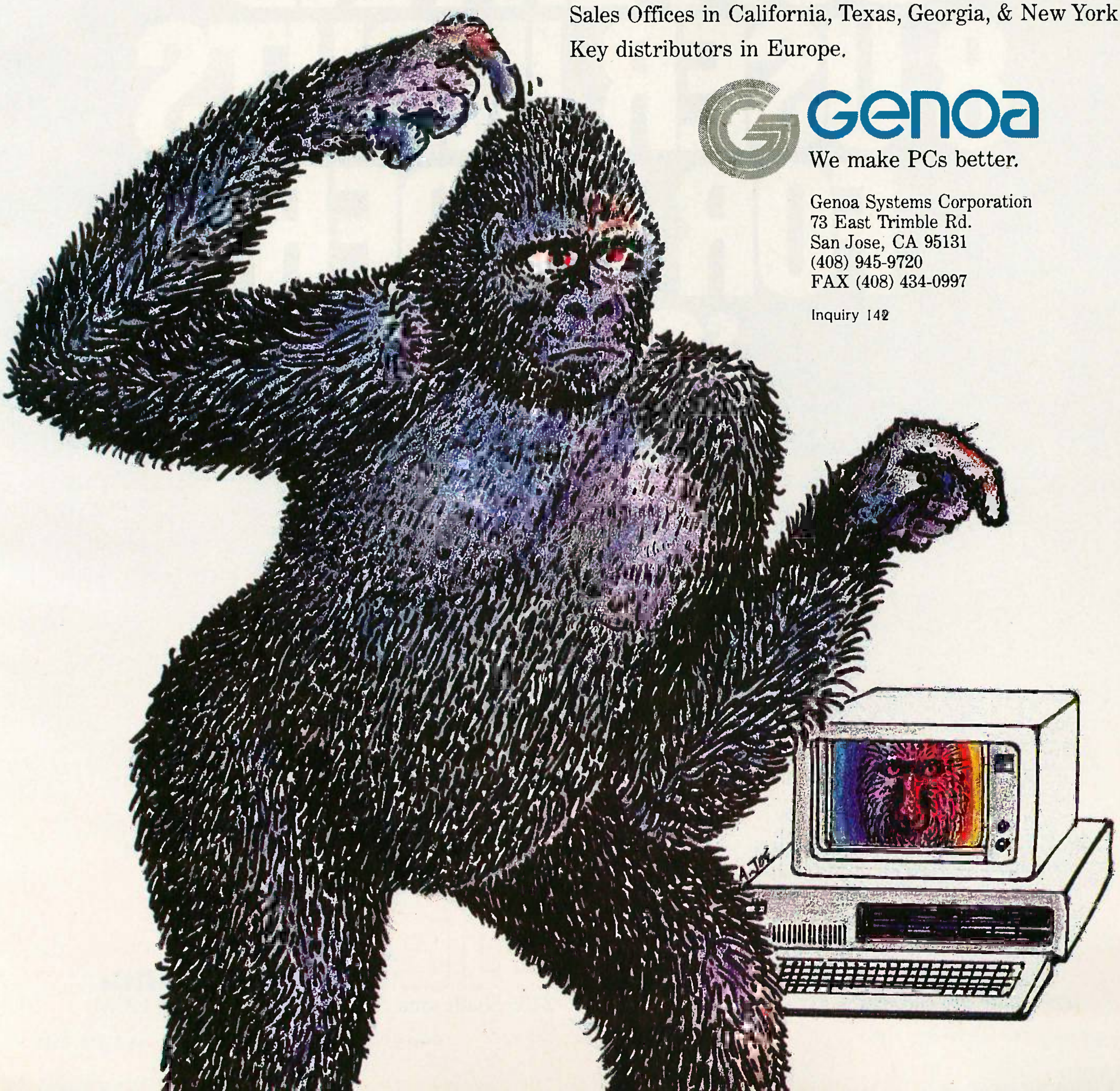

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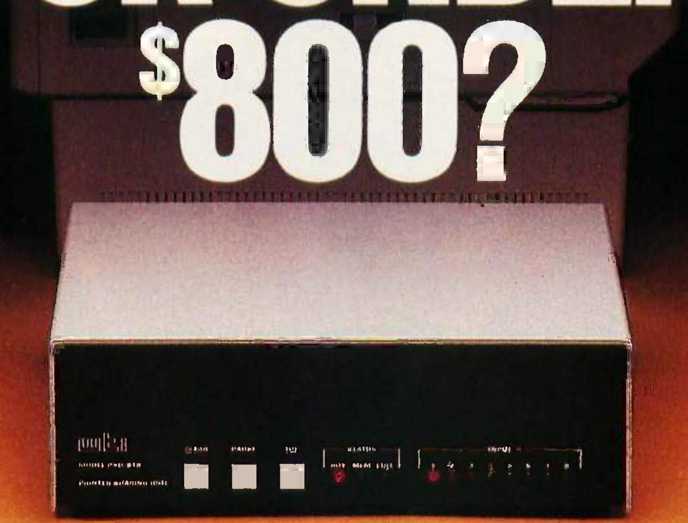

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PARADOX 1.1

BY RUSEL DEMARIA

This relational database has versatile features as well as a powerful script language

Paradox, a relational database by Ansa Software, balances contradictory features: a powerful script language (the Paradox Application Language, or PAL) against automatic keystroke recording of scripts; and a complex relational data structure against the intuitive query by example, which I will explain later. Paradox uses 512K bytes of RAM in conjunction with virtual disk file management. It does not take advantage of expanded RAM cards (like Intel's Above Board), and it does not work with memory-resident programs.

USING PARADOX

Initially Paradox seems rather familiar, with its Lotus 1-2-3–type command line (opened using the F10 Menu key) and tabular format (one record per row and one field per column). Creating a new database is also familiar. You simply name the fields and choose alphanumeric, numeric, integer, dollar, or date types. Some validity checking is automatic; for instance, numeric fields will not allow alphabetic entries. Later you can define additional validity checks for maximum or minimum values, default values, table lookups, or specific field masks. You can also format number and date fields in several ways.

Your first interaction with a file (which Paradox refers to as a table) will probably be the View option, which puts a table on the screen. After selecting this mode, you type the name of the table you want to see or press Return for a listing of available tables. You can use the cursor keys to highlight your selection. If you type the first letter of the desired table name, the listing automatically compresses to show all tables beginning with that letter. If there is only one such table, the command executes. While you are viewing a table, its name heads the list when you perform other commands. You can view up to 16 overlapping tables at once, moving from one to another using the Up Image (F3) and Down Image (F4) keys.

Even after entering data, you can rearrange, redefine, insert, or delete fields and change key-field assignments. I found the edit mode to be versatile and easy to use, although I had to get used to the idiosyncrasies of Alt-F5, which puts you in character-edit mode, and Ctrl-Backspace, which clears a field for a new entry. If you define key fields, Paradox automatically sorts according to key order. You can also resort into a new table. If a table has no key field, you can sort it to virtually any depth. Paradox then lets you choose whether to sort to a new table or within the existing table. Because Paradox creates temporary files on disk during a sort, the speed of the sort depends on the type of disk drive you are using (see table 1).

QUERY BY EXAMPLE

Query by example is the most significant feature of Paradox. It allows you to examine, modify, and filter data from multiple tables without using convoluted syntax-sensitive commands. Paradox performs simple queries with astonishing ease and intuition. Selecting Ask from the main menu and then selecting a table displays the query form for that table. The query form is similar to the normal tabular view. Field headings are at the top of each column with space beneath them for filling in selection criteria. To select information from several tables, you display a query form for each.

Entering find, insert, or delete in the leftmost column initiates these operations globally using the criteria you set. The insert command will take values from selected fields in one table and insert them into another (the add command is similar). The delete command will remove a selected set of records from a table. Deleted records are stored in a special table; therefore, you can back out of the operation by inserting the table of deleted records.

A simple query usually includes some fields selected to be displayed in the answer along with some selection criteria. Multiple table queries use what Paradox calls examples. These are temporary variables that link tables on a common field while expressing the relationship between the tables that you want displayed in the answer. An example does not really have to correspond in length or data type to its field. For instance, you could use a word as an example in a numeric field, or a number in an alphabetic field. After the example and other conditions of the query have been entered, Paradox writes and executes the program needed to answer the query. Other database programs require you to write the search program. Paradox not only writes it for you, but it also uses heuristic goal-reduction techniques to minimize the search time.

(continued)

Rusel DeMaria (443 Lilikoi Rd., Haiku, HI 96708) is a freelance writer and computer consultant.

Paradox 1.1

Type
Relational database

Company
Ansa Software
1301 Shoreway Rd.
Belmont, CA 94002
(415) 595-4469

Format:
Three 5¼-inch disks; not copy-protected

Computer
IBM PC with at least 512K bytes of available memory; color or monochrome monitor; two floppy disk drives or one floppy disk drive and one hard disk drive

Documentation
User's Guide, PAL User's Guide, Introduction to Paradox, Quick Guides for Lotus and dBASE users

Price
$695

You can select multiple criteria using AND, OR, EITHER . . . OR, or NOT operators. You do this by using examples and by placing criteria in the query forms. You can also use the powerful changeto command for altering values in a field. You can search for literal values, wild-card strings, or ranges. You can also use the like command to search for strings that are similar to the input criterion (useful when you aren't sure of a spelling, for instance). The QuerySave option creates an executable PAL script of the current query. You can use this script repeatedly either alone or within other PAL scripts.

You can create calculated fields from the query form. In fact, this is the only way to create a permanent calculated field. (A calculated field created on an input form does not become a permanent field in the table.) To recalculate a calculated field, you must run the query again.

A whole range of calculation and summary commands add power to queries but further complicate the query process. The more complex your queries become, the stronger your fundamental understanding of the uses of examples and checkmarks and their proper placement must be. For those willing to learn query by example thoroughly, however, Paradox can become a powerful and multifaceted tool.

FORMS

If you don't want a tabular listing of your file, you press the Form Toggle (F7) key. Paradox then displays a standard form, a simple listing of all fields, and allows you to define up to nine custom forms. Each form can be up to 15 screens long. You can use regular, display-only, and calculated fields, or a special record-number field. Display-only fields are useful for repeating field information on other pages. You can choose from an impressive list of mathematical, scientific, financial, and other functions to create calculated fields. One limitation, however, is that you cannot format calculated fields. For instance, if you are calculating a dollar amount, the amount will not display in dollar format. This is an annoying drawback.

You can also create borders using single- or double-lined boxes or any ASCII character. You can move fields or entire areas within the form, create different video display characteristics, and display or suppress field names.

A fairly simple definition process lets you create a special form for entering data into more than one table at a time. Pressing the Do-It! (F2) key posts the data in the appropriate tables. This added feature is very handy, but it is not without its limitations. Although you can determine where the data will go, you can't determine how it will be processed. For example, if you sold some products and needed to update an inventory file, you could do this only from within a PAL program (explained below), not from standard Paradox. Another missing feature is automatic table lookup, which is the ability to complete entries by entering data in one field. For instance, only a fairly convoluted PAL procedure can take a customer number and automatically fill in the name and address. Also, unlike the Paradox norm in which changes in a table automatically update associated files, changing a table associated with a multientry form invalidates the form; you must redefine it.

REPORTS

The Paradox report generator is potent but, like the queries, using it becomes more difficult as you attempt to release more of its power. You can generate an Instant Report at any time. This is a simple tabular printout of the table you are working on. You can also custom-design reports that are up to 2000 characters wide. Paradox will separate these wide reports into separate pages for paste-up. You can even use Paradox for simple mail-merge and form-letter processing.

First-time database users may find the Paradox reports confusing. Paradox bands are similar to what some programs call partitions. The difference is that a partition simply defines a section of a report, while a band actually defines a concentric area, visually displayed on-screen,

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The outer bands of a report control all the inner bands.

which may contain several other bands. One advantage of the band concept is that it allows any subdivision or partition to have its own header and footer. A disadvantage is that bands can become confusing with complex reports. The report band controls the header and footer information for the entire report. Other bands include the page, group, and table bands. The table band is at the center with all the others surrounding it. It defines fields and field headers. Surrounding the table band, the group bands control the sorting and grouping of the data in the table band. Since the band concept is concentric, group bands can contain up to 16 other group bands. The outer bands control all the inner bands.

You can create groupings for individual field values, ranges of field values, or a particular number of records. For instance, it would be easy to divide a sales report by date and subdivide it alphabetically by product. Another band could produce a space or other divider at regular intervals. The sales report would contain three group bands: one for date, one for product, and one to control the divider.

The lower section of a band displays subtotals. In the example above, you could easily subtotal sales by date. You can also create summary fields to count records or to give statistical summaries of each group or of the whole report. You can create calculated fields anywhere on the report.

Many standard reports use the tabular setup, but you can design your own reports to write checks, fill in standardized forms, or do form letters. Paradox's free-form report feature lets you create variable-width fields so data can appear within text without distorting the results.

Paradox does not generate multitable reports. The only way to create a report that contains data from multiple tables is to create a new table from a query. Still, the query process is fast and easy enough to be an effective alternative, unless you are short on disk space and don't have room for a new table.

Another problem with Paradox forms and reports is that each associates with only one table. Although you can borrow table structures when creating a new table, you can't do this when defining forms or reports. In-

(continued)

Table 1: *Benchmark results. (Times are in seconds.)*

File load:		
Bernoulli Box (1.38)*	1.2,1.2,1.2	(1.2)
Floppy disk drives (3.4)*	1.5,1.7,1.7	(1.6)

* First time file was loaded. Next three times are subsequent loads. Time in parentheses indicates average load time. (Paradox builds a special internal directory to locate tables as they are used, thus optimizing later retrievals.)

Sort test (within same file):		
Bernoulli Box	25.4,25.6.25.4	(25.5)
Floppy disk drives	82,80,80	(81)
Find last record in table:		
Bernoulli Box (nonindexed)	22,23,23	(23)
Bernoulli Box (indexed)	3.6,3.5,3.6	(3.6)
Floppy disk drives (nonindexed)	104,104,105	(104)

(Home/End keys instantly find first and last record in present table.)

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THE APPLICATION GENERATOR AND RUNTIME MODULE

Paradox is already an excellent database, but Ansa continues to improve and augment it. The newest additions to Paradox are the Application Generator (ApGen) and the Runtime module.

ApGen is an elaborate PAL script designed to create well-structured code. The whole program is menu-driven and easy to follow. Using ApGen, you can create Paradox menus and submenus up to 10 levels deep with up to 15 selections per menu and 15 tables per application. By choosing combinations of tables and scripts, you can design sophisticated Paradox environments. The resulting scripts are not only efficiently coded for you, but many standard error-trapping routines are automatically included. For instance, whenever you design a report to go to a printer, code is automatically included to warn the user if the printer is not ready to print.

There are a few limitations to ApGen. Its applications contain many individual files, including scripts, databases, and forms, all of which must be in the same subdirectory as the ApGen files. The manual recommends that you use a separate subdirectory for each application. Although ApGen automatically creates a script to copy the application to a different disk or directory, file management would have been easier if ApGen had been able to consolidate some of these files.

Although you can use PAL to modify any script you create with ApGen, these modifications will be lost if you use ApGen to modify the application. In addition, you can't use the table view from within ApGen, although you can add scripts or hard-coded routines that do. When editing records in multitable environments, the tables must contain key fields. Finally, you must have at least 1.8 megabytes of available memory on a hard disk to install ApGen, and at least 640K bytes of RAM to run it.

ApGen is easy to use; you create and select tables just as you would with Paradox. You can design reports and forms or borrow them from existing examples. You can also create selection criteria using familiar query forms and design customized help screens.

ApGen runs much slower than Paradox, perhaps because it is a PAL script and not a compiled program. Despite its sluggish responses, the program is useful, especially for nonprogrammers who would never be able to put together a sophisticated application without this kind of help. Systems developers will find that ApGen saves them a lot of time when coding applications, and it creates an excellent framework from which they can further customize their efforts.

After you finish creating an application, you can use Paradox Runtime to run it, even without Paradox installed. Ansa will supply this run-time package for only $9.95.

There are very few limitations to the Paradox Runtime package. Basically, it can run any Paradox script or application. Typing PDOXRUN <*filename*> is all that is necessary to run an application. The Runtime files are quite large and fill the better part of two floppy disks; therefore, Runtime would be most useful in a hard disk environment. However, Runtime will run Paradox scripts and applications but not the main body of the Paradox program.

About all that is missing now is a Paradox compiler.

stead, you must make a macro script out of the definition process itself.

PAL

PAL (the Paradox Application Language) is a powerful programing language that contains a full set of mathematical, statistical, transcendental, and financial functions. It is easy to create a PAL script with the full-screen editor provided with Paradox. In addition to having a syntax that should be sufficiently familiar to dBASE and R:base programmers, PAL offers sophisticated menu generation, password protection, definable procedures and procedure libraries, and an array structure that can capture entire Paradox records, even when the data types are inconsistent. PAL also has a debug mode that is activated automatically when a script fails to run properly.

I found that I had to program with PAL to accomplish some of my goals with Paradox, but most users will not need to do much programming. If you want to use PAL, you can record keystroke macros and then read them into your PAL script. This saves having to learn the whole language, and examining recorded macros can help you to understand the PAL syntax.

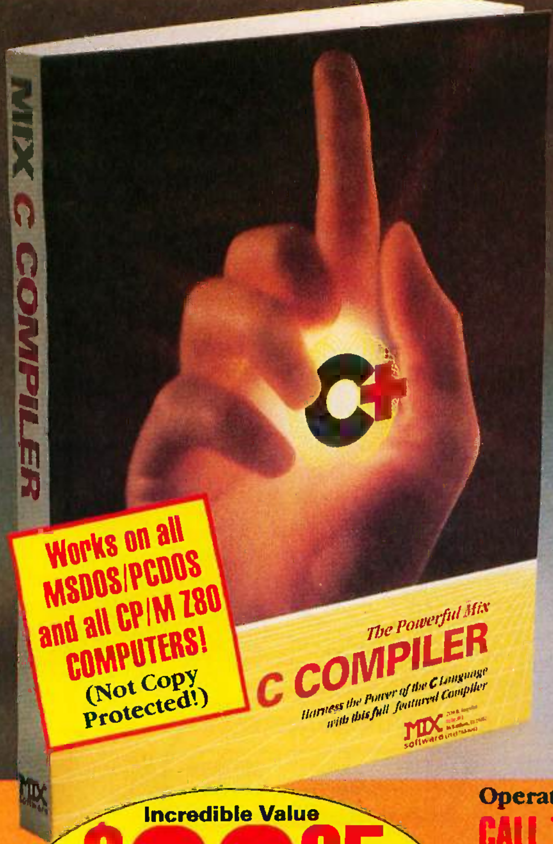
SUMMARY

Paradox has several other strong points, including an incremental Undo feature; exit to DOS (DOS shell); fast import and export to and from ASCII, Lotus 1-2-3, Symphony, dBASE II and III, pfs:File, and DIF formats; keystroke macros; and convenient date, arithmetic, and string handling.

For the most part, Paradox lives up to Ansa's claims of easy-to-use power, although it can become difficult as its operations become more complex. Paradox rivals programs like dBASE and R:base and may even be more suitable for many database projects. Within its self-imposed limitations, Paradox offers tremendous power, and a little dabbling with PAL can produce wonderful results. With the addition of Ansa's $9.95 Runtime module, Paradox can become a program for turnkey system design at a reasonable cost (see the text box "The Application Generator and Runtime Module" above).

Learning Paradox is not an effortless process, but the manuals are informative and the help screens are adequate. Especially pleasing are the short manuals that are included to get Lotus 1-2-3 users and dBASE users up to speed quickly.

I was impressed with the versatility and forgiving nature of the program. For intense but intuitive relational data processing, Paradox performs very well indeed. ■



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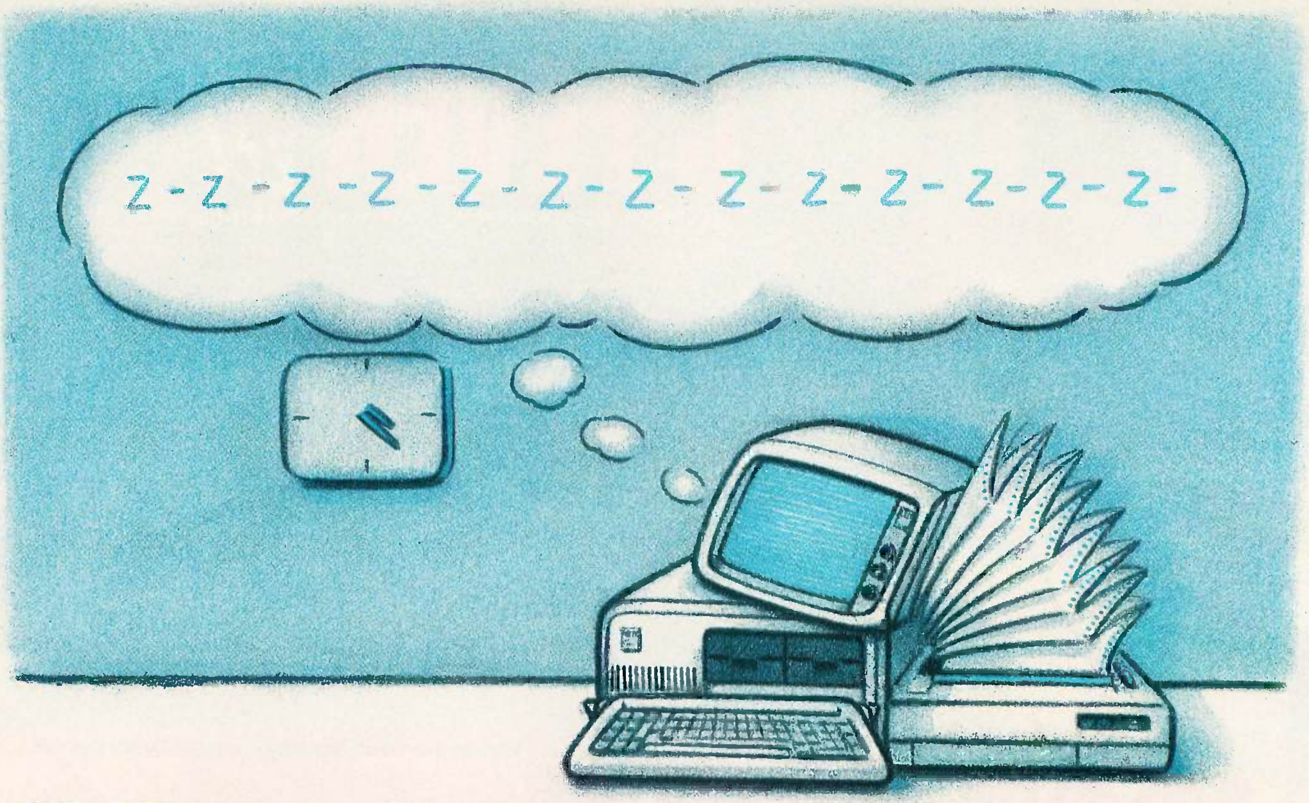

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QNX™	IBM PC	5Mhz 8088	787
XENIX™	Intel-286	5Mhz 80286	203
UNIX™	CODATA	8Mhz 68000	187
XENIX™	ALTOS	5Mhz 8086	96
UNIX™	FORTUNE	6Mhz 68000	95

The margin by which QNX outperforms UNIX-based systems is not accidental. QNX architecture is unique among multi-tasking small computer operating systems because it is modular, not monolithic. On the PC, this distinction is decisive: UNIX system overhead and processing demands sap any computer smaller than an AT.

Because QNX was developed specifically for smaller computers, not "kluged" from an OS written for larger computers, its structural advantages are apparent. QNX was the first multi-tasking, multi-user OS for the IBM PC (1982), the first again for the AT (1984) and the first networking OS for the PC and the AT (1984). For the forseeable future, QNX will remain the only real-time multi-user, multi-tasking OS for the PC, the AT and compatibles.

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Inquiry 290

WORDPERFECT 4.1

BY RICARDO BIRMELE

A word processor with a thesaurus, a dictionary, and many editing tools

This latest version of WordPerfect from WordPerfect Corporation is an improvement over version 3.0, which I reviewed in the December 1984 BYTE. While it retains many of the useful features of its previous versions, WordPerfect 4.1 has many new and impressive features.

IMPROVED FEATURES

A number of WordPerfect's old features have been improved. The block command highlights the text contained within a block to be moved; remembering what is included within the block is no longer necessary. Previous versions of WordPerfect let you work on two documents at a time and move text between them, but they required you to go through menus. Now switching between two documents is accomplished by pressing a dedicated key, making the operation much faster.

Now you also have the choice of having two documents appear on two different screens, or as two windows on one screen.

If you need to switch to another program, you can do so by exiting to DOS from within WordPerfect. You can then run the other program, leave it, and return to your place in WordPerfect by typing EXIT.

Footnotes can still occupy the traditional bottom of the page, or you can put them at the end of a document. Notes can be up to 16,000 lines (approximately 300 pages) long. They can be numbered in sequence (with WordPerfect keeping track of the numbers as you insert or delete other notes) or marked by asterisks or number signs.

WordPerfect protects you from your errors better than before. For instance, a big help in error protection is the Undelete feature. A group of characters that you erase before moving the cursor is saved to a buffer. From there the characters can be recalled with two keystrokes. This also provides a shortcut for cutting and pasting small amounts of text.

Directory listings are still alphabetized, but WordPerfect now has a number of added features. For instance, you can look at a file's contents without having to actually load the file. You can also search through the files within the directory for a word or word pattern.

An undocumented feature of the directory is the ability to batch-print or batch-delete. If you have a number of files that you want deleted or printed, you simply move the cursor to highlight the name of each file and press the asterisk key. Then you enter a command to either delete or print, and WordPerfect will do it all at once.

SPELLING DICTIONARY

WordPerfect's spelling dictionary now has 100,000 words (without taking up more disk space than the smaller old dictionary), and it has room for you to add about 10,000 words of your own. The dictionary includes some common legal and medical terms, which will be a bonus for some business users.

The dictionary works by comparing the document on your screen with three lists of correctly spelled words. The first list contains common words that are in the main spelling file. If a word is not found there, the dictionary goes to the second list, which contains less common words that are also in the main spelling file. Finally, the dictionary checks with the third list, which contains words that you have entered in the dictionary yourself.

One of the most difficult errors to find in a document on a computer screen is the same word inadvertently typed twice. WordPerfect's dictionary looks for this kind of error while it checks for correct spelling.

If the dictionary finds a misspelled word, you can have it automatically corrected by selecting it from a list of numbered words on your screen. You can also use the dictionary to look up words that you are not sure of by pattern matching (for instance, checking all words beginning with *ind*) or by phonetic spelling. WordPerfect also includes a utility, SPELL.EXE, which allows you to easily manipulate any part of the dictionary.

After the dictionary is finished proofing your text, it tells you how many words the document contains. If you simply want a quick word count while you are still writing, one keystroke when you are in WordPerfect's dictionary mode will give it to you.

EDITING TOOLS

WordPerfect has an outlining facility that you can use as an outline processor. It will also automatically number paragraphs or whole sections of text.

One error that many beginners make is not saving their work. WordPerfect 4.1 helps out by automatically saving your work into a special file if you choose. You can set up this facili-

(continued)

Ricardo Birmele (P.O. Box 1166, Bothell, WA 98041) is president of The Cantilever Group.

WordPerfect 4.1

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ty as a default or when you first start the program.

WordPerfect lets you create tables of contents and indexes almost automatically. You simply indicate that you want a particular word or phrase from the text included in them. WordPerfect will also keep track of individual items to be incorporated into the table of contents or index while you modify a document's text.

Two other useful editing tools are the new Redline and Strikeout features. With Strikeout, you can mark text that you may want to delete later by having a dash overwritten on each letter. Redline text—text that is added, but you aren't sure you want to keep in—is marked by a vertical bar to its left. Both Strikeout and Redline text can be deleted automatically before a final printout.

WordPerfect also has a thesaurus that will look up a word you specify and provide you with choices for its replacement. You can also scroll through successive lists of words until you find the word you want.

MERGE FACILITY

WordPerfect 4.1's merge facility is second to none. It will do the usual merging of mailing lists and boilerplate letters, but it also allows input from the console during a merge. In addition, WordPerfect can pick up the date from your computer's system calendar and insert it automatically into your text.

ADDITIONAL FEATURES

WordPerfect's programmers have gone out of their way to make word processing simple by anticipating the way users work. For example, when you press F3-Help, you have two choices: You can press any function key to get an explanation of what that key does, or you can press any letter key to get an alphabetical index. This index lists WordPerfect's features, the key that executes each feature, and the name that WordPerfect calls each key. Because Help is so easy to use, this program becomes almost second nature very quickly.

WordPerfect 4.1 has a new version of the PRINTER.EXE utility, which lets you drive almost any printer. If your printer doesn't appear on the list, you can define it in exhaustive detail by going through a simple fill-in-the-blanks process. You can use any of the 194 already defined printer patterns, or you can modify the installation of any included printer. The process is very easy to complete.

A Convert utility allows you to transform WordStar files to ASCII files. This utility also lets you interface data between WordPerfect and database programs. I used it to insert data generated from a Reflex database into a text file with no difficulty.

DOCUMENTATION

WordPerfect 4.1's documentation is divided logically into step-by-step tutorial and reference chapters. The more involved functions, like mail merge, math functions (which are much like a spreadsheet), and special features, are discussed in separate chapters. Each of the program's commands is clearly explained with an illustration color-coded to the keyboard template.

CONCLUSION

Usually, updates to established programs are simple bug fixes or rehashes of the previous versions. This is not the case with WordPerfect 4.1. It retains all the good points of its earlier versions, especially things like its clean screens and fast response to keyboard input (see the benchmark results in table 1). In addition, WordPerfect's capabilities have been increased. It will do anything you can reasonably require a word processor to do. ■

Table 1: *Benchmark results (in seconds).*

	WordPerfect 4.1	WordStar 3.3	Microsoft Word 3.0
Program load	12.8	9.5	24.3
Load 4000-word file	4.2	4.2	5.7
Save 4000-word file	15.6	26.7	30.0*
Cursor through file	75.7	48.6	90.1
4000-word search	8.7	12.5	18.2
400 replacements	12.8	25.3	85.7

*average time using MS-DOS 3.1

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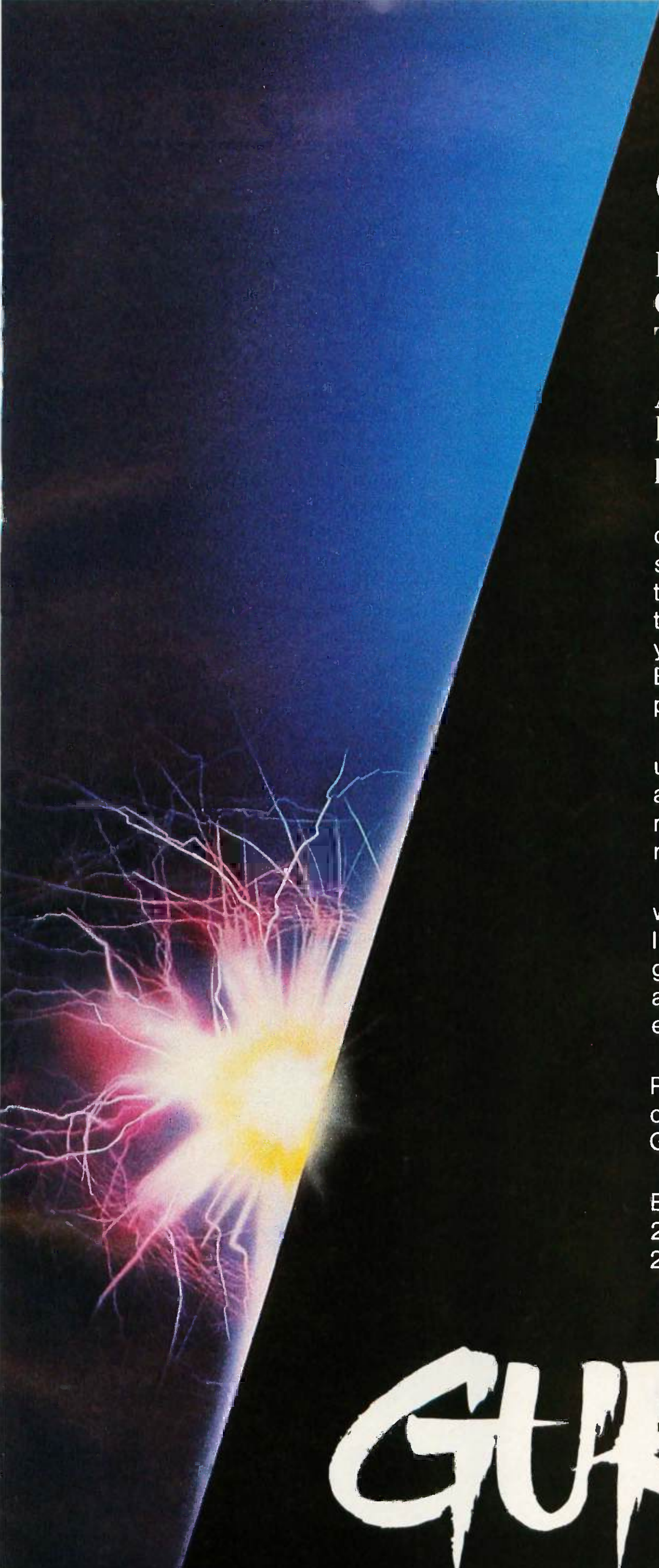

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REVIEW FEEDBACK

EXPEROPS5

"ExperOPS5" by William Jacobs (July) references the OPS5+ product and indicates that it is owned by Artelligence Inc. This is incorrect. OPS5+ is the exclusive property of Computer Thought Corporation.

GLENN CARTER
Plano, TX

Computer Thought (1721 West Plano Parkway, Suite 125, Plano, TX 75075) now owns OPS5+ following a legal settlement with Artelligence Inc. Version 3.0 sells for $1850.

Jon Edwards
Senior Technical Editor, Reviews

PANASONIC EXEC. PARTNER

Having purchased a Panasonic Exec. Partner, I was quite interested in the review (April). My impression of the machine roughly parallels Rich Malloy's. However, I have a few observations to add.

The Exec. Partner is a "quickie" design by Panasonic to put its plasma display technology to consumer use. The system ROM and BIOS seem to be taken directly from the Sr. Partner, and the motherboard looks very similar to the one inside the Sr. Partner as well. Since the 8086 is in a socket, I tried for a performance upgrade with a NEC V30 chip. However, it didn't work. I continually got a PIT (programmable interface timer) fault message with more than one chip. I heard there is a "mystery" component on the motherboard that needs to be changed, but I was unable to find the needed information, and I had my 8086 reinstalled.

I agree with the author that the internal printer is of marginal use. Still, from a convenience point of view, no one can argue with having a printer built into a machine. If the printer could be induced to use regular bond or tractor-feed paper, it would be much more useful.

If a printer that uses normal paper cannot be adapted to the machine, Panasonic should get rid of it. Then there would be room for three full-length IBM expansion slots or six half-size cards. With all the half-size expansion cards that are emerging, there would be plenty of room for customizing the machine.

The long memory check on power-up is annoying, but I think it could be bypassed with a proper setting on the motherboard DIP switch. I find that Peter Norton's SI utility gives some strange readings every now and then. This may be related to the difficulties the author had running SideKick. However, I have experienced no such problems with SideKick.

The annoying habits of the display are more of a system ROM problem than a hardware problem. However, Panasonic has demonstrated a full-color version of its plasma screen. Add an EGA chip set and you have a very impressive machine.

CHARLES KUHLMAN
Berlin, West Germany

AT&T UNIX PC

As a current user and programmer of a UNIX PC, I noticed a few mistakes in the review of the AT&T UNIX PC by Alastair J. W. Mayer (May). The article is based on the old UNIX operating system (version 2.0), which is slower than the current version 3.0 (if you have 2.0, AT&T will give you a free upgrade to 3.0). An example of the higher speed of the current version is the resizing of windows, which the author stated took 2 seconds with 2.0. It now takes under 1 second with 3.0.

The motherboard is available with 512K bytes or 1 or 2 megabytes of RAM. A memory-expansion card with up to 2 megabytes of RAM can be added, which brings the system up to 4 megabytes. Currently, 20-megabyte, 40-megabyte, and 67-megabyte hard disk drives are available. A point worth noting is that all hard disk drive and floppy disk drive accesses are done through direct memory access; thus, the microprocessor will not be slowed down.

The UNIX PC can read MS-DOS files as stated in the review, but it can also run most MS-DOS applications with the use of the DOS-73 expansion card. This card contains an Intel 8086 processor as well as the ability to support the 8087 math coprocessor. The card also allows you to maintain full multiprocessing.

The author said there was a need for a graphics package to create device-independent graphics. This is already available with an industry-standard GSS-Toolkit.

A point that was not mentioned was that the PC is well suited for a multiuser environment. AT&T recommends that five users can be added, although up to nine can be connected.

Additional software is available that was not listed in the review, including dBASE III, Multiplan, WordStar 2000, Smart, File-it, 3270 SNA Emulator, GSS-Chart, FORTRAN, COBOL, BASIC, and more.

DOUGLAS J. GARDNER
Adelphi, MD

Editor's note: For information on upgrading from version 2.0 to version 3.0, call the AT&T UNIX PC software upgrade coordinator at (900) 432-6600.

ITT XTRA XP

I found the review of the ITT XTRA XP by John D. Unger (July) very well done and informative, although there is one statement that I hope you can expand upon.

The sentence states, "The ITT XTRA XP is essentially a hardware upgrade of the IBM PC XT." Is this correct, or should it say "hardware upgrade of the ITT XTRA?" What are the hardware differences between the ITT XTRA and the XTRA XP?

ROBERT A. MARGADONNA
Sea Bright, NJ

The main difference between the ITT XTRA and the ITT XTRA XP is their central processors. The XTRA XP uses an 80286 CPU the same processor as the IBM PC AT, whereas the ITT XTRA uses an 8088 CPU like the IBM PC and PC XT. However, the rest of the XP is designed to be compatible with the IBM PC or PC XT rather than with the PC AT. The 80286 enables the XP to run IBM PC or XT software faster than the ITT XTRA and the IBM PC or PC XT. The net result is that both the XTRA and the XTRA XP are compatible with the IBM PC XT, but because of its CPU and memory design, the XP can run programs much faster than the standard ITT XTRA.

—John D. Unger

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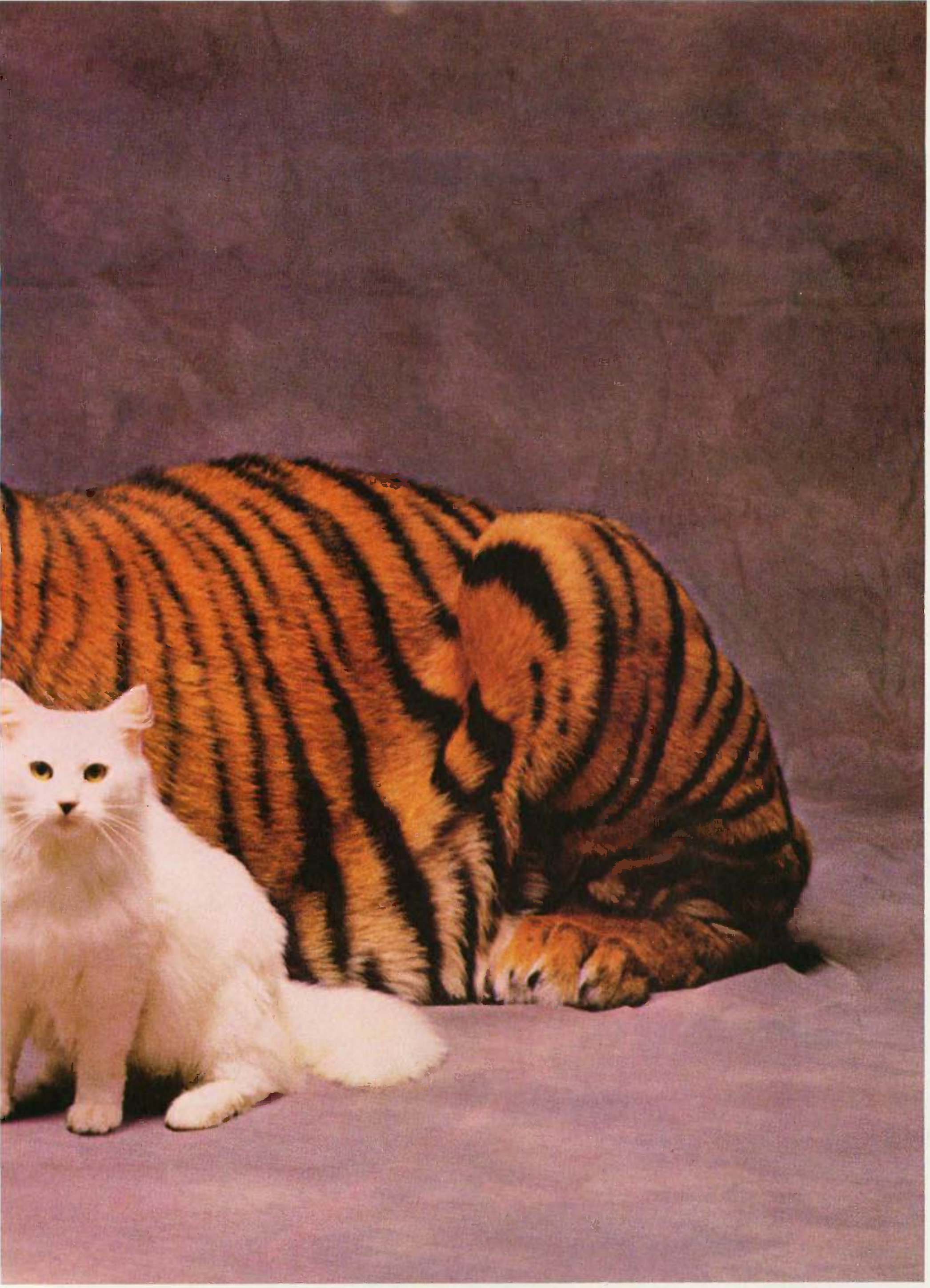

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Inquiry 171

Kernel

IN HIS POEM "EPITHALAMION," Edmund Spenser includes the following line: "Ah! when will this long weary day have end." Jerry Pournelle was probably ready to utter this on the day he describes in his article, a day that was typical of his heavily traveled month. In between his peregrinations, he did have a day at home. Of course, you say, a day to rest and see his family. No such luck. Numerous things to accomplish made for an exhausting day—but he did get everything done. This column also covers what Jerry found of interest at the Spring COMDEX in Atlanta.

The title of According to Webster refers to Bruce's *two* products of the month: Turbo Prolog from Borland International and LightspeedC from Think Technologies. Bruce is impressed with Turbo Prolog, a development system for the IBM PC and compatible machines. He believes it is Borland's best product since Turbo Pascal. LightspeedC, a development environment for the Macintosh, goes a long way toward making C Bruce's language of choice on the Mac. Bruce also reviews the predictions he made last January (probably because most of them have proven to be correct).

Bill Raike begins his column by mentioning some computer applications he has found in unlikely places—a noodle shop? He then goes on to describe two interesting products he saw at the annual Microcomputer Show in Tokyo. The Vectra-D Dual-Mode Workstation is from Yokogawa Hewlett-Packard. The company has combined two computers into one, letting you use both English and Japanese modes. The second product is Yamaha's Piano Player, a piano and computer rolled into one.

This month's BYTE U.K. is a continuation of Dick Pountain's last column, which was in July. There, he touched briefly on the topic of dynamic load balancing, a programming technique that can be used to optimize performance in parallel computing systems. This month, Dick goes deeper into this technique. To illustrate it, he looks at a graphics demonstration program written in Occam. This program draws views of the Mandelbrot set.

Ezra Shapiro has not been a fan of the Macintosh—for many reasons. However, he admits that he is being won over to the machine because of the excellent software that is appearing. In almost every application category, Ezra finds at least one first-rate Mac product. He is not sure whether More from Living Videotext is an outline processor or an operating system, but he does find it a spectacular piece of software. FullPaint, a program from Ann Arbor Softworks, is a lot like MacPaint. But it is also loaded with significant enhancements that make it a richer and more useful program.

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A BUSY DAY

BY JERRY POURNELLE

A long day is representative of what Jerry's month was like

It has been a day. I'll explain.

I was on the road most of last month, and this one wasn't much different. Some time ago I accepted an engagement to speak at the U.S. Navy's Micro Convention—more on that later—and every year I go to the annual meeting of the American Association for the Advancement of Science. When Tom Clancy, author of the successful *Hunt for Red October*, heard I was going to be out his way, he arranged for me to go with him to the Navy's flight center at Patuxent River in Maryland, where we got to climb around in the latest aircraft. I wouldn't have missed that for worlds, but it used up two more days.

The Navy Micro Convention was in Virginia Beach. That isn't quite the end of the earth, but on a clear day you can probably *see* the end of the world from there. Returning involved flying with Agony Airlines out of Norfolk. I had two days at home, then we were off to Philadelphia for the AAAS. While I was here I worked on the final edit of *Legacy of Heorot* and left it for Larry Niven to finish. I also worked all night on the final report of the Citizen's Advisory Council on National Space Policy, since it had to be in Washington before the first of June.

I came back to find galley proofs of the new release of *The Mercenary*, most but not all of *Heorot* done, a zillion BIX messages about the Council report, an Atari 1040ST, the usual four tons of software, and 28 telephone messages. One was from our editors at Simon and Schuster: they wanted the final manuscript of *Heorot* right away. So did my agent, who was traveling to England and had a really good offer for British rights, only he'd have to take a manuscript with him. Another was from Ken Sheldon, my long-suffering BYTE editor, who really would like to know when he'd get this column (already two weeks late).

Heorot existed—more or less—on disk, but what was needed was paper copies. Some day, I hope, that won't be necessary. I ought to be able to deliver books on disk or by telephone. Alas, not yet: I'd have to print the book out, and *now.*

It was clearly time to use every bit of computer power available.

SPELLING, ANYONE?

It wasn't easy, but I got everything done in one day.

First things first: our manuscript had never been through a spelling checker. You might think that with three authors—Larry Niven, Jerry Pournelle, and Steven Barnes—all working with computers to produce this book, there wouldn't be many errors. One of the great things about writing with little computers is that you can not only write faster, you can write *better*, since it's so very much easier to make changes. Given the rush, surely we could leave the rest to copy editors?

I suppose we could have, but Larry and I have had sad experiences with copy editors who not only didn't catch the real mistakes but decided they could write better sentences than we can. We have developed the theory that the fewer genuine errors, the less incentive for the copy editor to make needless changes; which means that *everything* goes through the spelling checker, even if it's a 565-page manuscript that has to be printed and ready for Federal Express in one day.

First thing, then, was to fire up the Golem, our big CompuPro 286/Z80 machine. The Golem has 2 megabytes of M-Drive/H RAM disk memory; more than enough to hold all of *Heorot* as well as The Word Plus complete with dictionaries. Since a good part of a spelling program's activity involves long searches through files, a RAM disk speeds things up something wonderful.

The Word Plus allows you to use multiple dictionaries: the main dictionary, an update dictionary, and a special dictionary that can be dedicated to this particular manuscript. The update dictionary is needed because you can't add words to the program's main word list; that's encoded to allow very fast searching. The special dictionary is great because I can fill it with stuff unique to this book: character names, slang expressions, and stuff like that.

When I was ready to begin, I turned on Big Kat, the Kaypro 286i. While the Golem was working on the text files, I used Big Kat to connect to BIX and clean up some of my BIX mail. Of course, this was clearly the wrong day to quit using Crosstalk; that is, I'd intended to check out Mirror, the Crosstalk clone program, but I sure wasn't about to do *that* in the middle of a crisis.

It all worked quite well. *Heorot* is organized into 34 chapters of about 20K bytes each. It took The Word Plus a little more than a minute to read a chapter, make a list of unique words,

(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 didn't have the foggiest notion of what to do next. I'd never had trouble with the Printer Optimizer.

sort them, and check them against the three dictionaries in use. During that minute I could answer a BIX mail inquiry or read a couple of items in a conference. Then I'd turn back to the Golem and deal with the spelling situation.

The early chapters took more attention, of course, since I started with a blank special dictionary. I had to build it up, adding character and place names and slang. Even so, I found I could get a chapter done in five minutes, one of which I'd spent on BIX.

Once I had ten chapters done it was time to print.

CRITICAL JOB DETECTOR

When we designed my new offices, we included a small soundproofed room with its own air conditioning. I was tired of being in the same room with a machine gun; the printers would lurk in their own special place. It would be inconvenient to have printers at a distance, but it sure would be quieter.

By the time we were actually building, though, I had the HP LaserJet printer; and it's so quiet that there's no need to put it elsewhere. It does generate a bit of heat, but fans take care of that.

The LaserJet is normally connected to Big Kat and to Zeke II, the ancient CompuPro Z80 I write all my books on. Actually, neither machine is connected to the printer: they both connect to the Printer Optimizer, which is a box full of memory that connects to Big Kat by a parallel port and to Zeke II by a serial port. It's very handy: whichever computer is sending, the Optimizer catches what's being sent and puts it off into the LaserJet. The Optimizer can also translate various print formats into stuff the LaserJet understands; if you have a LaserJet, you probably ought to have an Optimizer.

However, the Optimizer, like most electronic equipment, is apparently furnished with a "critical job detector." I say this because I've had that Optimizer for more than a year now and *never* had one iota of trouble with it; but today was different.

My plan was to connect the Golem to the Optimizer. This is simple enough: I just get an RS-232C cable (I buy mine from Inmac, a pricey but reliable mail-order supply house) and run it across the floor. The Golem isn't normally connected to any printer. Once a month I roll the NEC Spinwriter out to write checks because the LaserJet doesn't take tractor feed, but normally the Golem's jobs don't include printing. If I really need for him to produce hard copy, it's easy enough to string the cable; both Zeke II and the Golem talk to the Optimizer at 9600 baud with the same handshaking protocols and such, so I just unplug Zeke's cable and plug in the Golem's.

Having connected the cable, it was time for a test: the Golem runs under Concurrent CP/M. Do a Control-P and type a couple of characters to be sure things worked right—

And the Optimizer began to squeal.

The first rule is Don't Panic. Machines know when you're scared. It's that "critical job detector" circuit. Work carefully. . .

Maybe I'd connected something up wrong. Better test it; but first, go over to Big Kat and do a "print screen" just to be sure the Optimizer and the LaserJet are working.

More squeals. The Optimizer just wasn't going to accept input.

I didn't have the foggiest notion of what to do next. I'd never had trouble with the Optimizer. Of course, I'd never had such a critical job before.

"Usually," I told myself, "usually it's a cable." Check all cables. No luck, of course. Next, look at everything very calmly and carefully—aha. Normally the Optimizer's little LED display blinks to tell you whether it wants to print serial or parallel (it can be connected to two different printers as well as two computers). It wasn't blinking. It wasn't doing anything.

Hmm. Time to open it up and look inside. That's easy enough. Now push down all boards and tap all chips. No luck. Then I noticed: the Optimizer has a small lithium battery. This lets it remember what it's supposed to do even when you've turned off the power. The Optimizer seemed to have forgotten something. Could that be it? If that battery is dead I'm in real trouble, but suppose the contacts to it are corroded? Worth a try, anyway. I rotated the battery in its holder, then reprogrammed the Optimizer.

Voilà! Suddenly everything worked fine. Screen dump came through. Connect the Golem, do a Control-P; works fine.

The moral of the story is that if you're very, very careful and stay very, very calm, you can defeat the critical job detector.

AN ORGY OF PRINTING

From there on things were easy. I had one more glitch: I'd never put a version of WRITE configured for the HP LaserJet onto the Golem. Attempting to print to a LaserJet with a program that thinks it's talking to an NEC Spinwriter will produce interesting results: it *fills* the LaserJet with form feeds, so that even if you halt input into the printer you'll get a dozen or so sheets of paper with one or two lines of garbage. The only way I've found to stop things when they get that far is to turn the LaserJet off, which usually results in a paper jam. Fortunately, paper jams are easy to clear.

Installing a new version of WRITE took less than five minutes. After that it was a piece of cake. At eight pages a minute the LaserJet can print a chapter about as fast as I can check the spelling, so after I sent over the ten chapters I'd already done, things went very smoothly. You do have to keep the LaserJet's paper tray filled, and that has to be done at *its* convenience: if you try to add paper while it's printing, you get a paper jam. The good news is that the LaserJet remem-

(continued)

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Inquiry 279

bers which page it messed up in the paper jam and does that page again once you have the paper tray filled and the jam cleared.

By this time I'd caught up with most of the BIX mail, and the special dictionary for *Heorot* was doing a lot of the work, so that I could check a chapter's spelling in four minutes or so, meaning that I could now relax a bit. I thought of firing up Zeke II and beginning this column, but I didn't.

What I did manage was to get one copy of *Heorot* done in time for Federal Express to come get it. The spelling check was worth it, too: there were 6 to 10 errors per chapter, including inconsistent spelling of character names, and once a character apparently changed sex without an operation, or would have if The Word Plus hadn't caught it.

So. That's done. Now to do the column.

WORD PROBLEMS

Of all the spelling checkers I've used, I like The Word Plus best; but it does have some problems. For one thing, it doesn't know any plurals, and it doesn't know the full conjugations of most verbs: it knows "analyze" but not "analyzes" and "dog" but not "dogs." By now I've put most of those into the update dictionary, but it can be annoying while you're building it.

There are also bugs in the dictionary. The worst one is that any word that contains the root "cen" will be reported as wrong; somehow Oasis got "cei" in there as the root, so The Word Plus believes "ceitered" is correct but not "centered." I've found a couple of other odd anomalies like that. Once in a while, too, The Word Plus wants to run two dictionary words together, which makes no sense.

For all that, The Word Plus is fast. It can find suggested words quickly, and it's very responsive to user control. I wish Oasis would update the main dictionary, but whether that happens or not, The Word Plus is the spelling-check program I recommend.

SPRING COMDEX

The Spring Computer Dealers Exposition, better known as COMDEX, happens in Atlanta. Every year I say I'm not going, but I always do, lest I fall even further behind. Of course, keeping up in this crazy business is impossible, just as it's impossible to see everything at a COMDEX. I hope I didn't miss anything important, but I probably did.

From what I did see, four products stood out. First, Sayette Technology (an Eastman Kodak company) has a wonderful gadget called the Sayette System 10. It's a transparent gizmo about the size of a loose-leaf notebook. You lay it on top of your ViewGraph overhead projector and run cables to your IBM PCompatible computer. Now anything that appears on the PC screen will get projected onto the ViewGraph screen.

There are limits. No color, to start. On the other hand, it will translate color output into 16 shades of monochrome, so this isn't a severe handicap.

Many places, such as the civil engineering department at the U.S. Air Force Academy, have developed really nifty software that can be used to demonstrate engineering and science principles. Up to now, projectors that could handle computer output have been very costly, so most schools couldn't afford one. Students either have to huddle around a computer screen or take the instructor's word for what's happening. The new Eastman projector will change all that. At present it sells for less than a thousand dollars. I expect that price to fall. I also expect to see some kind of adapter for the Macintosh, after which this thing is going to have a real impact on education.

AT&T PC 6300 PLUS

My second pick of the show is the AT&T PC 6300 Plus.

I don't know what to do about AT&T. The company has really great technological capabilities. I freely confess to being a Bell Labs fan. Moreover, AT&T is one of the few companies with both the finances and the technical resources to be real competition to IBM, something this industry sorely needs.

With all that going for them, AT&T needs only one hit in the small computer market. The company may have it with the 6300 Plus, which is a 98 percent PC AT–compatible box that happens to be faster than an AT and also happens to speak UNIX. More than that, the 6300 Plus can run one job under MS-DOS and simultaneously do UNIX tasks. It's also a rather handsome piece of equipment, with a sensible design, unlike the AT&T PC 7300 (now called the UNIX PC), which takes an acre of desk space and has a keyboard cable coiled so tightly it can drag the desk to your chair.

The 6300 Plus I saw had terrific graphics. Text on the color screen was large, clear, and as steady as anything I've seen in monochrome.

In a word, I was impressed.

The AT&T people said they'd get me a 6300 Plus, and I confess I'm rather eager. Certainly it could take the place of Big Kat, and it could possibly become the main machine here.

That's the plus side.

On the minus side, AT&T could take marketing lessons from just about anybody, including some companies in Chapter 11. That isn't just in the computer field, either. As I was writing this, I got what must have been my tenth call from AT&T urging me to choose them as my long-distance carrier. The only problem is that I *already* chose them. Both by mail and every time they called before. I'm afraid I screamed at the poor chap on the phone. I also told him that the next time AT&T calls me, I'm going to change to anyone *but* them. Think that will work?

AT&T does believe in telephones. They believe so much that they don't put addresses on their press releases. They do give phone numbers, of course, both office and what they say is the home number of their press officer. Calling that after business hours gets an answering machine. I wonder: do they figure people will call for an address? And do they need the business?

ATARI ST

My third pick of the show was the Atari ST; the software base for this machine continues to grow, and it's now quite clear not only that Atari will sell a lot of them but that the third-party support base is growing.

For example, Mind Mine Computer Center has kits to upgrade the 520ST to a full megabyte and also to install a permanent battery-backed clock/calendar. Installing the calendar requires pulling a chip and inserting it into a piggyback board. The instructions are clear, and anyone but a certified klutz could do it. The memory expansion is a bit more difficult and requires soldering. Mind Mine warns that it's no job for a novice. I agree, but the instructions are very clear, and it's a *lot* easier to use their kit than to expand the 520ST by piggybacking chips, as many have done. With those provisos, I recommend both boards and look forward to Mind Mine's future efforts.

Another Atari product I have no trouble recommending is Zoomracks from Quickview Systems. Zoomracks was written by Paul Heckel, the author of *Elements of Friendly Software Design* (Warner Books, 1984), which was my book of the month a year or so ago. It's a kind of database program that's the simplest thing in the world to use. Remember a few years ago when the Execuscan Scan Card systems were all the management rage? I sure do; I bought several of them and even gave a few as presents. Alas, like most such organization schemes, the paperwork was too much, and my leatherbound Execuscan systems languish on bookshelves. Zoomracks, though, is very like Execuscan except that it's computerized, meaning that it's very simple to set up racks of "cards," label the racks, and put whatever you like on the cards. It really works on the Atari. There's a version for the IBM PC, too; it's a bit slow, but fast enough on an AT. With that reservation, very much recommended. You'll hear more about Zoomracks in the future.

More Atari software: a ton of stuff from Antic Software, ranging from some of the most absurd joke programs to Maps and Legends, which has lots of maps and map-drawing tools. Antic specializes in low-cost software that comes without manuals. Alas, they've also set things up so that most of their help files have to be printed out, and I don't have a printer

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assigned to the Atari just now. On the other hand, much of their stuff is self-explanatory.

I could go on, but surely the point is clear: Atari ST software pours forth like a flood. The Atari is here to stay and delivers more computer power for the buck than anything else that I know of.

AMIGA

My top pick of Spring COMDEX was the Amiga.

The Amiga did have some problems. For instance, when Ken Sheldon and I approached the Atari booth, they practically ran out to grab us; I stood in the Amiga booth for 15 minutes before anyone spoke to me. Atari software was demonstrated by hackers; most of the Amiga software was demonstrated by clerical employees from Commodore headquarters.

None of that really mattered. What was important was that the Amiga booth was jammed. I could feel the excitement. It reminded me of the early days of microcomputers. Moreover, once I got past the clerks and secretaries, there were plenty of real hackers.

Mike Lehman, who originally wrote Pascal MT+ and was later a vice president of Digital Research, has started a new company called Maxisoft. The product is MaxiPlan, a combination spreadsheet and database with chart capability. MaxiPlan knows how to do a lot of statistical calculations. It will make databases and charts, and it will talk to you through the Amiga's speech synthesizer. You'll spend a while on the manual—this thing is powerful, and the instructions can be complicated—but it's worth the investment. Highly recommended.

TDI Software has Modula-2 compilers for both the Atari and Amiga machines. The Atari version is a new release that fixes some problems with the original. Both versions work and should make it simpler to transport programs from Atari to Amiga. Longtime readers know I'm a Modula-2 fan; this is a reasonable implementation, and TDI is working to make it better. The chief problem is the documentation: TDI needs to give more and better examples of just how to write and compile simple programs. Pournelle's law of software documentation: You can't have too many examples. I wish TDI would learn it.

The Amiga is known for its graphics; one of the best graphics programs is Deluxe Paint by Electronic Arts. Alas, they use an obnoxious copy-protection scheme. That's its only real fault; otherwise, Deluxe Paint is glorious. There's just very little you can't do with it. You can color-cycle portions of your drawing, so that waterfalls have running water; zoom in for fine details; and suchlike. It's a lot of fun. EA also has various games, some interesting, some boring.

Mindscape is another company that has developed some interesting Amiga software. The Halley Project is a spaceflight game that's part arcade but largely strategic; it helps to know something about planetary astronomy.

Activision has a whole bunch of Amiga software, including Music Studio, which I haven't much got into but which looks wonderful, and a series of illustrated text adventure games, including Hacker, which some say is the most difficult adventure of that type ever written.

In other words, there's a great deal of Amiga software: business, games, educational, programming tools. That, however, wasn't the real hit.

What was really impressive was the Amiga Sidecar, a box that turns an Amiga into a 99 percent PCompatible. Moreover, since the Amiga is a multitasking machine, they were able to run PC software as just one job. It was eerie to watch Flight Simulator running as if on a PC and still see the famous Amiga bouncing ball in the background and a word-processing program running in the foreground. The Sidecar has both 8088 and 8087 chips and is supposed to sell for significantly less than a thousand dollars. An Amiga plus Sidecar plus hard disk would be one of the most powerful combinations around, and I had no problem designating that the number one pick of Spring COMDEX.

PROBLEMS

One problem I've had with the Amiga is that while I kept hearing about all the new software for it, I never got any. Commodore's people sent catalogs, while the Atari people sent software. At COMDEX, Bob Pariseau, vice president for software development and one of the original Amiga development team, promised to fix all that. He also arranged to get me a Sidecar as soon as it was available. I left COMDEX convinced that the Amiga was likely to be the product of the year.

Two weeks later, Commodore laid off nearly 200 people, including Bob Pariseau. There were 55 Amiga people in the West Coast office; 20 were let go. Moreover, many who didn't leave immediately were put on notice; others, seeing the handwriting on the wall, quietly began sending out their résumés. The rumor I hear is that the investment bankers want Commodore to reduce their payroll by 50 percent; given Commodore's financial situation, the company is in no position to argue.

The question, then, is whether Commodore has—and can keep—enough high-tech people to support the Amiga properly. Commodore says they can. So do Amiga enthusiasts.

Me, I don't know. The situation is made vastly more complicated because many of those laid off were required to sign, as a condition for getting a few more severance benefits, a particularly severe—I would say obnoxious—nondisclosure agreement, the first term of which is that the agreement itself is secret. This has made it very difficult to get a decent picture of what has really happened at Commodore, and as I write this in early June I don't think anyone knows.

So, I like the Amiga, and I was much impressed by the enthusiasm of the Amiga people at COMDEX. Of course, even then the Commodore top brass must have known that many of those enthusiasts wouldn't be with the company two weeks later. By the time you read this, we may know the end of the story. I can't say I'm very fond of Commodore's management, but I do wish the Amiga well. It's a heck of a machine.

NAVY MICRO

The Navy Micro Convention at Virginia Beach was quite an interesting affair. The exhibitions tended to be dominated by Zenith, which is hardly surprising since Zenith is furnishing the armed services with most of their personal computers. Indeed, the demand for the new Zenith Z-248 PC AT clone is so great that I can't get one. Real Soon Now, they tell me.

One absolutely fascinating product at the Navy Micro exhibition was from Eastern Computer. I don't even know the product's name: I have a brochure, but it's all in Chinese.

What Eastern makes is a board for the IBM PC, XT, or AT that, coupled with their 24-pin printer, will let your machine write Chinese—using an ordinary PC keyboard.

You enter Chinese into the machine by keystrokes or phonetically. That is, I watched James Cheng of Eastern Computer type in

TKNL YFEMBNKG

which resulted in Chinese characters appearing on the PC (monochrome) screen. He could also have typed in "Zheng Su-timg," which is phonetic for the same result: his name.

Clearly this system isn't much use unless you know Chinese; but if you have ever seen a Chinese mechanical typewriter, with its great number of keys and different platen wheels, you'd appreciate just how revolutionary Eastern's board is. With traditional Chinese typewriters, really fast typists are lucky to do about 10 words a minute; Cheng tells me that with his system they get up to 40 or 50 words a minute.

If you're thinking of publishing in Chinese, you'll want to give Eastern a call.

HOW'S THAT?

I met Wayne Rash at the Navy Micro show. Wayne works for American Management Systems and also does reviews for BYTE and other computer magazines. I'd corresponded with him

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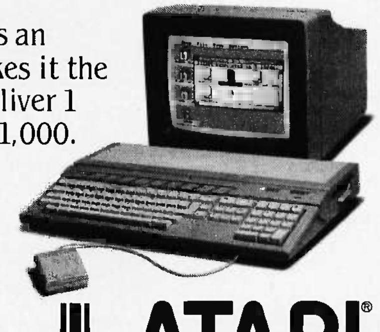

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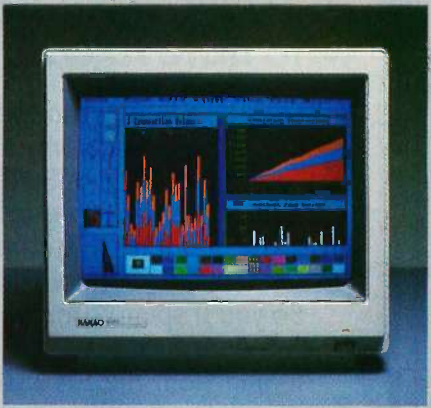

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on BIX, but until I got to Virginia Beach I'd never met him.

I'm glad I did. He has some fascinating stories. One of the best concerns the HP Integral.

The Integral came with a single floppy disk and was supposed to do UNIX—which came on several disks. Needless to say, that setup didn't work very well. You could, however, get an external hard disk for the machine. Wayne got one. Now the problem was to format it. HP had furnished a format program, but it didn't seem to work. Finally he called HP.

It took a while, but eventually he found someone who knew how to do it. It seems you were supposed to start the format program, and as soon as it began to run, quickly disconnect the data cable. After that the lobotomized hard disk would happily format itself.

I don't see very many HP Integrals any more. I think I can guess why.

T.N.T.

A couple of weeks ago, someone on BIX came up with the notion that a bunch of hackers should work together on BIX to design a program. There followed considerable discussion as to what that program should be. Eventually someone suggested an indexing program, which generated more discussion on what features such a program might have.

Before they could settle the details, Bruce Tonkin of T.N.T. Software leaped in. First he gave a long list of features an index program ought to have. Then he announced that he would write it. A week later he announced that he had written it.

"It" turned out to be My Index, a whole series of programs that, working together, produce an index. The only requirements are that you're running PC-DOS and that your text editor/word processor be able to "print to disk," so that the index program can figure out what page things are on by counting form feeds. Once you have that you can get started with the indexing.

The first program in My Index makes a list of unique words in the document. A second program will then remove common words you don't want to index. You can also go through the list with a text editor and eliminate words by hand; and to make life simpler, Tonkin provides you with a file of common words you're unlikely ever to want indexed. From there you proceed step by step, until you have an index.

It won't be what I consider a professional index, with sublevels, and phrases, and suchlike; but it has its uses. Back when we were doing computer books (something I've just about given up), I'd have been extremely happy with My Index as the starting point for a full index; it would have saved days of work.

My Index works best with Tonkin's MyWord! text editor, which itself is about as much bang for the buck as you're likely to find in a word-processing program. Like all T.N.T. software, MyWord! and My Index have ridiculously low prices compared to the competition. If you run CP/M, TRSDOS, or PC-DOS, you definitely ought to have the T.N.T. catalog; there's an awful lot of good stuff in there.

FONTASY

ProSoft has once again improved their already excellent Fontasy desktop publishing program for PCs. I'm running their demo on Big Kat as I write this, and it's impressive. Fontasy has a whole bunch of fonts, 60 small pictures like file cabinets and little shapes; and it works with a variety of printers, including the Epsons, HP's LaserJet and ThinkJet, and most other standards.

It does kerning—that is, tucks small letters in under the wing of large ones—proportional spacing, and all the other stuff you'd expect. In addition to the 28 fonts that come with Fontasy, some 300 more, and 400 pictures, are available separately. At $69.95 for the basic program, Fontasy is quite a bargain. If you're thinking

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of publishing a newsletter, you could do a lot worse.

REPORTS PLUS

One of the people I met at Spring COMDEX was Sue Currier, president of Softsync. She'd arranged to meet me in the press lounge at an ungodly hour in order to tell me about Reports Plus, a program intended to rival Borland's Reflex.

She began talking about the program. It will take SuperCalc3, Lotus 1-2-3, R:base, dBASE, or other files and transform them in interesting ways to generate and format reports. It would sell for $99 and is all menu-driven to make it simple to use. No programming required.

It all sounded good, but then came the fatal question. "Copy-protected?" I asked her, thinking that I would just get it on the record.

"Uh, well—we're thinking about it," she said.

There followed 15 minutes of conversation. It turned out that the review copy she'd brought to hand me was indeed copy-protected with one of those crazy schemes that let you install it on your hard disk.

"Not me," I said. "You won't get that stuff within miles of *my* hard disk."

The upshot was that I refused the copy and told her to get back to me if they decided to remove the protection scheme. Three weeks went by. Then came a box from Softsync: a copy of Reports Plus and a letter explaining that they'd decided to put the program out unprotected. It also explained that the program, called twenty/twenty in Britain, had won some competitions against Reflex and Paradox over there.

What with running around to Navy Micro and AAAS, I haven't had a lot of opportunity to work with Reports Plus; but what I have seen I like a lot. I've already used it to reformat some expense reports I put up with SuperCalc3, and it's certainly easy enough to use. It comes with both demonstration and tutorial disks, and so far I haven't found any glitches. I've become somewhat used to Reflex, but I had no trouble adapting to the Reports Plus method.

All in all, Reports Plus is a formidable rival to Reflex.

AT-STYLE KEYBOARD

A lot of people hate the IBM PC keyboard. Certainly I do, and I've said so often enough.

I have it on good authority that the designer of the IBM PC AT's keyboard was given explicit instructions to "make it so that d**n Pournelle won't trash it in his column." They succeeded, too: the PC AT's keyboard is pretty good.

Robert Solomon at Data Desk International thought so too, and he brought out an AT-style keyboard for the PC called the Model 8700. There's also a version available for AT compatibles.

It's a good keyboard. Good feel: the keys have tactile feedback. No mush

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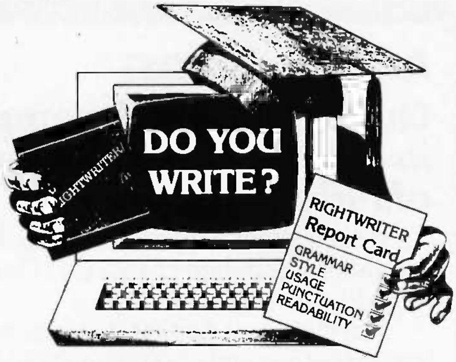

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SYSTEM V/AT is more than a look-alike. It was derived from AT&T's own UNIX System V release 2 iAPX286. It thereby contains standard System V features the competitors don't support, such as the powerful symbolic debugger, sdb, the shell-layering job-control facility and the F77 Fortran compiler, as well as programming tools such as ctrace, cflow, and bs. Also standard is File System Hardening which greatly reduces data loss in a power failure.

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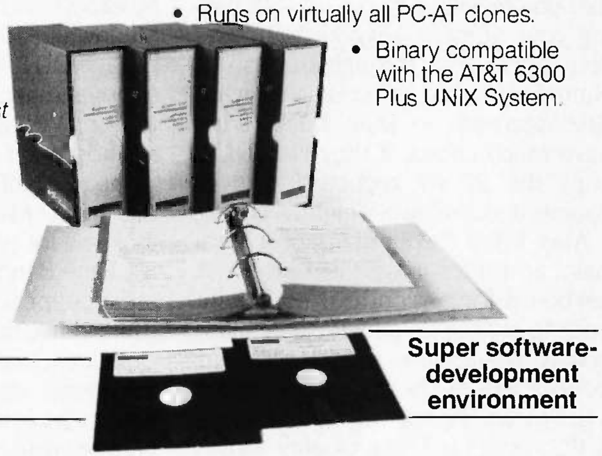

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at all. It has a Selectric layout. There's a two-year warranty. To make the deal even better, it comes with Borland International's SuperKey keyboard enhancer bundled in.

This is about as good a keyboard deal as you're likely to find, provided that you're willing to put up with having your numeric keypad double as your arrow keys through the use of Num Lock. That, of course, is what IBM decreed, so Data Desk didn't have much choice if they wanted to copy the PC AT keyboard; and of course it does save weight.

Alas, I find it something of a royal pain, and after using the Data Desk keyboard for a month or so, I went back to my big Enigma Research keyboard. The Enigma does *not* have as good a feel as the Data Desk, and if I get to where I'm writing books on a PCompatible, I'll probably switch back to the Data Desk; but for BIXing and game playing and spelling checking and all the other stuff *except* writing for hours on end, the Enigma is just one whack of a lot more convenient. In any event, I have absolutely no hesitation in recommending the Model 8700.

ORCHIDS

Last minute department: Orchid Technology keeps coming up with more and better stuff to keep your PC from becoming an anvil. Now they have a 286 upgrade for your IBM PC XT. It won't work on your older PC. Actually, it will, but you'll need to upgrade the power supply; kits for doing that are advertised all over the place, so that shouldn't be difficult.

With the Orchid PCturbo 286e, your XT will run programs around twice as fast as will a normal PC AT, which makes it about five times as fast as a normal PC. Orchid also makes the ECCELL, a memory board that not only finds memory errors but corrects them. (The name is an acronym for error correction.)

I'll have more about Orchid's new stuff in a later column. We've been using the PCturbo 186 board for two years now without glitches; I've no reason to believe we won't have as good an experience with the PCturbo 286e as soon as I get a new power supply into Lucy Van Pelt, our (quite old) IBM PC.

WINDING DOWN

Barry Workman tells me he's selling lots of copies of FTL Modula for CP/M; and by the time you read this, he expects to have an IBM PC version. Meanwhile, Tony Pietsch says he'll have WRITE for the PC done very soon; and another associate is trying to port WRITE onto the Atari ST. It all sounds good to me.

The game of the month is Time Bandit from MichTron Inc. MichTron makes a lot of software for the Atari ST. Time Bandit on the ST is the best arcade-type computer game I have ever seen, either on a home computer or in an actual arcade. It has some 11 dungeons, each with four levels. I haven't *begun* to master the silly game. I haven't quit trying, either. Watch out, Starship *Excalibur*, here I come! Full speed ahead, and damn the Watch Tribbles. . .

The book of the month has to be the report of the Citizen's Advisory Council on National Space Policy. It has to be, because it has taken up just about every spare moment I have.

The Council consists of some 50 aerospace experts and meets irregularly at Larry Niven's house. I'm chairman, in part because they figure they can stick me with writing the final report, which indeed got done at 6 a.m. on the morning we left for Philadelphia and the AAAS meeting.

This year's Council meeting was different: long before we had the actual meeting, we got many of the issues settled through conferences on BIX. G. Harry Stine, who's collaborating with me to turn the Council report into a book (*America: A Spacefaring Nation Again*; Baen Books, late 1986), will probably do an article on how we used BIX before and after the meeting. We learned a lot, including some of the strengths and weaknesses of electronic conferencing. More on that another time; but I guarantee you we'd not have accomplished half what we did if it hadn't been for BIX.

The computer book of the month has no author: it's *Programmers at Work, First Series* from Microsoft Press (1986,

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$14.95), and it consists of interviews with a whole bunch of hackers, including Dan Bricklin (VisiCalc), Andy Herzfield (Macintosh OS), Bill Gates (Microsoft BASIC), Wayne Ratliff (Vulcan, which became dBASE II), and many others. Quite readable and provides good insight into the varieties of hacker mentality.

I am now out of space, which is just as well because I'm also out of time: it's 2 a.m., and this has to be at BYTE by dawn. (I'll use BIX to send it.) Of course, it first must go through the spelling checker.

As I said, it's been quite a day.■

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE, *One Phoenix Mill Lane, Peterborough, NH 03458. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.*

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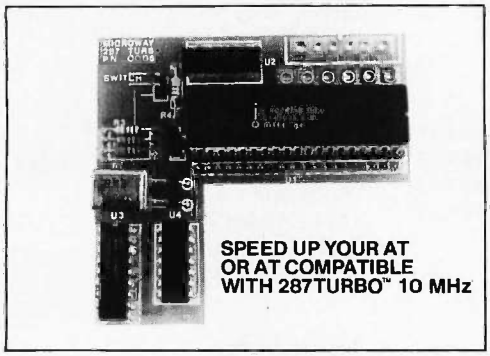

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TWO FINE PRODUCTS

BY BRUCE WEBSTER

Turbo Prolog from Borland and LightspeedC from Think

It's now mid-May as I write this; wonder of wonders, I'm going to get this column in on time. It should make the folks back at Peterborough happy; I know it's a relief for me. Maybe I can make a habit of it.

There have been a few columns in which I haven't picked a product of the month; this is the first time I've picked two: Turbo Prolog (from Borland International) and LightspeedC (from Think Technologies). Both deserve it, and I considered sliding one back a month to avoid "diluting" the honor. But I felt that both also deserved timely coverage (or at least as timely as anything with a three-month lead time can be), so here they are.

STANDARD DISCLAIMER

Since I am about to say some nice things about a product from Borland International, I thought I would once again make it clear that I have had business dealings with Borland in the past. I wrote most of Turbo Tutor back in 1984, and I contributed to the rewrite of Turbo Tutor early last summer. In both cases, I was paid a lump sum for my work in lieu of any royalties, so there was and is no ongoing financial connection with Borland. If you feel that somehow invalidates or makes suspect what I've written below, fine. Frankly, I feel a little silly even mentioning this. However, over the last several months I've had people accuse me of a suspicious bias for or against (a) Apple, (b) Atari, (c) Commodore, (d) all of the above, so I thought I'd make everything clear right from the start. And for those of you who are curious, the answer is (e) none of the above.

PRODUCT OF THE MONTH: TURBO PROLOG

When I first got my hands on Turbo Pascal a few years back, it excited me as few software products had. With all its quirks, bugs, and rough edges, it represented a real breakthrough in computer software and set Borland on the path to becoming a major power in the microcomputer software industry. Borland has come out with many products since then—perhaps too many—and none have excited or impressed me as much as Turbo Pascal did, though most have been successful. And even though I have copies of just about everything Borland has put out, Turbo Pascal has been the only product I've used for any length of time.

Well, I can now say "Borland's done it again!" and really mean it. As I'm sure most of you are aware (wouldn't you like to get just a percentage point or two of Borland's ad budget?), Borland has released Turbo Prolog, a Prolog development system for the IBM PC and compatibles. [*Editor's note: See a review of Turbo Prolog on page 293.*] It requires 384K bytes of memory, can actually be run on a one-floppy-drive system (and works nicely on a two-drive system), and runs under MS-DOS/PC-DOS 2.0 or later. It is an actual compiler, capable of producing stand-alone applications (.EXE files). It comes with two disks: one contains the actual Prolog system; the other has more than 60 example programs. Much of the manual, which is over 200 pages, is dedicated to a Prolog tutorial. Turbo Prolog is not copy-protected and sells for the amazing price of $100 (less a nickel).

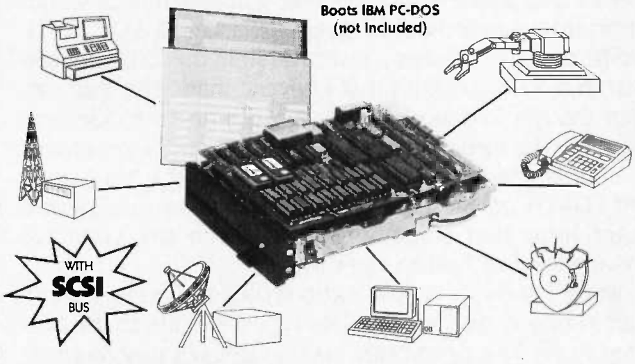
What's so interesting about Prolog in the first place? Well, it's a nonprocedural language that allows (requires) you to specify a set of rules, data, and relationships, then tries to find answers to goals that you give it. It is so different from procedural languages (Pascal, C, FORTRAN, BASIC, etc.) that it takes a radical shift in thinking to move over to it. I freely admit that I haven't made the shift yet, even though I've worked through the first six chapters, following the tutorial and keying in all example programs. Of course, the fact that I was using C on the Macintosh and FORTH on the Amiga during the same time period might have had something to do with the cognitive dissonance I've had to deal with.

Listing 1 shows a simple Turbo Prolog program. The domains section defines any data types specific to the program itself. The predicates section defines any relationships between domains. The clauses section gives actual implementations of predicates. These can be facts, like the various assertions of likes, or they can be rules, like the definition of the predicate friends.

For example, given the program in listing 1, you could specify a few different goals. If you asked for the goal likes(X,reading), the program will find names X such that likes(X,reading) is true; in this case, the values returned for X are eva and george. You could ask for the goal likes(eva,X), which would return the solutions reading and biking. For a different approach, you could ask likes

(continued)

Bruce Webster, a consulting editor for BYTE, *is reached c/o* BYTE, P.O. Box 1910, Orem, UT 84057, *or on* BIX *as bwebster.*



Listing 1: A *simple Turbo Prolog program.*

```
domains
     person, hobby  =    symbol
predicates
     likes(person,hobby)
     friends(person,person)
clauses
     likes(gregg,gerbils).
     likes(eva,biking).
     likes(george,reading).
     likes(eva,reading).
     likes(ezra,driving).
     likes(phil,flying).

     friends(X,Y) if
       likes(X,Z) and likes(Y,Z) and X <> Y.
```

(phil,flying), which would return the solution TRUE; likewise, the goal likes(gregg,driving) would return FALSE. Similar goals can be specified for the predicate friends. The goal friends(eva,X) will return the solution george.

When you boot up Turbo Prolog, you first notice the user interface. It's a multiwindow, keyboard-controlled, menu-driven system that works smoothly and well. Your environment consists of five windows. The top one, the menu bar, is fixed and unchangeable. It lists your main commands—Run, Compile, Edit, Options, Files, Setup, and Quit—which you can execute by typing the first letter of each command or by using arrow-key selection. Three of the commands (Options, Files, and Setup) have pop-down menus that let you select options by the first letter or by arrow commands. Some commands (like Load File) will open up other windows (like when you need to enter a filename). You can always travel back up the chain of windows by pressing the Escape key.

All the action takes place in the other four windows. The window names—editor, dialog, messages, and trace—may clue you as to their function. You actually enter and modify your Prolog programs in the editor window. You interact with your running Prolog program in the dialog window; that is, all program input and output take place here. You can see which clauses are being invoked in the messages window, while the trace window gives you a more detailed step-by-step evaluation of your program's execution if you have the trace function enabled. You can resize and relocate all four windows using the arrow keys, then save your custom setup.

The editor window accepts both a WordStar subset of commands (Control-X, Control-S, etc.) and commands from the function keys and arrow keys. The window automatically does horizontal and vertical scrolling as needed while you type or move through your text. A Help key (F1) brings up a pop-up window from which you can get a description of the basic set of editing commands.

When you have entered your program, you hit the Escape key to get out of the editor window, then you type "C" (for Compile) or "R" (for Run). In both cases, the pro-

(continued)

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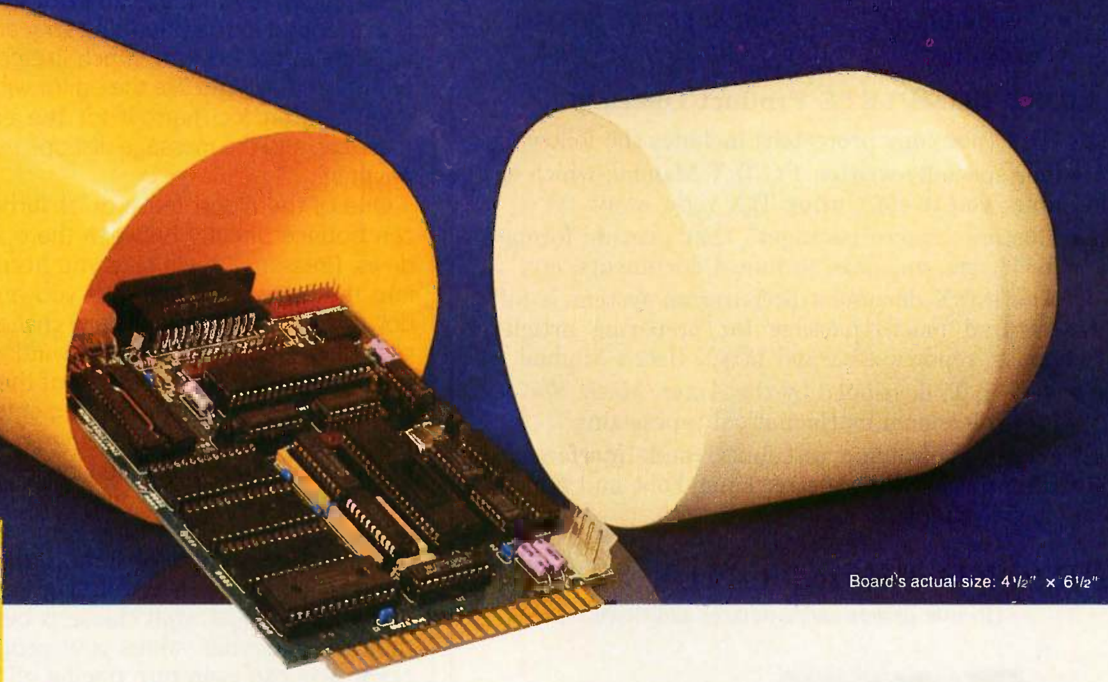

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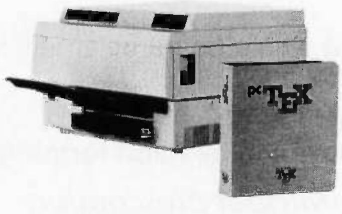

gram is then compiled; in the latter case, it is also executed. If an error is found during compilation, the editor window becomes active, the cursor is placed at the offending location, and an error message is displayed across the bottom of the window. The error message vanishes as soon as you hit any key; unfortunately, the message is often wider than the editor window, and any attempt to scroll the text over to make the message visible results in the message's departure.

When the program compiles correctly and is executed, control passes to the dialog window. Any program output shows up here; likewise, any input takes place in this window. If you have defined a goal (or goals) within your program, running it initiates an attempt to solve those goals. If you have no defined goal (as is the case with the program in listing 1), the program asks you for one; you can then type in an appropriate goal, for instance, likes(phil,X). If you make an error in the goal, the cursor is positioned at the offending spot and an error message appears at the bottom, much like compiler errors in the editor window. And like the editor window, the dialog window is often too narrow for the error message to be readable, and the message disappears as soon as you type anything.

One of the nicest features of Turbo Prolog is that you can bounce directly between the dialog and editor windows. Pressing F9 will take you from the dialog window into the editor; F10 will take you out of the editor window, incrementally compile any changes made, and (if successful) take you to the dialog window. Incremental compilation is a key to the speed of the Turbo Prolog interface. In effect, Turbo Prolog remembers most of what it has compiled. When you change a clause, it usually has to recompile only that one clause. This makes for quick development, allowing you to try out different ideas and add different rules.

Some strong points of Turbo Prolog are the trace and debug features, which let you single-step through your programs, seeing just what clause is being evaluated at any moment and what values your program is using at that point. You can even turn tracing off and on again within your program, so that you don't have to step through sections that you've already debugged.

Another asset is the long list of predefined predicates that not only make for a full Prolog implementation but also give you easy access to screen I/O, graphics, system calls, arithmetic functions, and string handling. Furthermore, Turbo Prolog has the capability of calling external predicates written in assembly language, C, or Pascal. Note that you can't call routines written in version 3.0 of Turbo Pascal; however, version 4.0 (due out sometime in the future) will produce linkable code files that can be called.

The manual is generally well written, more so than many of the Borland documents. The style is clear and readable, and it is well organized. I have only two complaints. First, more examples would have helped, especially in the early chapters. Prolog is such a different language from the ones I and many other programmers have used, that it would help a lot to see the best approaches to different problems (like loops). Also, the exercises given in the book are probably easy for a Prolog programmer with any experience, but they can prove to be tough for someone (like me) who's just learning Prolog and has no good idea of where to start.

I had done a little Prolog programming before receiving Turbo Prolog, using Chalcedony Software's PROLOG-V Plus interpreter. But I'm not qualified to judge how good the implementation is, so I showed it to two instructors—Dr. Dan Olsen and Gary Stokes—at Brigham Young University who have worked with Prolog. They were impressed with the implementation itself, especially its speed and completeness, and also with the development environment. They said it was superior to the Prolog systems they've been using (including an implementation on a VAX-11/780 minicomputer), and they are looking at switching to Turbo Prolog for class use. Stokes also took a program that he was unable to debug on the VAX and got it quickly running using the trace features of Turbo Prolog.

Their main complaint about Turbo Prolog involves the limitations on having a program expand its own clauses (or rules). You can add facts, like the assertion likes(eva,reading); you cannot, however, define new rules or expand on old ones. This, I suspect, stems from the compiled nature of Turbo Prolog programs. An interpreter has an easier time accepting new rules, since it is maintaining the source code somewhere in memory, to which the program can add new definitions. For stand-alone Turbo Prolog programs to do the same, they would have to somehow include the compiler (or a subset thereof) in the code file, which would greatly increase memory and disk requirements.

The biggest question about Turbo Prolog is how much demand there is for it out there. My first inclination is that there wouldn't be much, especially since the folks most likely to buy it—do-it-yourself programmers—are going to be firmly entrenched in procedural thinking and will have difficulty switching over to the appropriate mind-set. On the other hand, the demand for Pascal compilers was grossly underestimated at the time Turbo Pascal hit the market or, more accurately, the positive qualities of Turbo Pascal radically enlarged the market. The same may be true of Turbo Prolog; given its performance, quality, and low price, it may well create a much larger market than might otherwise exist.

The other big question in my mind concerns the problems that Turbo Prolog is best suited to solve. I don't have a good feeling for the type of problems that Turbo Prolog addresses and the ways in which it might solve them better than, say, Turbo Pascal. This is probably due more to my own ignorance (which, as always, I'm trying to eliminate) than anything, but it will remain a question until I know enough to answer it myself.

Even with those questions, Turbo Prolog may be as significant a leap in software design as Turbo Pascal represented three years ago. I am not sure that the height of that leap is obvious, for a number of reasons. First, there are few Prolog programmers in the microcomputer world,

(continued)

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at least compared to the number of Pascal programmers who were around when Turbo Pascal came out, so there aren't nearly as many people who can appreciate what Borland has done. Second, Turbo Pascal has spoiled us, both with respect to what we generally expect from compilers and what we specifically expect from Borland. Third, Prolog is such a different language from what most of us grunt-work programmers are using that it's hard to compare its capabilities to those of the languages (C, Pascal, BASIC, etc.) we've been using. I suspect it will be a few years before we can evaluate just what Borland has released here: a curiosity or a milestone.

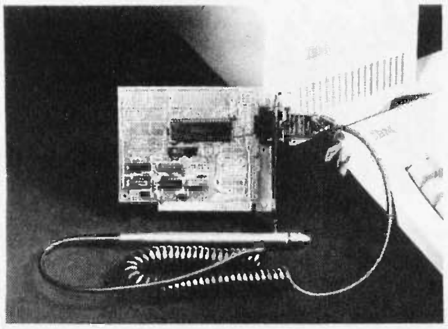
My recommendation: If you're at all interested in artificial intelligence, databases, expert systems, or new ways of thinking about programming, by all means plunk down your $100 and buy a copy of Turbo Prolog. I plan to keep using it.

PRODUCT OF THE MONTH: LIGHTSPEEDC

I mentioned LightspeedC in my column last month, and it certainly deserves more coverage. For those of you unfamiliar with it, LightspeedC is a C compiler—or, more accurately, a C development environment—for the Macintosh. It produces native 68000 code and stand-alone applications, including desk accessories. It requires 512K bytes of memory and 800K bytes of storage (RAM disk, floppy disk, hard disk, or any combination thereof). The manual claims that you could get by with a single 400K-byte disk drive, but save yourself a lot of grief and make sure you have at least 800K bytes (two single-sided floppies, one double-sided floppy, etc.). It comes with three single-sided disks; one has the actual system, one has examples, and one has utilities and libraries. As for the manual, it's about 400 pages long, is large and readable, and can occasionally be convinced to stay open, though it helps to hold it down with other books, disk drives, rocks, etc. The product is not copy-protected and sells for the reasonable price of $175.

In LightspeedC, the basic development unit is called the project. A given project, represented on the desktop by a LightspeedC icon, is a collection of C source files, object code libraries, and other projects. You can add files to a project, remove them from the project, and group them into segments. (Before you ask, no, you can't add a project to itself. When you ask to add files to a project, the file-selection box is smart enough to screen out that project as well as all files already added to the project.) You can also set the project to one of four types: application (the default), desk accessory, device driver, and code resource. By using the project approach, LightspeedC performs a lot of bookkeeping and other project management for you, eliminating the tedium of tracking lots of different files.

When you start up LightspeedC, either directly or by double-clicking on a project icon, you come up in a standard Mac environment: desktop, menus (seven in all), and a window listing the files that comprise the current project. You can then double-click on any of the source filenames and go into the editor to make additions and



changes. If you're creating a new source file for your project, you can open up a new (untitled) file, edit it, save it out under some name, then add that file to the project. The editor itself is a simple, clean, Mac-style editor: not too many features, but I haven't found any bugs yet, either. I started opening up files for editing to see how many I could have open at the same time. Once I got 12 open, I started moving and resizing windows, then I closed them all. No problems. Also, the editor is not a separate "mode" from the compiler and linker; you can have editing windows open at all times.

So far, so good, but nothing terribly spectacular or innovative. That comes when you decide to compile and run your program. The first time through, LightspeedC compiles each of the source code modules. The compiler *is fast*, especially if you're running off a hard disk or a RAM disk. On my system (512K Mac, old ROMs, MacBottom 20-megabyte hard disk), it took just 40 seconds to compile some 3000 lines in four separate source code files. This included the time to open and close each file and to save the object code out to disk.

If an error is encountered during compilation, that file is brought up in an editing window (if it's not already there), the cursor is positioned at the start of the line with the error in it, and a window is brought up at the top of the screen describing the bug. You must acknowledge the error by clicking in that window, and you can then correct the error and restart the compilation. The error messages are sometimes maddeningly vague ("Syntax error" seems to be a favorite catchall); on the other hand, I've always managed to figure out just what the error is, and I'm still a relative neophyte when it comes to C.

LightspeedC starts to show its strengths when you have to recompile your program. It knows which files you have modified and which you haven't and recompiles accordingly. But wait! It's even smarter than that. If you edit a file not listed in the project window—like an ".h" include file—it will recompile only the source files that include that file. And if you edit a file not used by the project, none of the source files are recompiled. Someone—I assume it was Michael Kahl, principal author of LightspeedC—did an outstanding job of making the recompilation algorithm very intelligent. At the same time, you are not locked in by that algorithm. At any time, you can force a recompilation of any or all source code files. You can also force it to reload any library files from the disk. It then performs an incredibly fast link, based, I suspect, on linkage information being held in memory and updated during the compilations. If that isn't successful, it pops up an error window ("Link failed") at the top of the screen and also brings up a text window with the unresolved references. Again, you can use that information to track down your problems, correct them, and start a recompilation.

Once your program compiles and links, you can execute it without ever leaving LightspeedC. Your program takes over the computer, but when it exits (providing it hasn't crashed the system), it returns control back to LightspeedC, not the Finder. At this point, you can create a

(continued)

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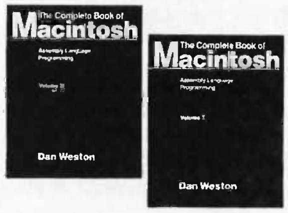

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The real beauty of LightspeedC appears when you make a change to a working project.

stand-alone code file by selecting the appropriate menu option; it takes only a few seconds for the executable file to be created. You can also use a project to create a library file, which can then be used in other projects.

The real beauty of LightspeedC appears when you want to make a change to a working project. You edit the appropriate source file and then select the Run option in the project menu (or type Cmd-R). That one source code file is recompiled (usually in a matter of seconds), all necessary relinking is done, all the windows are closed (saving any files currently being edited), and the updated program is launched. For example, I changed one line in the largest of the four modules in my program, then typed Cmd-R. Total elapsed time until the program was running and waiting for my commands: 20 seconds.

How good is the code produced by LightspeedC? I can't say with great accuracy, since I haven't run any benchmarks through it yet. What programs I have run would indicate that the code speed is generally comparable to the other Mac C compilers (Consulair, Aztec, Megamax); but I still plan to run some tests and report on them when I can. Code files seem to be fairly small, too.

What are some of the features and extensions that LightspeedC offers? Well, for starters, it's a superset of Kernighan and Ritchie's C, including structures, enumerated data types, and bit fields. Data type sizes are as follows:

char	8 bits
short	16 bits
int	16 bits
long	32 bits
float	32 bits
short double	64 bits
double	80 bits (full IEEE)

LightspeedC supports the Mac operating system and Toolbox routines, though it apparently doesn't support AppleTalk (as of this writing). It has about 200 other predefined functions in other libraries (math, unix, stdio, strings, etc.) to provide compatibility with other C systems. In-line assembly language is not supported; however, a utility is provided to convert Macintosh Development System (MDS) object files to libraries acceptable to LightspeedC. LightspeedC also provides a plain-vanilla I/O interface (using stdio.h) that turns the Mac into a standard terminal; if you include the unix library, you get simple cursor control and graphics functions. In either case, the QuickDraw procedures appear to still work in "terminal" mode. LightspeedC supports resource files (and includes a copy of RMaker). It also comes with the Macsbug debugger and instructions on how to use it. And it even has

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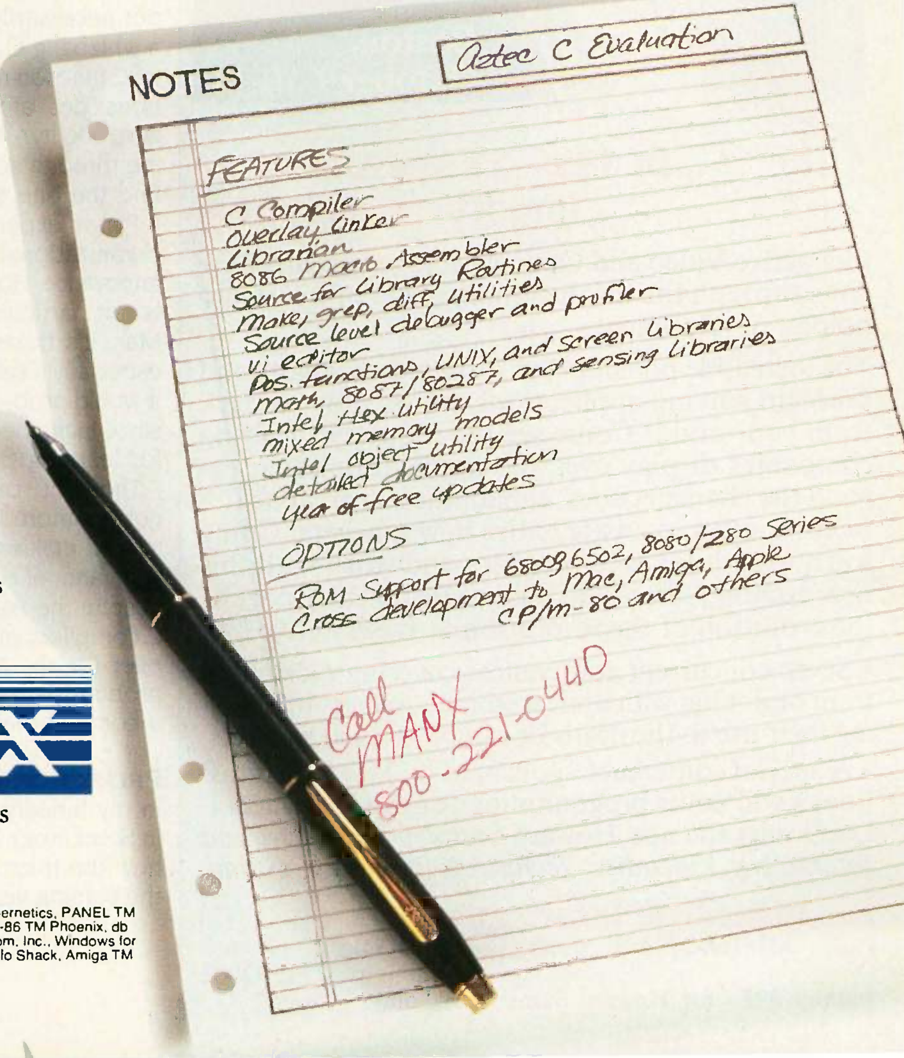

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The single greatest weakness with LightspeedC isn't the product itself, it's how big and poorly organized the manual is. It's difficult to dig out the information that you need and that is usually (but not always) there. More than half the manual is devoted to documenting the 200-plus library functions (a few per page, listed in alphabetical order) as well as the calling sequences for the Mac routines (listed according to the manager groupings of *Inside Macintosh*). The irony is that the ordering for both sets of routines probably should have been the other way around. If you are a programmer, you probably already know the name of the Mac routine and just want to find the calling sequence; the manual forces you to find out what manager it's in. If you're looking for a particular C library function, you probably know what you want the function to do, but not necessarily what its name is, especially if you're not a whizbang C programmer. Given the penchant for cryptic C function names (quick! guess what the following functions do: atol, cputs, getuid, iscsymf, sbrk, stci_d, strrpbrk, ttyn, vsprintf), you may have to resort to thumbing through some 162 pages of function descriptions to find the one you need.

For an experienced Mac C programmer, this and other organizational problems are probably no more than an annoyance. However, for an experienced programmer who is not particularly familiar with either C (like me) or the Mac, it's frustrating; for someone familiar with neither, especially if said person isn't an experienced programmer, it would probably be a nightmare. Which is really a shame, since LightspeedC strikes me as an excellent environment for learning C and programming on the Mac.

Those of you familiar with my column know that I am not enamored of C, but LightspeedC goes a long way toward making it my language of choice on the Macintosh (and, of course, LightspeedC my compiler of choice), despite the Pascal/C interface problems that confront all C compilers on the Mac. If I had to own just one C compiler for the Mac—indeed, just one compiler—it would probably be LightspeedC. Until someone comes out with a comparable Pascal development system.

PREDICTION UPDATE

In my January 1986 column (which was actually written in September 1985), I made a series of predictions about how the microcomputer industry would develop during the coming year. Much to my surprise (and delight), most

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of those predictions have been coming true within the past month or two or at least appear to be headed in that direction. To wit:

- The Apple IIe/IIc is losing ground to the Amiga and the Atari ST (though not nearly as fast as I thought it would); in response, Apple is working on the IIx (which may be out by the time you read this) and will probably cut prices on the IIe and IIc to well below the $600 level, especially as Christmas approaches.
- Apple has committed itself (in its annual report, no less) to an open-architecture Mac. Apple has made no official statements on what the open Mac will have, but the grapevine indicates slots, a 68020 processor, faster disk drives, more memory, a larger display, and possibly even color. And, I suspect, a fan.
- John Scully told analysts that all future Macintosh products would be capable of running both UNIX and MS-DOS. Also, at least one third-party vendor should be shipping UNIX System V for the Macintosh around the time this column sees print.
- Analysts are generally pleased with Scully's commitment to MS-DOS and UNIX (and with Apple's direction in general), especially since (according to said analysts) it gives Apple a better shot at getting into corporate markets. Apple stock now stands (this is mid-May, remember) at around $32/share, up substantially from last fall and more than double its low value during the last year.
- Commodore showed (at COMDEX/Atlanta) the Sidecar, an MS-DOS box with an 8088 processor, an IBM PC–compatible BIOS, expansion slots, and 5¼-inch disk drives. (Atari is also developing an MS-DOS box for the ST, but I didn't predict that.)
- In addition to Apple's open commitment to UNIX, sources at both Atari and Commodore have indicated that future products will include UNIX-based systems, or at least systems with UNIX (or a look-alike) as an option.
- The 68000 family is having a good year, though the leading edge of the market already seems to be shifting away from the 68000 to the 68020 (bypassing the 68010 completely). Motorola is apparently selling all the 68020s it can make (and then some). And anyone not making an IBM PC compatible appears to be choosing the 68000 (with the exception of the IIx, which apparently will use the 65816).
- IBM announced (finally!) the PC Convertible, its laptop computer, which does, indeed, look to be decently designed; the surprise is that the pricing and marketing appear to be better than average, though I wonder how hard IBM will actually push the machine. The only other announcements have been slight improvements (along with price cuts) on the XT and AT, mostly to catch up with the clone makers. And speaking of the clone makers. . .
- During the last week or so, articles in the *Wall Street Journal*, *Newsweek*, and elsewhere have focused on the cheap, well-built IBM PC compatibles that are flooding the MS-DOS market and are threatening to (as a group) pass IBM unit sales by the end of this year or early in 1987. It has reached the point where the name "IBM" on the front

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panel is seen as a liability in some market segments because it usually means higher prices and lower performance.

Okay, so where did I mostly go wrong? Well, the ST and Amiga have not been runaway successes, though both appear to be selling better than competitors and detractors wish to believe. And I'm not sure there's been the "big upswing" in the home market that I predicted. On the other hand, this is only May; that surge may hit at Christmas. That (together with production problems) has probably held down sales of the Amiga and the ST; given the lack of reliable sales figures from either firm, though, it's hard to judge. The open Mac appears to be slower coming to market than I thought it would be and may not even show up until early next year. But it is coming.

The big question right now is the ultimate impact of the layoffs at Commodore, which included some key people at the Commodore-Amiga (Los Gatos) facility. This could be an honest-to-goodness belt-tightening move, such as Apple made back in 1985 (to good effect). Or it could signal serious trouble at Commodore. By the time you read this, you should have a better idea of which it is. My guess? I think Commodore and the Amiga will still be around come September.

IN THE QUEUE

Well, it looks like next month may be Round 3 of the 68000 wars. I now have for a few brief weeks a Prodigy 4 from Levco, which I mentioned a few columns ago under the name Super Mac 20. From the outside, it looks like a regular Mac; on the inside, it's got a 16-megahertz 68020 processor, a 68881 floating-point coprocessor, 4 megabytes of RAM, and a 20-megabyte hard disk (running on an SCSI interface). I also hope to line up Computer System Associates' 68020/68881 expansion board for the Amiga, as well as General Computer's HD-2000 upgrade for the Macintosh. And Apple wants to swap the plain-vanilla 512K Mac that they've been lending me for a Mac Plus. I've got some software products I want to get to as well, including Multi-FORTH, Aztec C, and TDI Modula-2 for the Amiga. But, as always, I'm making no promises. Until then, I'll see you on the bit stream. ■

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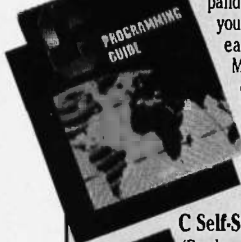

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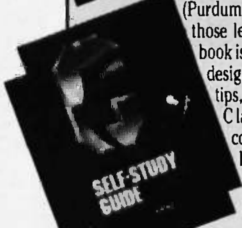

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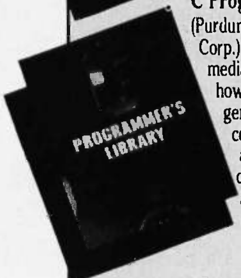

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PERSPECTIVES ON HARDWARE AND SOFTWARE

BY WILLIAM M. RAIKE

This is the season of the annual Microcomputer Show in Tokyo, and with it came several interesting new computer products. Surprisingly, while NEC and, to a lesser extent, Fujitsu often dominate the show, this year neither company introduced new computers. The most interesting new computer, the Vectra-D, came from YHP, Hewlett-Packard's Japanese company. Yamaha displayed a fascinating gadget, a piano and computer rolled into one. But even when I'm not going to computer shows, I'm still on the lookout for other computer applications in less likely spots.

HIGH-TECH FLAVOR

It's hard to paint a meaningful picture of modern-day Japan in words. When I visit the U.S., most people there seem to imagine Japan as either a high-tech wonderland or as a semimystical land of peaceful meditation, martial arts, and traditional handicrafts. Sometimes, all the realities overlap in amusing, if somewhat jarring, ways.

For instance, one way many Japanese briefly escape the crowded conditions of most Tokyo offices and businesses is to stop in at the local coffee shop in midafternoon. These tiny shops, called *kissaten*, are found everywhere, and they provide a place to meet clients, relax with coworkers, or just duck out of the office to read a book or magazine over a quiet cup of coffee. The proprietor of one such nook in the Shibuya district of Tokyo decided to attract customers by offering a new service: word processing. He installed several personal computers on a large central table, and customers are encouraged to use them, gratis, for whatever purpose they choose while sipping coffee and nibbling cakes. According to the manager, the idea seems to have worked; people often come in just to find out how a word processor works and return when they discover how easy it is to operate one. And so far, no one has spilled coffee over the keyboard or smeared pastry on the screen!

Advanced hardware—why hasn't software managed to catch up?

But one nearby noodle shop, confronted with competition from its neighbor, may have had the last word when it decided to give itself a "new media" edge. It decided to take advantage of rapidly dropping prices by buying a FAX (facsimile) machine; now I can send in my order for traditional Japanese *soba* or *udon* noodles directly from my home FAX machine!

PERSPECTIVE ON SOFTWARE

Just last month I was lamenting the lack of hardware and/or software that would allow IBM Personal Computers and their work-alikes to process Japanese-language text. Despite the fact that a number of Japanese computer manufacturers have developed IBM PC AT–compatible computers for the U.S. market, the number of IBM PC–compatible machines sold in Japan is minuscule compared to the sales of the NEC PC-9801 series, for example. IBM Japan Ltd. offers its Model 5550 and 5540 workstations, which are popular office computers in many banks and large corporations here. (Recently the company announced upgraded models based on the 80286 microprocessor, the same chip used in the PC AT.) But these computers aren't directed toward the personal computer market, they aren't PC-compatible, and they carry substantially higher price tags than most personal computers.

The reason for so few IBM PC and PC AT machines and work-alikes being sold here is no mystery. I've pointed out several times in this column that you can't expect to sell large numbers of computers in Japan if those computers can't handle the Japanese language. Hardware produced by the leading personal computer manufacturers (NEC, Fujitsu, Oki, Sanyo, Sharp, Hitachi, and others) is very powerful and has undergone a long and arduous winnowing process in the fiercely competitive Japanese market. Demands include extensive and sophisticated Japanese-language processing features that are built into the hardware, as well as more familiar hardware features like fast microprocessors, massive onboard RAM, large floppy disk and hard disk capacities, and extensive interfacing capability.

However. . .about software. Now it's true that hundreds upon hundreds of

(continued)

William M. Raike, who has a Ph.D. in applied mathematics from Northwestern University, went to Japan in 1980 looking for 64K-bit RAMs. He has been there ever since as a technical translator and a software developer. He can be contacted c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

Computer users are becoming more demanding in terms of what they want their software to do.

Japanese-language application software packages are available for Japanese personal computers. These include word processors, spreadsheets, database managers, graphics programs, business and accounting programs, integrated software packages, communications programs, and so on, not to mention games. That's over and above the large amount of imported generic MS-DOS and CP/M software (including many compilers, interpreters, assemblers, utilities, and other software development packages) that runs perfectly well on Japanese personal computers. But all that software is merely a drop in the bucket compared to the enormous number of packages you can choose from if you have a PC, a PC AT, or a work-alike.

The growth in the level of sophistication of the new software products developed for computers that obey the de facto IBM standard is mind-boggling. And I say that from the viewpoint of having used and developed software for more than 25 years! The increasing power and range of available software has an explosive positive-feedback effect, with users becoming more demanding in terms of what they want software to do. Also, the number of people buying and using the software is dramatically expanding.

Japanese software, in comparison, hasn't yet shown this growth curve. Japanese-language software products have not approached the circulation (numbers of copies in use) of products like WordStar, Lotus 1-2-3, Smartcom, SideKick, or ProKey. Except for word-processing software, Japanese-language versions of Multiplan, SuperCalc, and dBASE II are among the most popular application packages. This doesn't necessarily discredit the creativity of the Japanese software industry; rather, a large part of the reason for the low circulation is simply the low volume of mutually compatible computers, like those found in the IBM PC family.

Regular BYTE Japan readers know that my latest in a series of Japanese computers is the Fujitsu FM-16β and that I'm very happy with it. But I don't heavily use its Japanese-language features, and I can't help feeling occasional twinges of regret at not having access to the flood of useful software

(continued)

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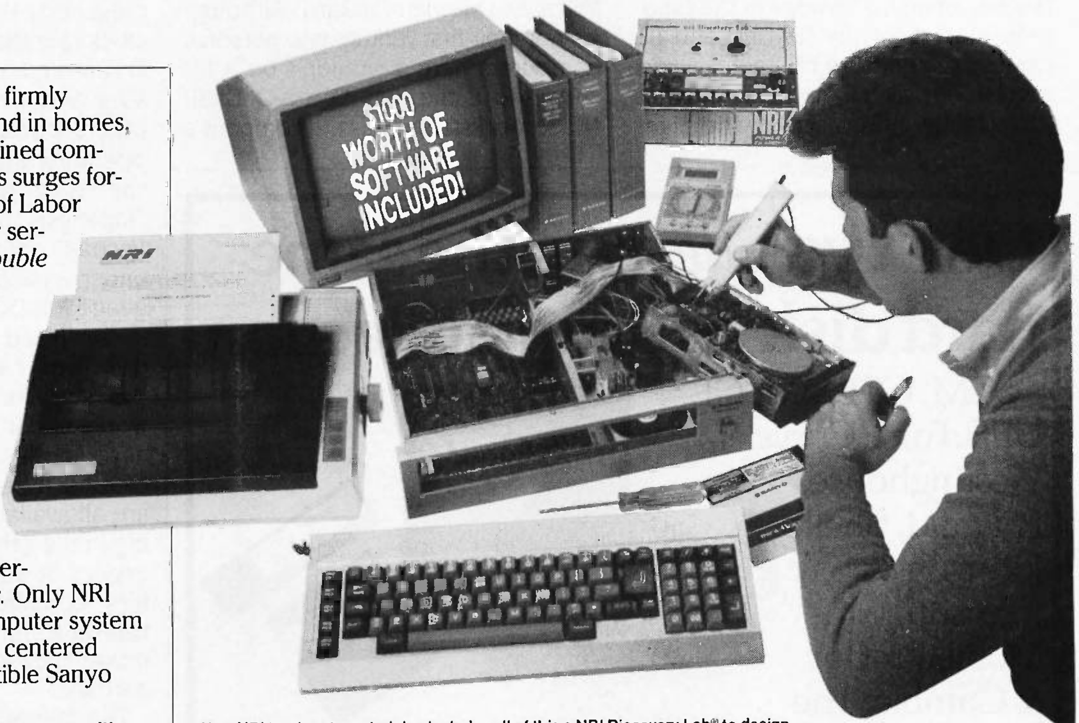

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that works only on the PC, the PC AT, or fully compatible machines. In last month's column, I suggested that someone ought to develop an add-on board for the IBM PC to give it Japanese-language processing ability. Besides opening a wedge in the Japanese market for the IBM PC and its clones, it might give me the excuse I need to buy such a machine. And that topic brings me to one of the highlights of the recent Microcomputer Show.

A PC AT WORK-ALIKE

The Hewlett-Packard people in Japan are called YHP, which stands for Yokogawa Hewlett-Packard. Although it's not their first venture into personal computers here, I wouldn't be a bit surprised if the new Vectra-D Dual-Mode Workstation was the company's most successful project. What YHP has done with the Vectra-D is to combine two computers into one.

The Vectra-D can work as an IBM PC AT–compatible computer. With an 80286 microprocessor running at 8 megahertz (in contrast to the 6-MHz clock rate that IBM uses), the Vectra-D can run Lotus 1-2-3, SideKick, TopView, Symphony, Flight Simulator, and others. If you type a command at the operating system level, though, you can switch from "English mode" to "Japanese mode." This turns the Vectra-D into a computer running under version 3.1 of the Japanese-language MS-DOS operating system. As a convinced and enthusiastic RAM disk user, I was happy to hear that YHP supplies RAM disk software that works under both English and Japanese modes. Of course, data files created by a program in one mode are all available to programs operating in the other mode. As you might expect, however, if you try to display files containing Japanese kanji or katakana characters while in English mode, they appear on the screen as garbage.

The kanji ROM contains both the JIS No. 1 and No. 2 character sets, plus a number of additional characters, totaling nearly 7000 characters. Kanji characters are displayed on-screen in a 24- by 24-dot font, which is quite readable. You get 1024- by 768-dot monochrome graphics in Japanese mode, with either 640- by 200-dot or 640- by 400-dot monochrome graphics in English mode. The price you pay for having the Japanese mode on hand is that no color graphics are available, though such options may be available later. YHP wouldn't make any promises. And if you buy a Vectra-D, the price includes a monochrome (green) monitor.

I saw the Vectra-D operating in Japanese mode and running several Japanese-language programs, including the jX-Word word processor and SuperCalc3. YHP says that the R:base Series 5000 database manager will also work, along with GW-BASIC, Lattice C, and a terminal emulator/communications package. In English mode, YHP says that most popular PC AT software will work, although tim-

> *If you type a command at the operating system level, the Vectra-D switches from English mode to Japanese mode.*

ing problems could conceivably arise as a result of the faster 8-MHz clock rate; there's no switch for selecting between 6-MHz and 8-MHz rates.

The Vectra-D system comes with some impressive hardware as standard equipment. Standard memory is 640K bytes, expandable to 3.64 megabytes. One 1.2-megabyte/360K-byte floppy disk drive is standard; there are two more internal shelves for one more floppy disk drive and one hard disk drive. You can order either a 20-megabyte or a 40-megabyte internal hard disk. The Vectra-D includes seven expansion slots: two are 8-bit bus slots, while the other five are 8-/16-bit bus slots. Both an RS-232C serial interface and a Centronics-type parallel printer interface are standard equipment, along with an RS-422 interface; that will be a handy feature when some of the new (and less expensive) laser printers start appearing on the market. Not surprisingly, the Vectra-D also incorporates an HP-IB interface, useful for interfacing to other Hewlett-Packard equipment. And there's a socket on the main board for installing an 80287 numeric coprocessor.

The price for this kind of power and flexibility is a lot lower than I would have guessed. In a version that comes with one floppy disk drive and one 20-megabyte hard disk drive, and including the high-resolution monochrome monitor as standard equipment, the list price of the Vectra-D is about 1,300,000 yen. (In the past, I've always converted amounts in yen to

(continued)

Inquiry 415

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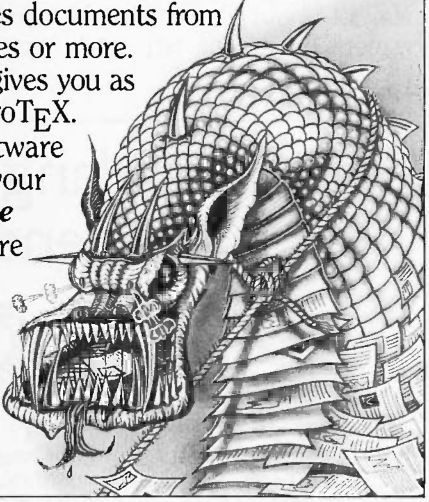

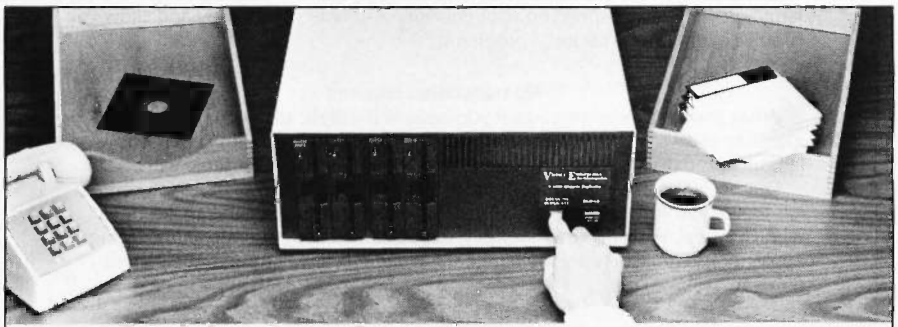

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their dollar equivalents. But exchange rates have fluctuated so much in recent months that I feel it will be more useful from now on to give the yen amount directly and to mention the dollar/yen exchange rate only when appropriate.) At today's dollar/yen exchange rate of about 170 yen to the dollar, the Vectra-D carries a price tag of about $7650. That's a pretty steep price, but not really much higher than the NEC PC-98XA, for example, which is not compatible with the PC AT.

YHP sees a market for the Vectra-D primarily in companies that want to have access to the world of PC AT software and hardware, including CAD/CAM applications, and yet still provide Japanese-language capabilities within a fully compatible framework—all on a single computer. I agree, and if YHP's distribution system is up to the challenge, I see a bright future for the Vectra-D. YHP said that it hadn't considered marketing the Vectra-D outside of Japan, but I think it would find a lucrative, if small, market in American universities.

YAMAHA'S PIANO PLAYER

Would you believe an upright piano with a 3½-inch microfloppy disk drive and an LED display? The people at Yamaha, who make MSX computers and musical instruments, have managed to reinvent the *old-fashioned* player piano, and they put in a few new twists while they were at it. For about 930,000 yen (less than $5500 today), you can buy a piano that will store on a microfloppy disk what you play and at the touch of a button play it again. But simply using a magnetic disk to replace the old-fashioned perforated paper rolls isn't all that the new Piano Player does (that's the name Yamaha has given this gadget). Yamaha has combined modern sensor and servo technology with a high-quality conventional piano. Unfortunately, Yamaha was not very communicative about the details of the sensor and servo techniques they use. But I can verify that this intriguing instrument can accurately reproduce the dynamics, nuances, and phrasing of the original performance, besides simply playing the notes. It's so good that it's eerie.

Yamaha plans to offer a floppy disk library of prerecorded performances to address the home entertainment market, although only a handful of titles are now available. But they'll probably sell a good number of Piano Players to professional musicians. After seeing and being impressed by the Piano Player, one prominent oboe player said, "Imagine how helpful it would be for my accompanist to record one of our rehearsal sessions on disk. After he left, I could continue to practice!"

NEXT MONTH

Bill covers the Computex Show in Taiwan and finds surprising prices with a focus on IBM compatibility. The show yields more unexpected happenings, too. ■

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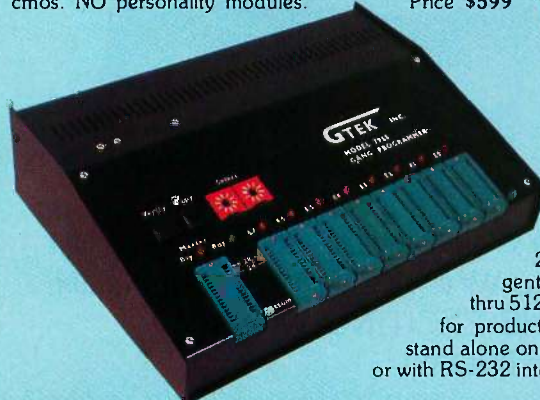

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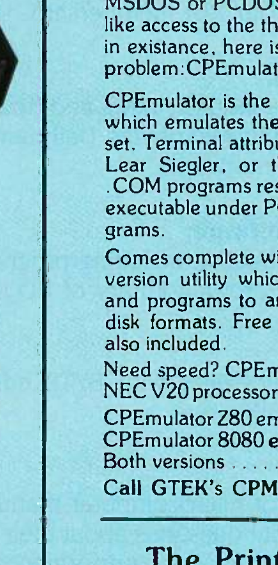

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TURBOCHARGING MANDELBROT

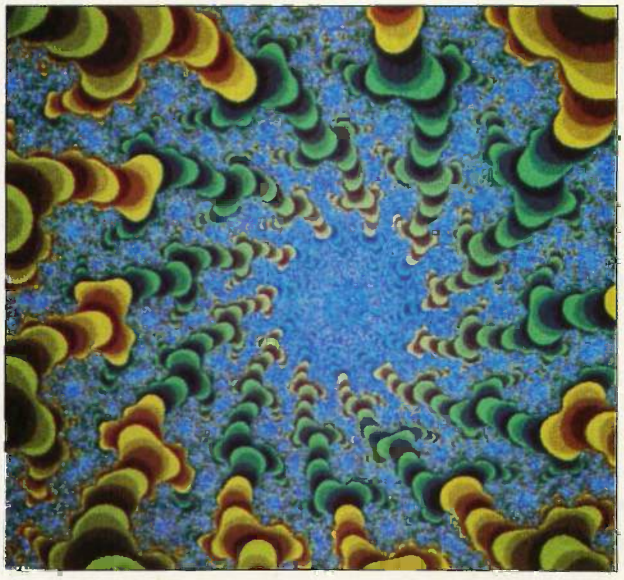
BY DICK POUNTAIN

An Occam technique to boost performance in parallel computing systems

In July's column I gave an update on the Inmos Transputer and also touched briefly on the topic of dynamic load balancing, a programming technique that can be used to optimize performance in parallel computing systems. Because the topic deserves more space than I could give it, this month I'll dig a little deeper.

As you'll recall, one issue when dealing with parallel computing systems is to achieve a correct balance between communication time and computation time. With dynamic load balancing, an Occam program can redirect the flow of data at run time to keep the processors as busy as possible and help achieve that balance.

To illustrate this technique, I'll look at a graphics demonstration program written in Occam by Phil Atkin of Inmos's Demonstration Software Group. The program draws views of the Mandelbrot set (see photo), a gorgeous mathematical object that wins hands down the title "Fashionable Demo Program of the Year" and makes rotating three-dimensional cubes look passé.



I won't go into the full mathematics of the Mandelbrot set here. (Anyone who has been on a desert island and wants to refresh their knowledge thoroughly should see A. K. Dewdney's "Computer Recreations" column in the August 1985 *Scientific American*.) Essentially, the Mandelbrot set is generated by iterating a simple function on the points of the complex plane. The points that produce a cycle (the same value over and again) fall in the set, whereas the points that diverge (give ever-growing values) lie outside it. When plotted on a computer screen in many colors (different colors for different rates of divergence), the points outside the set can produce pictures of great beauty. The boundary of the set is a fractal curve of infinite complexity (see "Fractals" by Peter R. Sørensen in the September 1984 BYTE), any portion of which can be blown up to reveal ever more astounding detail, including miniature replicas of the whole set itself.

The reason for the sudden popularity of a Mandelbrot program as a demo is that it's hugely computation-intensive but produces a pretty picture that even mathephobes can appreciate—there aren't too many programs like that around. The program requires hundreds of floating-point multiplications to calculate each individual pixel and is thus a stern test of any processor. Mandelbrot is a stern test even for a parallel computer because we can't predict how long the calculation of any given point will take; the individual processors will be kept busy for truly random periods, which makes simpleminded schemes for sharing out the work load grossly inefficient.

My own program in Turbo Pascal for the IBM PC takes 4 to 8 hours to draw one Mandlebrot screen in four colors (without the benefit of an 8087); a VAX-11/780 takes about an hour. Phil Atkin's program was designed to use several Transputers to draw Mandelbrot sets interactively; you can select an area with the mouse and have it blown up while you wait, typically in 20 to 60 seconds. I describe the program here not because the world is crying out for faster Mandelbrot sets, but because it illustrates nicely the technique of dynamic load balancing.

THE MANDELBROT PROGRAM

The program is structured in three main sections: the system controller, the pixel evaluator, and the graphics engine. The system controller takes the *x,y* coordinates of slices of the video display screen and feeds them to the pixel evaluator; the screen is written concurrently in horizontal slices. The pixel evaluator performs

(continued)

Dick Pountain is a technical author and software consultant living in London, England. He can be contacted c/o BYTE, *One Phoenix Mill Lane, Peterborough,* NH 03458.

Listing 1: *The outline program in Occam.*

```
CHAN feedSystem, feedGraphics:   -- channels for
                                 -- communication
                                 -- between the
                                 -- processes
PAR
  systemController( feedSystem)
  pixelEvaluator( feedSystem, feedGraphics)
  graphicsEngine( feedGraphics)
```

Listing 2: PLACED PAR *lets the three processes be run on three different processors.*

```
CHAN feedSystem, feedGraphics:   -- channels for
                                 -- communication
                                 -- between the
                                 -- processes
PLACED PAR
  PROCESSOR 0
    PLACE feedSystem AT link0out:
    systemController( feedSystem)

  PROCESSOR 1
    PLACE feedSystem AT link0in, feedGraphics AT link0out:
    pixelEvaluator( feedSystem, feedGraphics)

  PROCESSOR 2
    PLACE feedGraphics AT link0in:
    graphicsEngine( feedGraphics)
```

Listing 3: *How to map a program onto a pipeline of Transputers.*

```
VAL lineSize IS 9:                -- a constant

[lineSize+1]CHAN pipeline:        -- channels for communication

PLACED PAR
  PROCESSOR 0
    PLACE pipeline[0] AT link0out:
    systemController( pipeline[0])

PLACED PAR i = 1 FOR lineSize
  PROCESSOR i
    PLACE pipeline[i-1] AT link0in, pipeline[i] AT link1out:
    pixelEvaluator( pipeline[i], pipeline[i+1])

  PROCESSOR lineSize+2
    PLACE pipeline[lineSize] AT link0in:
    graphicsEngine( pipeline[lineSize])
```

the dirty work of computing the points in the Mandelbrot set, and here is where the dynamic load balancing takes place. The pixel evaluator is, in fact, distributed over an array of processors (10 Inmos B001 Evaluation Cards, each containing one Transputer and 64K bytes of RAM) and works as a pipeline. Finally, the graphics engine (running on an Inmos B00G1E Graphics Card) plots the points on each slice of the screen in 256 colors at an overall screen resolution of 256 by 256 pixels. The outline program in Occam is shown in listing 1.

This program merely says the three processes are to run in parallel and communicate results to each other over the two channels, and it could be run on a single Transputer using pseudoconcurrency. The three processes can, however, be run on three different processors by using PLACED PAR (see listing 2), which specifies where each is to be run.

PLACE. . .AT maps the logical channel names onto the physical Transputer serial links called *link0in* and link0out. A program might be mapped onto a pipeline of Transputers as shown in listing 3. An array of channels called pipeline replaces the previous two channels, and the replicator (PLACED PAR i = 1 . . .), which works like a FOR. . .NEXT loop, attaches them to an array of parallel processes that forms the pipeline. This illustrates Occam's use as a hardware-configuration language; if you want to add more Transputers to the system, the only change required in the program is to alter the value of the constant lineSize. A simplified diagram of the 11-processor system is shown in figure 1.

The actual Mandelbrot demo program uses a slightly more complex configuration, in which the pipeline becomes a two-way affair with data flowing in both directions (see figure 2). This means that both raw and processed data flow through the system controller, with the advantage that the system controller can now monitor the output of the system, which is essential for dynamic load balancing. In the actual program, the pixel evaluator needs four channel param-

(continued)

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Inquiry 52

The pixel evaluator contains three parallel processes.

eters to reflect this two-way data of flow.

THROUGHROUTING

The most interesting of the three main sections is the pixel evaluator, which does all the hard work and contains three parallel processes itself. One is the actual number-crunching process, genPixels, and the other two are *throughrouters*. A throughrouter is a process that merely takes input data and passes it to its outputs unchanged. However, a throughrouter can make an intelligent decision about where to send the outputs. The pixelEvaluator process contains one throughrouter for raw screen slices and another for evaluated pixels.

The pixel throughrouter is quite dumb and merely permits finished results to be passed hand to hand along the pipeline to the system controller without being worked on by the processors they pass through. The screen-slice throughrouter is the smart one and actually performs load balancing. The algorithm it uses is very simple, although the conventional (i.e., sequential) pseudocode shown in listing 4 cannot capture the concurrency that's the essence of the algorithm. This algorithm guarantees that all the processors in the line are kept as busy as possible, yet it need not specify exactly which processor will evaluate any particular screen slice.

The systemController process first fills up the pipeline with as many screen slices as it can hold and thereafter supplies a new slice only when it gets an evaluated slice back, indicating that a processor in the line has free capacity. The controller doesn't know (or care) which one got the slice.

To minimize any latency in the system due to the finite time required to communicate results back to the controller, each component process of the pixelEvaluator pipeline actually stores an extra screen slice in addition to the one currently being worked on. This means that the number cruncher can be fed as soon as it finishes a slice, without waiting for the previous result to traverse the pipeline. The number of slices buffered in this fashion is a parameter that the programmer can play with to fine-tune the system.

In Occam, pixelEvaluator at its outermost level looks like listing 5. The channels feedPixels, pixelTrigger, and pixelsOut are local to the process and shunt data and messages between its components. PRI PAR creates prioritized parallel processes; the first process that follows it has priority over the next, and so on. Low-priority processes can only proceed when higher-priority ones are waiting to communicate. In this case, the effect is to give the WHILE TRUE loop high priority (SKIP is a do-nothing process).

The pixelBypass process is the throughrouter for processed slices on their way back to the graphics engine. This process passes back data to the previous processor in the line, mixing the data neatly into the stream coming from processors that are further down the line (see figure 3). In Occam, this process reads as is shown in listing 6.

(continued)

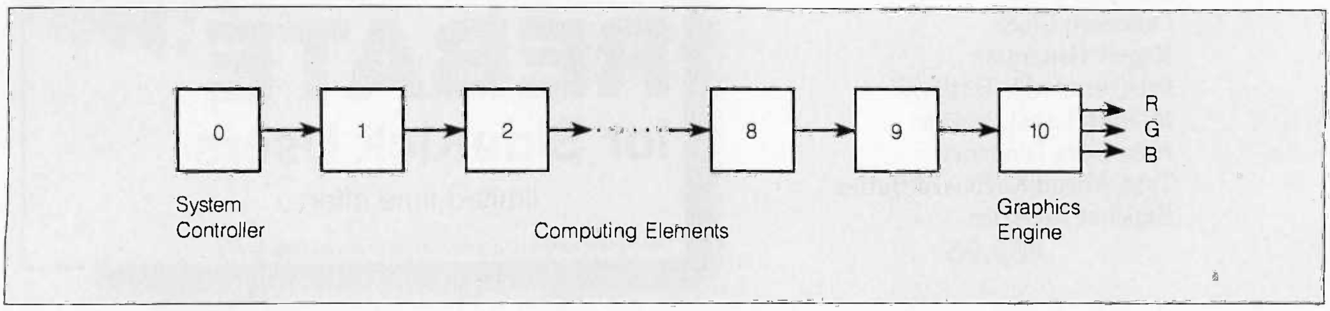

Figure 1: *A simplified diagram of the 11-processor system.*

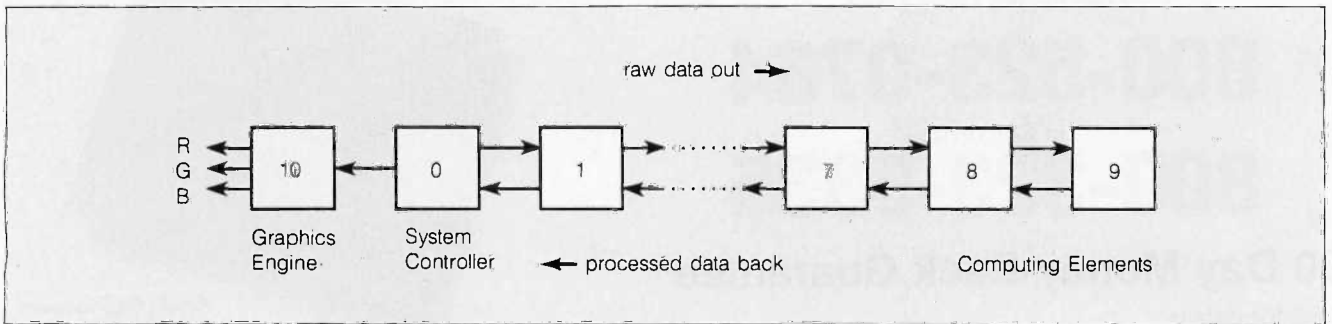

Figure 2: *Actual hardware configuration used for the Mandelbrot demo.*

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The second part of pixelEvaluator, the smart thruPut process, watches both the stream of raw data and the genPixel process and also maintains a buffer for the extra screen slice. The genPixel process lets thruPut know it has finished evaluating a slice by sending a signal on the channel pixelTrigger. In Occam, a simplified account of thruPut's action is shown in listing 7. In the actual demo program, a simple message protocol permits the contents of command to be used to control the process (including stopping it, for which no provision is made in listing 7). The demo program also includes a detailed buffering mechanism.

But the main point of interest is the PRI ALT construct, which is how thruPut monitors two channels at once. In an ordinary ALT, whichever channel—pixelTrigger or fromPrev—is ready first gets to input into command (? command signifies an input process), assuming that the relevant flag—thruputActive or pixelsActive—is TRUE. In a PRI ALT the same thing happens. However, in the event of a dead heat between the channels, pixelTrigger has higher priority and wins the coconut. Diagrammatically, the processes fit together as shown in figure 4.

Listing 4: *Pseudocode for the load-balancing algorithm.*

```
input a slice of screen
IF   my genPixels is busy
THEN pass the slice on unchanged to the next processor in
   the line
ELSE send the slice to my genPixels
pass evaluated pixels on to pixel throughrouter
```

Listing 5: *The* pixelEvaluator *process at its outermost level.*

```
PROC pixelEvaluator( CHAN fromPrev, toPrev, fromNext, toNext)
  CHAN  feedPixels, pixelTrigger, pixelsOut:
  PRI PAR
    WHILE TRUE
      PAR
        pixelBypass( toPrev, fromNext, pixelsOut)
        thruPut( fromPrev, toNext, feedPixels, pixelTrigger)
        genPixels( feedPixels, pixelsOut, pixelTrigger)
    SKIP
```

THE NUMBER CRUNCHER

The final component of the pixel evaluator, genPixels, is quite straightforward. It contains a number-crunching process called mandelbrotPixel, which looks pretty much like a Mandelbrot program would look in Pascal (see listing 8).

Anyone who has written a Mandelbrot program will note that the only trick used here is to test the square of the modulus against four to save a square-root calculation. The processes complexMultiply and so on do exactly what their names suggest; they're written using Occam floating-point library routines (Occam can support both 32- and 64-bit reals, to the ANSI/IEEE standard 754). The three dots in . . . PROC represent what you would actually see in the Occam editor when the bodies of the PROCs are folded away, ThinkTank style.

The line beginning with [complex]REAL32 demonstrates Occam's way of defining arrays; in this case, the arrays contain two 32-bit reals to represent complex numbers. Occam 2 provides record types in addition to

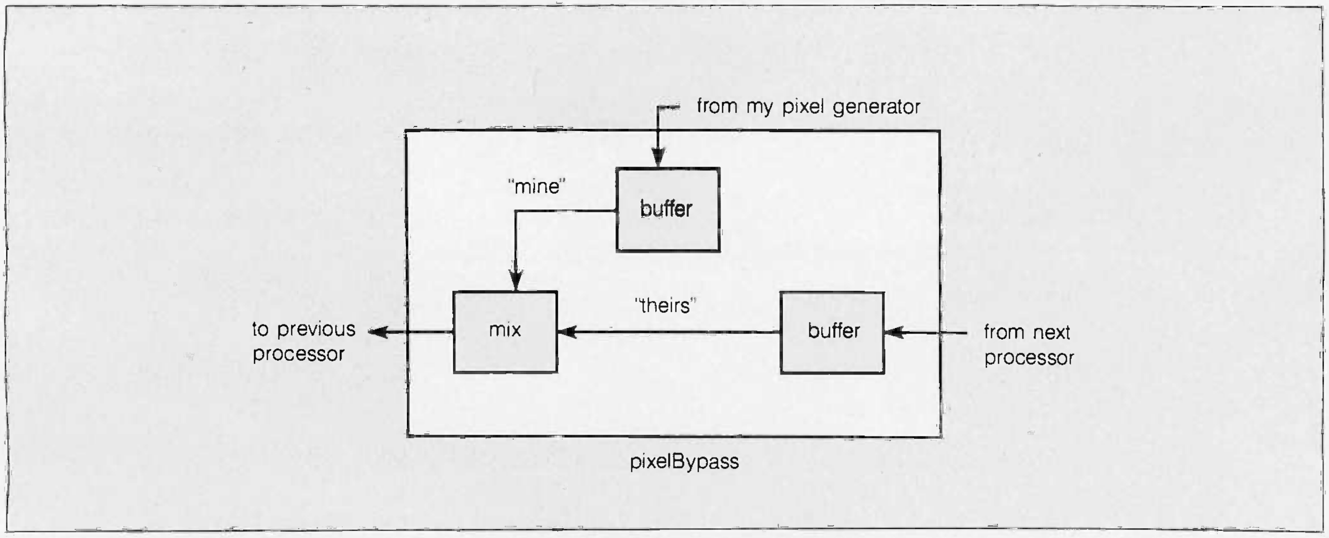


Figure 3: *The* pixelBypass *process.*

arrays, but at present they can only be used in communications over channels, as a convenient way to input or output complicated objects.

LOAD BALANCING

A most interesting aspect of the genPixel process is that it contains a PRI PAR that does the exact reverse of the one we saw earlier; that is, it sets the Mandelbrot calculating process to lowest priority:

```
PRI PAR
  SKIP
  ....
    mandelbrotPixel( etc. . . .)
```

This should surprise you: In a hugely computation-intensive program, we are giving lowest priority to the computational part! The point is that in a parallel computer, computational power is a variable; you can add more processors to get more power. (The speed of this program is, in fact, directly proportional to the number of processors that are employed; doubling the number of processors halves the time it takes to generate a Mandelbrot.)

Keeping all those processors busy (i.e., load balancing) becomes the crux of the problem. In this program, communication must take precedence over computation; if we impede the flow of throughrouted data, the latency time increases and the perfor-

(continued)

Listing 6: *The* pixelBypass *process.*

```
PROC pixelBypass( toPrev, fromNext, fromMe)
  CHAN mine, theirs:
  PAR
    buffer( fromNext, theirs)
    buffer( fromMe, mine)
    mix( mine, theirs, toPrev)
:
```

Listing 7: A *simplified account of* thruPut's *action.*

```
PROC thruPut( CHAN fromPrev, toNext, feedPixels, pixelTrigger)
INT command:
BOOL thruputActive, pixelsActive:
SEQ
  pixelsActive := FALSE
  thruputActive := TRUE
  WHILE thruputActive OR pixelsActive
    PRI ALT
      pixelsActive & pixelTrigger ? command   -- genPixels
                                              -- needs feeding
        IF
          bufferEmpty
            pixelsActive := FALSE             -- genPixels
                                              -- is idle
          TRUE
            ... send buffer contents to genPixels
      thruputActive & fromPrev ? command      -- a new slice
                                              -- has arrived
        IF
          NOT pixelsActive
            ... send new slice to genPixels and set
                pixelsActive to TRUE
          bufferFull
            ... we can't help, pass new slice on toNext
          TRUE
            ... put new slice in buffer
:
```

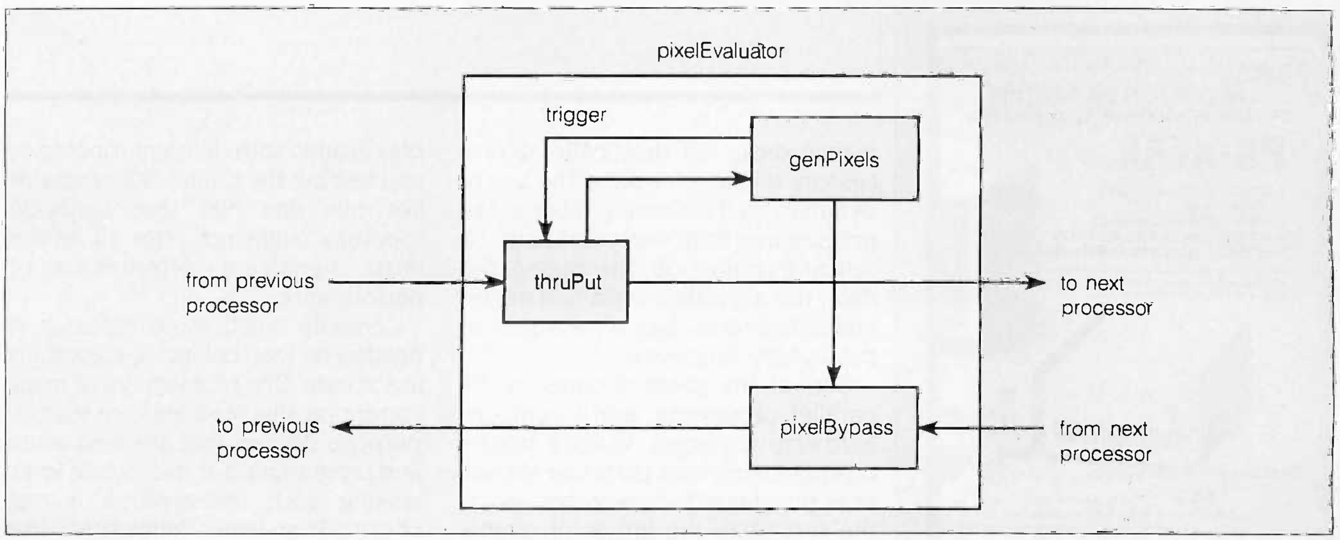


Figure 4: *The* pixelEvaluator *process.*

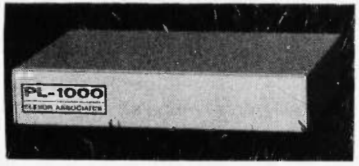
Listing 8: *The* mandelbrotPixel *process.*

```
PROC mandelbrotPixel( INT color, VAL INT x, y)
  VAL complex  IS 2:                       -- a complex number has
                                           -- two parts
  VAL real     IS 0:                       -- ... the real
  VAL imag     IS 1:                       -- ... and the imaginary

  ... PROC complexMultiply( [complex]REAL32 result, a, b)
  ... PROC complexAdd( [complex]REAL32 result, a, b)
  ... PROC modulusSquared( REAL32 size, [complex]REAL32
      number)

  [complex]REAL32 z, c, zsquared:          -- declare some complex
                                           -- variables

  VAL zero IS 0.0 (REAL32):                -- zero as a REAL32
                                           -- constant
  VAL four IS 4.0 (REAL32):                -- ditto four
  VAL maximum IS 256:                      -- maximum iterations
                                           -- for divergence

  INT iterations, size
  SEQ
    z[real] := zero                        -- set z to 0+0i
    z[imag] := zero
    c[real] := x                           -- c is the current
                                           -- point
    c[real] := y
    iterations := 1
    complexAdd( z, z, c)
    modulusSquared( size, z)
    WHILE (iterations < maximum) AND (size <= four)
      SEQ
        complexMultiply( zSquared, z, z)
        complexAdd(z, zSquared, c )             -- z^2 + c is the
                                                -- function
        modulusSquared( size, z)
        iterations := iterations+1
    IF size <= four                        -- point in set; color
                                           -- it black
         color := black
       size > four                         -- point out of set;
                                           -- color it
         color := iterations
:
```

mance drops off drastically as processors wait idly for data. The use of dynamic load balancing relieves the programmer from worrying about the synchronization of distributing the data; the algorithm explained earlier guarantees that data always gets to the hungry processor.

One of the great debates in the parallel processing world concerns hardware topology. Various parties champion their own particular shapes, from doughnuts to hypercubes and all the rest. With the arrival of off-the-shelf computing elements like the Transputer, it's becoming easier to play around with different topologies and test out the claims. But programs like this one hint that hardware topology might not after all be the most significant determinant of performance.

Certainly much more research is needed on load-balancing algorithms in software. One problem is that many current parallel machines are special-purpose devices that are hard-wired and programmed at microcode level, making such investigation a real chore. High-level languages like Occam can take the sting out of it to a remarkable extent. ■



SING YE MACPRAISES

BY EZRA SHAPIRO

Mac software: the spectacular More and the solid FullPaint

There's no room on my desk for a Macintosh mouse; a friend has suggested an all-terrain model equipped with giant ribbed tires as the only way to negotiate through the mounds of junk I collect. I don't like the dull, echoing thunk of the Macintosh keyboard; it makes me worry about rousing some angry subterranean being miles beneath the surface of the earth's crust. And I have about as much use for a machine that boots up with a cutesy, happy-face computer icon as I have for an automobile horn that plays "The Yellow Rose of Texas." But die-hard MacSkeptic that I am, I'm being won over by the software.

Apple promised us a blizzard of business programs when it introduced the machine. It never materialized; all we got were scattered flurries. Those of us—including a bunch of folks at Apple—who believed that the only way to guarantee good software was to have lots of it were disappointed. In the mad quest for quantity, nobody mentioned quality.

But that's exactly what we've been getting of late. I haven't seen zillions of Mac programs, but what's been coming in has been first-rate. In almost every application category, I can pick at least one Mac product that runs rings around its MS-DOS competitors. Programmers are figuring out the uneasy balance between friendliness and power, they're mastering the good points—and sidestepping the bad ones—of the Mac ROM, and they're producing excellent software.

If this keeps up, when it comes time for me to pick my next-generation machine, it may well be a Macintosh.

NEW HORIZONS IN OUTLINING

I'm not sure whether More (Living Videotext, $295) is an outline processor or an operating system. The product is an extension of the basic concepts of the original ThinkTank (which started life as an Apple II program before migrating to the IBM PC and the Macintosh), but it packs so many features and self-contained applications that I could see using it to cover the bulk of my regular tasks. In that sense, More is a lot like Framework, although it's far stronger as an outliner and not as well suited to traditional database management and number crunching. Whatever you do call it, though, More is definitely one spectacular piece of software.

If you're familiar with ThinkTank or Ready! under MS-DOS or ThinkTank 512 on the Mac, you've got a good idea of where the program begins. You organize data as an indented outline; any line can be treated as the root of a tree, with subordinate headings and subheadings branching off beneath it. Blocks of flat text or MacPaint drawings can be attached to any heading. By clicking the mouse on a heading and collapsing or expanding the outline, you choose how much detail you want to view at the moment. Reorganization is also a simple mouse operation; select a heading, move the cursor to the new location, hit a command, and the heading with all its subsidiary data is transported to the new spot. So much for the refresher course; if you want the heavy-duty theory, check out my blatherings a couple of years back ("Text Databases" in the October 1984 BYTE).

A number of the enhancements that differentiate More from ThinkTank 512 have been lifted from Living Videotext's MS-DOS offerings. These include hoisting (temporarily bringing a section of your outline to full screen for close work), cloning (creating a duplicate of a heading that changes as the original is altered), and mark and gather (selecting a group of headings from different places and pulling them into a new section). The instant recall of outline templates, one of the best ideas in Ready!, has been implemented in true Mac fashion; instead of assigning four outline chunks to function keys, you can install 16 templates (32 with the 1-megabyte Mac Plus) on a pull-down menu. Sample templates for things like address book entries, personal records, daily appointment calendars, and suchlike are included with the program. Ready!'s point-and-dial, which lets you select a phone number for a voice call and have your modem dial it for you, has also been implemented. (I find this a singularly useless feature, but I assume there must be *someone* out there demanding it.)

More can handle six outline windows at a time, which can be tiled vertically, horizontally, diagonally, or arranged as you see fit. ThinkTank 512's hot borders, which scrolled your text away from a window's edge if you clicked the mouse anywhere on the border, have been replaced with standard Mac scroll bars.

Now we get to the fun stuff: More has moved outlining into presentation graphics. You can now display an outline as either a bullet chart or a tree

(continued)

Ezra Shapiro is a consulting editor for BYTE. *Contact him at* P.O. Box 170040, *San Francisco,* CA 94117-0040.

chart. Anyone who has had to prepare transparencies for overhead projection or who has been forced to generate graphics for reports will love this.

You construct bullet charts by selecting an outline; the first heading becomes the title, and subordinate heads become bulleted points underneath it. The whole process can be nearly automatic—any head with subheads becomes a chart. On the Mac screen, choosing the bullet-chart option whisks you from your outline to a display of the chart as it will appear. A palette pops up from which you can select type fonts, sizes, spacing, borders, numbering styles, and so on.

Tree charts are just as simple, only the outline becomes a series of little boxes or circles connected with lines. Another palette lives along the left border; you can choose centered or flush text, line styles, orientation (top to bottom, bottom to top, left to right, right to left), drop shadows, and other options. As tree charts can easily extend over several pages, the charts appear on a grid showing position on a printed page, but the grid can be turned off.

All this stuff can be dumped to a printer (in fact, if you've got a color Imagewriter, you can choose different colors for each level of an outline) or saved in one of several file formats for use by page-makeup or drawing programs. If you'd like to use your Mac as a presentation tool, you can set up a slide show mixing outlines, text documents, bullet charts, tree charts, MacPaint drawings, MacDraw charts, and so on. The show can be orchestrated to bring up screens at timed intervals, or you can control it in a way analogous to controlling a slide projector, clicking the mouse to change screens. If it's a working meeting rather than a formal presentation, you can edit and reorganize the material as you proceed.

The last of the high points I want to touch is computation; you can calculate simple columnar arithmetic within an outline. Let's say you want to record a day's expenses; you'd enter each expense item as a subheading, and the grand total would appear in the title line.

Other reactions. The document editor is as good at text handling as any Mac word processor; I could be quite happy using it as my primary editor. Search functions are slick and well executed, as is output formatting. And while I'm not usually a fan of Mr. Mouse, he's well suited to trundling around an outline, and More provides a complete enough selection of keyboard commands to keep the mouse interruptions to a minimum.

I do have a brief wish list. I'd like to see more on-screen help; this is a big program that can be confusing. Some form of macro facility would be an improvement, and a nice long list of numeric functions (for those of us who are always calculating arctangents and net present value) would broaden the scope of the product.

I'm really sold on the package, but my testing has been done with beta versions 0.46 and 0.47 and a looseleaf draft of the manual, so I can't vouch for flawless performance. Some of More's functions were not quite finished (point-and-dial would point-and-dial me into a system crash), but the bulk of the program was running, and I didn't spot any bugs that Living Videotext hadn't warned me about. The company's other products have all been pretty thoroughly debugged by the time they've appeared on the shelves, and I'm assuming this one won't be an exception.

Conclusions? This is superb software. An owner of ThinkTank 512 might want to think carefully and look at the list of new features before upgrading, but for everyone else, this is exciting news.

BEYOND MACPAINT

MacPaint was the razzle-dazzle part of the original Macintosh package; it was the program that caused heads to turn and eyes to pop, the perfect showpiece you'd use to answer the question, "What does the Mac do that's so special?" It was something more than a game, but something less than a serious artist's tool. As software, it started the juices flowing, whetted the appetite for computer graphics, and made you wonder what was next.

The world has changed since then. The Mac environment is accepted; it no longer needs to be demonstrated to a disbelieving public. And Apple has stopped bundling MacPaint software with its new machines.

These days, you either have to cadge an illegal copy of MacPaint from a friend or buy it from Apple for 125 bucks (which seems a bit steep for what used to be a freebie). Or you can purchase **FullPaint** (Ann Arbor Softworks, $99.95), a program that takes the MacPaint concept to the next generation.

FullPaint looks a lot like MacPaint; in fact, it's so close that only an experienced MacPaint user could tell the difference at first glance. The initial layout and the pull-down menus are almost identical to the original; making the transition from MacPaint to FullPaint is a snap. All the familiar functions have been preserved. You can draw freehand lines or construct hollow shapes in the same variety of line styles, using the same mouse commands and keyboard shortcuts. You can fill screen areas with the same 38 patterns. You can stretch, trace, rotate, invert, and reposition objects; edit patterns and drawings pixel by pixel (what MacPaint calls "FatBits"); and add text in an assortment of type fonts and sizes. FullPaint uses the MacPaint file format, so you can transfer FullPaint artwork to other programs with ease.

However, scratch the surface and FullPaint turns out to be loaded with significant enhancements. Some of them are simply convenience features sorely lacking in MacPaint, but others give you new flexibility and power.

Freed from the tyranny of the original Macintosh's 128K-byte limit, FullPaint lets you edit up to four paintings at once. The four windows can be shown singly, overlaid along a diagonal, or tiled into four postage-stamp boxes. Each painting now is bordered with standard Macintosh scroll bars, so you can slide around a page without having to crank away with the mouse.

You're no longer locked into the MacPaint screen layout. You can zoom a painting to full screen, even eliminating the command line at the top of the display. The two palettes of tools can be dragged wherever you want them. Tapping the space bar hides them entirely; tapping it again brings them back. Once you've chosen a drawing tool, you can work on your painting without all the visual distractions of MacPaint.

Then you've got a number of new ways to manipulate images: free rotation to any angle, rather than MacPaint's 90-degree flips; Perspective, which lets you shrink or stretch one edge of an object; Skew, which allows you to move one edge (thereby turning a rectangle into a parallelogram, for example); Distort, which lets you pull out one corner of an image or push it in.

Text in a dark region can be entered as white on black. MacPaint is capable only of black on white.

But my favorite improvements are those that add precision controls to the MacPaint shell. First, you can display ruler lines (marked in your choice of inches, picas, centimeters, or pixels) along the top and left edges of any painting. Next, by selecting an option called MouseSpot, you can bring up a small status box that tells you exact cursor position as *x* and *y* coordinates measured in hundredths of units (excepting pixels, where fractions don't make sense) from the upper left corner of the page. Changing the units used in MouseSpot changes the ruler lines and vice versa. MouseSpot also shows the size of the object you're currently constructing, on both axes and along the diagonal. You can slow down the mouse to pixel-by-pixel motion by using FullPaint's MouseCrawl feature. The combination of ruler lines, MouseSpot, and MouseCrawl gives you pinpoint accuracy impossible with MacPaint.

ITEMS DISCUSSED

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My only real gripe is with the continuation of a major MacPaint annoyance: the invisible grid. You can turn on this feature, which locates objects along lines eight pixels apart, but you can't see the grid. Other graphics programs provide some form of visual reference; this is not the case with MacPaint or FullPaint. The grid is great for aligning text, but without MouseSpot you're practically running blind. I find this particularly frustrating because I see the grid as an important area for future development. Imagine being able to select single or multiple vanishing points, position a horizon line, turn on a grid, and construct drawings in *true* perspective! I guess I'll just have to wait for the next release.

The program seems to be solid—as well it should, considering how much of its design is borrowed from MacPaint. I was able to crash it only once, after a long series of distortions, and although I tried mightily, I couldn't do it again. The crash, which merely garbaged up one file without bringing down either the system or the software, easily could have been the result of using an older version of the Mac operating system—or phases of the moon; I don't know. Overall, I was pleased with FullPaint's performance.

The documentation is complete and usually comprehensible, in spite of a tendency to use MacSpeak (the jargon of FatBits, scroll bars, double-clicking, and such). The manual even has an index, so I forgive the authors the constant use of "it's" whenever they should have used "its."

Should you buy the product? Well, if you purchase a new, unbundled Macintosh, you'd be foolish not to get FullPaint instead of MacPaint. Not only is FullPaint a richer, more useful program, it's cheaper.

If you already own MacPaint, you ought to spend some time assessing your needs before plunking down a hundred dollars for FullPaint. Do you see MacPaint as merely an entertainment package—cute, but frivolous? On the other hand, do you need the power of full-blown professional CAD software? In either case, FullPaint is off the mark. But if you presently use MacPaint drawings in your work, or just spend a lot of time relaxing with the program, switching to FullPaint will give you capabilities you'll wish you'd had all along. ■

(continued from page 26)

tory entries do not change position) should survive sorting using his program.

Thanks for the continuing coverage of Apple topics.

Dennis Doms
Kansas City, MO

Mr. Doms is absolutely correct. The program does not update the parent pointer field found in a subdirectory's header entry.

To fix the oversight, one should modify line 380 of listing 1 (page 124) to include a GOSUB *subroutine call as shown below:*

```
380 IF A <= C0 THEN
        FOR K=1 TO 39: POKE
        DB+3+B×39+K,ASC(MID$
        (NA$(A),K,1)): NEXT: PRINT ".";:
        GOSUB 500: GOTO 400
```

Then append to the listing the following lines of code:

```
500 REM   THIS CODE IS ADDED TO
          UPDATE THE PARENT
          POINTER
510 REM   FIELD OF A
          SUBDIRECTORY
520 REM   AT THIS POINT, DL(J) CON-
          TAINS THE BLOCK NUM-
          BER OF THE ENTRY DEFIN-
          ING THIS SUBDIRECTORY.
530 REM   THE EXPRESSION (B+1) IS
          THE DIRECTORY ENTRY
          NUMBER WITHIN THE
          BLOCK SPECIFIED BY
          DL(J).
540 IF ASC(MID$(NA$(A),17,1)) <> 15
    THEN RETURN
550 POKE 791, ASC(MID$(NA$(A), 18,
    1)):
    POKE 792, ASC(MID$(NA$(A), 19,
    1)):
    XX = PEEK(791) +
    256×PEEK(792):
    REM XX = BLOCK NUMBER OF
           THE SUBDIRECTORIES
           KEY BLOCK
560 POKE 789, 0: POKE 790, PEEK(790)
     + 2:
    REM   ALLOW READING OF THE
          KEY BLOCK INTO $9800,
          AN AUXILIARY I/O BUFFER
570 POKE 776,128: CALL 768: IF
    PEEK(786) <> 0 THEN PRINT
    "ERROR IN READING BLOCK NO.
    ";XX: STOP
580 REM   NOW UPDATE THE PARENT
          POINTER AND WRITE IT
          BACK TO DISK
590 YY = PEEK(789) + 256 ×
    PEEK(790):
    REM   YY = ADDRESS OF THE
          AUXILIARY I/O BUFFER
600 POKE YY + 4 + 35, DL(J) -
    256×INT(DL(J)/256):
    POKE YY + 4 + 36, INT(DL(J)/256):
    POKE YY + 4 + 37, B + 1
610 POKE 776, 129: CALL 768: IF
    PEEK(786) <> 0 THEN PRINT
    "ERROR IN WRITING BLOCK NO.
    ";XX: STOP
620 POKE 789, 0: POKE 790, PEEK(790)
    - 2:
    REM   SET THE I/O BUFFER AD-
          DRESS TO THE ORIGINAL
          BUFFER
630 RETURN
```

Antonio C. Silvestri
Springfield, MA

MAKING RS-232C CONNECTIONS UNIVERSAL

Howard Mark (March Letters, page 30) misunderstood the operation of "hermaphroditic" connectors when he wrote that Pete Klammer's scheme for simplifying the RS-232C tangle (October 1985 Letters, page 22) would not work. He assumed that when two such connectors were mated, pin 1 would contact socket 1, etc. But that is only one way of constructing hermaphroditic connectors.

Suppose instead that a connector has, say, five male pins, numbered 1 to 5, and five female sockets, numbered 11 to 15. When two connectors are mated, pin 1 mates with socket 11, and so on. This allows a completely symmetrical scheme:

Connector A

Safety Ground	Pin 1 -->
Data-out-from-me	Pin 2 -->
I-am-not-busy	Pin 3 -->
I-am-ready	Pin 4 -->
Signal Ground	Pin 5 -->

Connector B

>-- Socket 11	Safety Ground
>-- Socket 12	Data-into-me
>-- Socket 13	Are-you-busy?
>-- Socket 14	Are-you-ready?
>-- Socket 15	Signal Ground

Connector A

Signal Ground	Socket 15 --<
Are-you-ready?	Socket 14 --<
Are-you-busy?	Socket 13 --<
Data-into-me	Socket 12 --<
Safety Ground	Socket 11 --<

Connector B

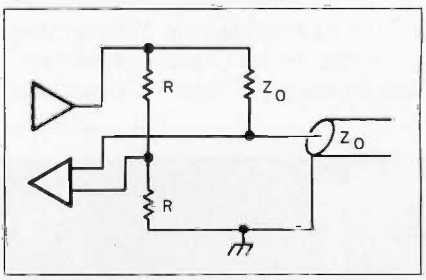
<-- Pin 5	Signal Ground
<-- Pin 4	I-am-ready
<-- Pin 3	I-am-not-busy
<-- Pin 2	Data-out-from-me
<-- Pin 1	Safety Ground

I have followed here the (no doubt sexist!) convention that signals go from male pins to female sockets. I have not used the RS-232C circuit names because those assume precisely the distinction between DCE and DTE that this scheme is intended to eliminate. However, the 3–13 connection would correspond to CTS or RTS, and the 4–14 connection to DSR or DTR.

The problem with RS-232C is that it was designed around the quite specific job of connecting a terminal or computer (DTE) to a modem (DCE). Borrowing it to use for serial connections in general has produced the present muddle. As I've shown above, it *is* possible to create a new standard so that any connector can plug into any other, and this is surely long overdue. So come on, connector manufacturers and standards organizations—it's over to you!

Robert Labourne
Palmerston North, New Zealand

I read with interest the letter about RS-232C connections in the October 1985 issue. I, too, have long been dissatisfied with RS-232C because of the amount of Brownian motion required in trying various combinations to get box A to talk to box B. Too often the makers of box A and box B simply use the phrase "RS-232C" without giving enough clues to allow the user to make the correct combination. If we make changes to the traditional method, I don't think we should stop with only changing the type of connectors used. I suggest taking each of the pairs that sometimes need to be crossed, and converting each pair to a single wire. Yes, you can send and receive asynchronous DC full-duplex signals on one wire. The basic connection is illustrated:



The differential receiver is relatively insensitive to the accompanying transmitter, while it is fully sensitive to signals coming from the cable. The circuit provides the added benefit of terminating the cable in its characteristic impedance at both ends. This method would allow you to connect any two of boxes A, B, or C using the same cable, and without making any jumper changes in any of the boxes. It would not matter if the boxes were computers, terminals, or modems. I don't think there is a need for hermaphroditic connectors; we could just as easily demand that all boxes have female connectors and all cables have male connectors. We could connect a terminal to a computer with a single coaxial cable and a small phone plug.

NEIL R. KOOZER
Oakland, OR

SPARKING INTEREST IN PERSONAL SUPERCOMPUTERS

Inmos is successfully programming their parallel computers in Occam, but I think the natural language/programming environment for a parallel computer is the electronic spreadsheet. Just have the system divide the spreadsheet into groups of cells and assign a processor to each group. The editing tools to create large spreadsheets already exist. There are also much more experienced users of spreadsheets than Occam programmers. And just think how big a spreadsheet could get before you'd have to defeat the "automatic recalculation"! The main extensions needed would be for nonnumeric input and graphics output.

JAMES R. VAN ZANDT
Nashua, NH

Especially enjoyed Dick Pountain's article on the Inmos Transputer (BYTE U.K.: "Personal Supercomputers," July). Since Sir Clive Sinclair is said to be working on a supercomputer using this chip, what can we expect in 1987 or 1988? If development reaches fruition on the 40-Mb wafer-scale disk, that could make quite a machine combo!

Since the Acorn RISC chips are now being sampled, I hope we can look forward to a BYTE PC board using them.

Pountain mentioned Occam. Are books available discussing this language?

CHUCK TRIER
Spokane, WA

JUKI PRINTER MAINTENANCE

I am writing about a maintenance problem on the Juki 6100. Recently my machine, which has run consistently for three years, began quitting in the middle of a printout. I hit Reset and it would go awhile longer and quit again. The problem worsened until I could only print a few lines before this "check" condition would arise.

Calling my local dealer wasn't too comforting. I was told it would cost $40 to $60 per hour just to have someone look at my machine. I had already upgraded the memory myself from 2K to 8K bytes without much difficulty, so I decided to take a look first.

Checking the user's manual, I learned that the "check" condition (the red LED lighting up) results from one of three conditions: when your printer is out of ribbon, out of paper, or when you have depressed the Pause switch. These are all considered "recoverable" errors.

The problem clearly wasn't related to Pause or paper, so it had to be a signal that the printer was out of ribbon. Of course, I already knew that I had ribbon in the printer, but the machine didn't seem to. I set out looking for a device that was telling the machine that there was no ribbon.

I took out the ribbon cartridge; nothing. I took out the black plastic platform that the ribbon cartridge sits on. Still nothing. Finally, I took out the black spool on the left that the new ribbon feeds from. I saw a little black sensor that was covered with black dust. The bottom of the spool was designed as a reflector for that sensor. It

(continued)

was set up with alternating black and silver spokes. The sensor is active when the silver passes over it but not when the black is present, I reasoned. If the spool didn't continue to get alternating signals, the printer could assume the spool wasn't turning and hence the ribbon had run out. I cleaned it and the bottom of the spool before reassembling. The dust was just carbon particles, but it was enough to cause a problem.

I have printed many perfect pages since then and I am still happy with my Juki. I hope that some of your readers can save money and frustration with this knowledge.

MARC J. VERBER

CORRECTIONS ON RUNGE-KUTTA METHOD

I would like to point out three errors that appeared in "The Runge-Kutta Methods" (April). In table 6, Benku Thomas presents the constants for the Runge-Kutta-Verner seventh-order method. Three of them are incorrect. B(11,4) was −20325/5225, but should read −20032/5225; B(11,6) was −42509/7125, but should read −42599/7125, and B(12,7) was −71681/1166400, but should read −71687/1166400.

These corrections were taken from Thomas's reference 5 at the end of the article. Using these new parameters, this method gives excellent results. For example, solving $dy/dx = y$ with solution $y = e^{15} = 3269017.372460315$. Comparing this to the exact result, the absolute error is -1.181×10^{-5}, while the error criterion given by the method is 7.689×10^{-8}. This calculation was made using double precision (8-byte words) with VAX/VMS FORTRAN-77.

FRANCOIS LADOUCEUR
Montreal, Quebec, Canada

A CALL FOR HELP

Could you put me in touch with any individuals who are working on the problems of computer applications in archeology?

SEAMUS ROSS
Institute of Archeology
Oxford University
Oxford OX1 1DP, United Kingdom
Tel. 865-241214

FOR A BETTER UNIFICATION ADAPTER

I am Japanese and am currently on assignment in Hong Kong. I own three NEC personal computers.

I read BYTE Japan: "An Innovative Program" (May) with great interest. But the article introduces only one operating system unification adapter, while completely ignoring the equal or even better systems for the NEC PC-9801 than EM/3+: Plus-80 and Spark from Canopus Electronics Co. Ltd. and Turbo-V from Kyoto Microcomputer Co. Ltd. I own both systems and am very happy with them.

This might be because William Raike's computer is a Fujitsu, which is said to make up only 10 percent or so of the total 16-bit personal computer market in Japan. Consequently, he can enjoy only limited software availability. The NEC PC-9801 series is doing in the Japanese 16-bit market what the IBM PC and its compatibles are doing in the rest of the world. I think Mr. Raike's article thus misrepresents the Japanese market for this kind of product, and I would like to tell you and your readers about the other two unification adapters.

The Canopus system includes a Plus-80 card, which has a Z80 running at either 6 MHz or 8 MHz and 64K-byte memory, and software. This has been on the market for three years and the company claims that there are now 6000 users. This system was originally for CP/M-86. The PC-9801 with this board and accompanying software works just like the 8/16 system by CompuPro. The Plus-80's enhanced CCP checks the extension of executable files and switches to the appropriate CPU. Canopus introduced separately sold software called Spark for MS-DOS late last year. With the Plus-80 card and Spark, you can read and write CP/M-80 and -86 disks without any modification. You are in MS-DOS, so you can enjoy MS-DOS's redirection and piping just as with EM/3+.

The Turbo-V system consists of three options: software, V30 (μPD70116), and a 180 card, which employs a Hitachi HD64180 (6.144 MHz) and 64K high-speed RAM. The first two were introduced last October and a 180 card this March. If your PC-9801 includes an 8086 chip, you must get a V30 to replace the original 8086 as well as software. If, however, your PC-9801 is one of the new series with the V30, you can run CP/M-80 and -86 and MS-DOS software only with the Turbo-V software. If you want to run Z80-code CP/M-80 programs, you need a 180 card. This system provides a program called MIA for media conversion. This lets you read and write CP/M-80 and

-86 files while in MS-DOS. My PC-9801 has a V30 and can execute CP/M-80 (8080-code) programs three to four times faster than my old PC-8801 (Z80A-based machine) can.

I understand that EM/3+ comes with a board with a number of chips on it. This is for copy protection. You can copy the software as much as you want, but you cannot run it without this board. The software checks the existence of the board and if there is no board, it terminates the execution. The PC-9801 has only two to four slots (depending on which model) and it is simply outrageous that such a board occupies one of those precious slots. The other system's boards are solid single-board computers, and software is, of course, not copy-protected. EM/3+ is only able to emulate a Z80, while the other two execute the object codes. As the price is in the same range or even less for Turbo-V, I am sure you can easily tell who is the winner.

I hope Mr. Raike will pay more attention to computer systems other than his own and will cover the Japanese market in wider areas.

MASAKAZU SONE
Hong Kong

SORTING LARGE FILES ON SMALL MEMORY

A sort that runs in $O(n)$ time? I know it's theoretically impossible, but it can sometimes be done in practice.

Jonathan Amsterdam touched briefly on a most significiant problem at the end of his article "An Analysis of Sorts" (September). In "real world" sorting, internal memory is rarely sufficient for the sort at hand, and when the sort must use disk space, the "key operations" that determine run time are no longer comparisons and swapping but disk accesses.

My "real world" involved sorting 50,000 to 60,000 records, each approximately 30 bytes in size, on a DEC 11/73. The sort ran several times a week and if it wasn't done by morning, other users slowed it down to a crawl. With task space limited to 64K bytes, my program could handle only 300 records in memory.

The solution: an algorithm that reads and writes each record twice. First, 300 records are read from the file to be sorted into a memory array. These are sorted by any handy routine (I use Quicksort) and written, in order, into the work file. The process is repeated for the whole input file. The work file now consists of sorted groups of up to 300 records. Further, the groups have been read and written sequentially to reduce head movement time.

Next, the first record in each sorted group is loaded from the work file into the memory array, along with a pointer indicating which group each record came from. The array is sorted, and the lowest entry is written to the final output file. The next record (if any) from that group is read into the first array position, and the array is again sorted by bubbling the new record up to its proper place. This "write and replace" process is repeated until all records of the work file have been transferred to the output file.

Now, I'm sure this technique has a fancy name and is nothing new to many, but it was new to me, and it taught me the power of the meager space in internal memory. With a 300-entry array, I can sort 90,000 records in two passes, and that's good enough for my real world.

(P.S.—A colleague spotted a method of exchanging the contents of two memory locations without using a third location. The trick involves XOR, but I like the BASIC version: A = A + B, B = A − B, A = A − B.)

JOHN W. WARD
Waynesburg, OH

FIXES

The Price of BYSO LISP

In the review of BYSO LISP and Waltz LISP (William Wong's article in the July issue, page 293), we erred on one of the prices. The real price of BYSO LISP version 1.17 is $150, not $69.95.

If you'd like more information, contact Levien Instrument Co., Sittlington Hill, P.O. Box 31M, McDowell, VA 24458, (703) 396-3345.

Ordering SPICE Thesis

At the end of Wolfram Blume's "*Computer* Circuit Simulation" (July), an editor's note told how you could get a copy of "SPICE: A Computer Program to Simulate Semiconductor Circuits" by Laurence W. Nagel. That information needs updating. Here's how to get a copy of the document. Write a check for $30 to the Regents of the University of California. Send it to Ms. Cindy Manly, EECS/ERL Industrial Support Office, 497 Cory Hall, University of California, Berkeley, CA 94720. ■

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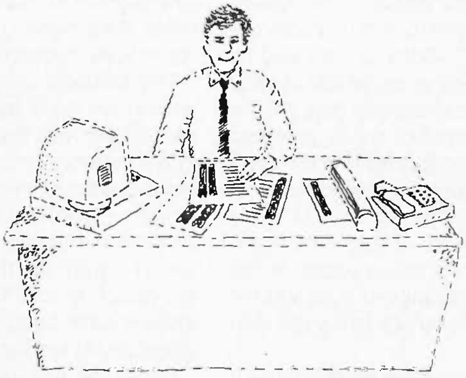

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DATA HANDLING

SEPTEMBER CASE HISTORY

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APPLICATION NOTES

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CHAOS MANOR MAIL

Conducted by Jerry Pournelle

MAC PROS AND CONS

Dear Jerry,

For the past few days, I have been browsing through old copies of BYTE, looking for information that I may have missed the first and second times through and especially to reread your columns. I must say, I learn more every time I reread them. At any rate, I feel compelled to write you after seeing once again your remarks concerning Apple's Macintosh.

I am a Macintosh owner, and I like the machine overall. However, I have to agree with some of your complaints about it. The most important problem with the Mac is the speed of disk access (when using floppies). I once read a rationalization that excused the slow disk access on the grounds that the Mac needs to load so much more information upon return to the Finder. Indeed, I've written a couple of programs in Microsoft BASIC that use disk files, and access times are acceptably quick in that use. However, the fact remains that loading an application is still dreadfully slow.

One problem I have with the Macintosh is one you haven't addressed, the difficulty of really programming an application. You've mentioned that you have MacModula-2 but have never said whether you have done anything with it. I purchased a Pascal compiler from TML Systems of Melbourne, Florida, along with both volumes of *Macintosh Revealed* by Stephen Chernicoff (excellent descriptions of most Toolbox routines). I have since sold the compiler. Why? Your old documentation complaint. The manual that came with the compiler was just about useless, unless you have already done extensive programming in Pascal on the Macintosh. As I consider myself to be a novice as far as programming is concerned, the documents did me no good. I quickly gave up on it, disgusted. Maybe I have a learning impediment or something, but the Mac is *not* easy to program. I now appreciate why it took six months to a year for any decent applications to appear for the machine.

I'm learning MS-DOS out of necessity, since that's most likely what I'll be confronted with when I start working as a programmer, but I want to learn how to program the Macintosh because I love it. Despite my complaints about the machine, Apple did so many things right, and its implementation of an extremely simple user interface is a step in the right direction. It's unfortunate that most people will never really appreciate the work and energy that goes into a well-designed Macintosh application.

PHILIP E. JURGENSON
Mankato, MN

I don't expect there will ever be an end to the Macintosh debate.

The first I ever heard of the Mac was when Pamela Clark, then editor in chief of Popular Computing, *told me that Apple was coming out with something wonderful that she couldn't tell me about. I continued to hear how great it was; the mountain was in labor. What came forth was the 128K-byte Mac that sold for $3000, followed by an overpriced upgrade that did nothing for the early loyalists who had bought the original.*

On the other hand, I agree: Apple changed the micro world forever with the Mac operating system. It was too slow, and some parts of it were too cute, but it sure beat A> all hollow. Unfortunately, much of the machine was dictated by ideology, not reason.

It's probably all moot. Apple is moving ahead with a machine related to the Mac in the same way that the new Ford Taurus is related to the Edsel, while Atari and Amiga have 68000 machines that take Apple's innovations and go off in new directions.

I love it when a bunch of smart people start competing to give me better machines.—Jerry

SALES HELP WANTED

Dear Jerry,

My family manufactures custom aluminum architectural products for domestic and industrial purposes. Our modus operandi is, typically, as follows: Clients phone us and specify a product, say, window series G2. Then they proceed to give us some dimensions, number of shutters, glass thickness, number of units, etc. The salesman, after a brief discussion with the client, elicits any other information deemed relevant, like cost, practicality, etc. So far, so good. The salesman then provides an estimate based on the cost of the materials and submits it to the client for approval. Invariably, the client requests a change, in which case the salesman must resubmit weeks of work. This is particularly true with industrial clients. Such delays do us no good. Furthermore, salesmen tend to depart frequently, and training new people to perform tedious tasks is no fun. Finally, after the client is satisfied, the salesman prepares a bill of materials that details, down to the smallest rubber washer, the parts to be removed from our inventory and sent off to the site.

Do you know of any software that will eliminate the need for these repetitive calculations? I envisage a situation where a client calls up and presto! an estimate is ready, a bill of materials is available at the press of a button, and the inventory is just waiting to be depleted.

SANJAY A. BULCHANDANI
Stanford, CA

General program, no; I'd think you need a special program. Fortunately, it need not be written from scratch. I think it could be handled with an application program in dBASE II, but if I were you I'd go to Guru from Micro Data Base Systems (P.O. Box 248, Lafayette, IN 47902, (317) 463-2581); costly, but worth it given the size of the problem. You'll have to get a programmer to customize, but that shouldn't be too difficult.

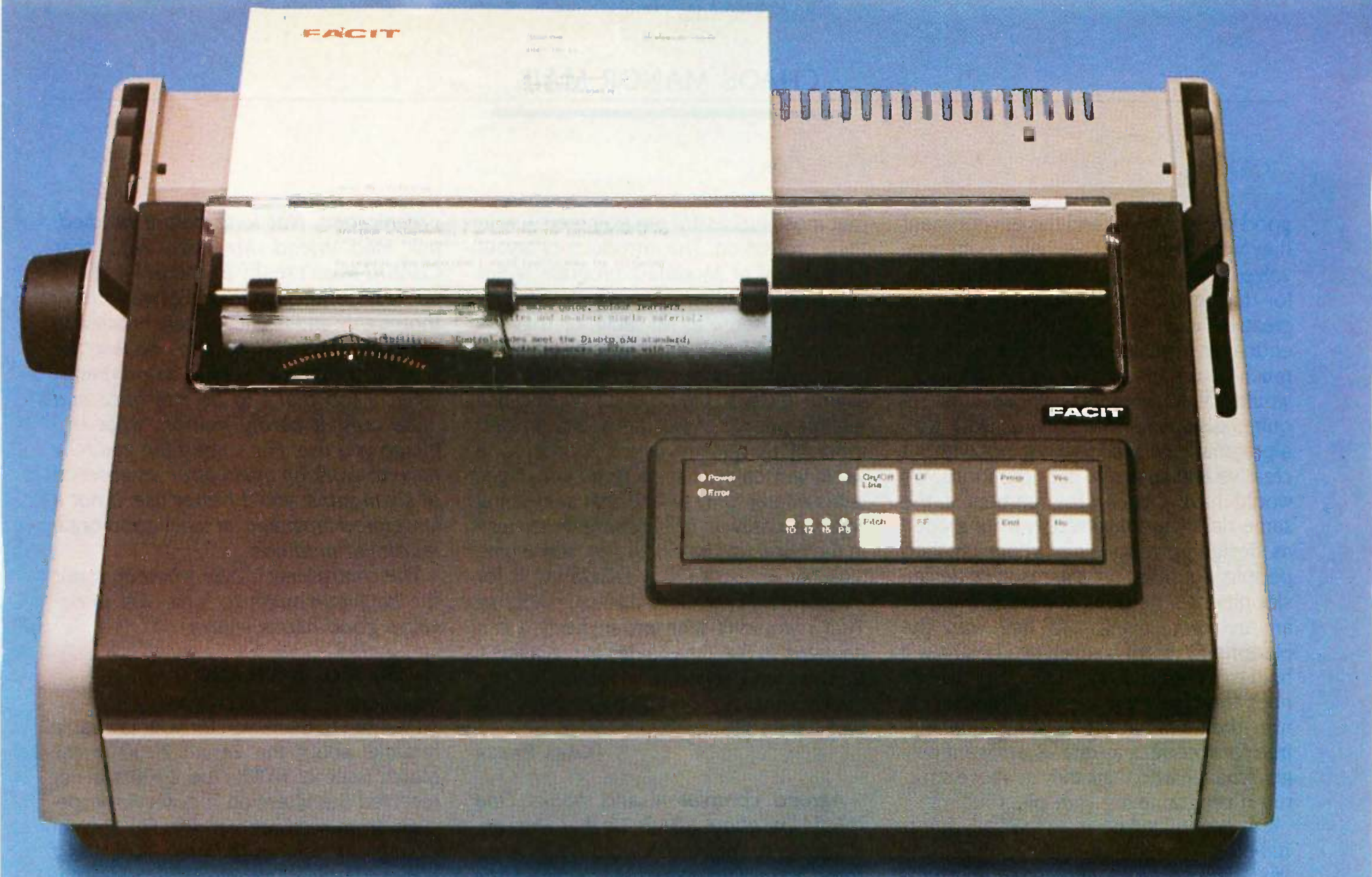
Guru is a sort of combination expert system and database; I'll have a full review in a later column. Meanwhile, I'm impressed.—Jerry

THUMBS UP ON TOP-DOWN PROGRAMMING

Dear Jerry,

I found Mr. Suits's letter to Chaos Manor Mail (March) most eloquent in his criticism of top-down programming. Unfortunately, I couldn't disagree more strongly with both the analogies he chose and the conclusions he drew from them. Musicians tinkering with notes, artists idly sketching, and writers experimenting with the effect of words are not good comparisons for

(continued)



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good programmers and the environment they work in. While creativity is often involved in programming (or any profession, for that matter), it is not, like true art, a creative end in itself but usually an endeavor with a practical goal in mind. A much better analogy with a programmer would be an architect, whose craft requires discipline, who pursues work with a pragmatic end, and who is not without creative and aesthetic considerations. We would have better programmers if the same risks were involved in writing code as designing a building, where crushed people, not bugs, are the result of design sloppiness. One does not easily imagine an architect saying, "To hell with the blueprint! I've got a hunch two beams will hold this baby just fine." Everyone resents rules and constraints, yet we should recognize their reason for existing. Efficient, free-form code is as rare as arrogant programmers— who think they're above structured programming—are plentiful.

Of course "ideas do not usually jump, full-blown, to the conscious mind," and yes, "the very *doing*" *does* help establish the framework or structure of a project. Thus the need for the preliminary design work that most successful programmers use in their profession. The introductory layout of a Pascal or Modula-2 program is not "ceremony"; it has a purpose. If that purpose is obscure to Mr. Suits or tries his patience ("I find it difficult to begin scanning a Pascal program without thinking, 'Damn it! Get to the point!'"), it's because it helps people to *find* the point. I'm sure most of us have reviewed source code we've written in nonstructured languages years earlier, only to find that something that was easily understandable when fresh in the mind was hard to follow some time after the event. Doubly frustrating is for a second party to wade through the mess. That I wouldn't wish on anybody, yet it happens 10,000 times a day in businesses, schools, and government offices across the country. Old computer languages and bad habits die hard.

JAMES BAKER

Agreed, completely, and thanks. One thing I like about CBASIC is that you can, if you're so inclined, write highly structured code, with everything declared (the compiler can detect undeclared variables if you tell it to) and generally top-down organization. Not long before he died, my mad friend MacLean said that CBASIC wasn't really BASIC at all; it was far too good. But then he was pretty thoroughly anti-BASIC, largely because in the early days you wouldn't believe the spaghetti that was served as programs.

For a job that's to be run once and once only, it hardly matters what language you use. For something you may have to work on again after an absence of six months, you'd better use, if not a structured language, at least good organizational methods.

The controversy is over whether or not the language ought to force you to develop good habits.—Jerry

Z-100 AND BORLAND

Dear Jerry,

I wanted to thank you for your favorable remarks about the Zenith Z-100 in the March issue of BYTE. The Z-100 has not received the attention it deserves, especially from software vendors. To give an example, I purchased Turbo Pascal last summer. When I attempted to order Turbo Graphix Toolbox for the Z-100, I was told that it was not available and that they were not sure if and when it would ever be available. What is especially irritating is that in the back of my Turbo Pascal reference manual, and on various order forms that came with the package, they specifically mention that Turbo Graphix Toolbox is available for the Z-100. I feel that I was deceived by this material published by Borland. Since they quote you as saying this is a high-quality product, I thought you should be aware of the situation.

ROBERT R. JUNE
Grand Forks, ND

The Z-100 with a PCompatible board is still a darned good option, if only because it runs WRITE and a whole mess of other CP/M programs as well as PC-DOS stuff. On the other hand, things flow in the computer world: what was best last year isn't necessarily so this year.

Borland told me they were going to do Turbo Graphix Toolbox for the Z-100; apparently they decided not to go ahead, which is a real pity. I hope they'll change their ads, or better yet, put someone onto doing it. Alas, though, since Zenith has sold mass quantities of the 248 (a very good machine) to the government, including the service academies, they've let the Z-100 fall between the cracks. I can understand, given market realities, but it's a pity; I'd hoped that dual-processor machines would reunite the micro users. Oh well.—Jerry ■

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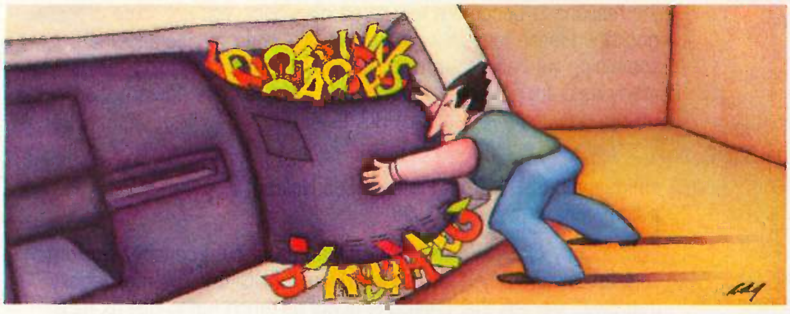

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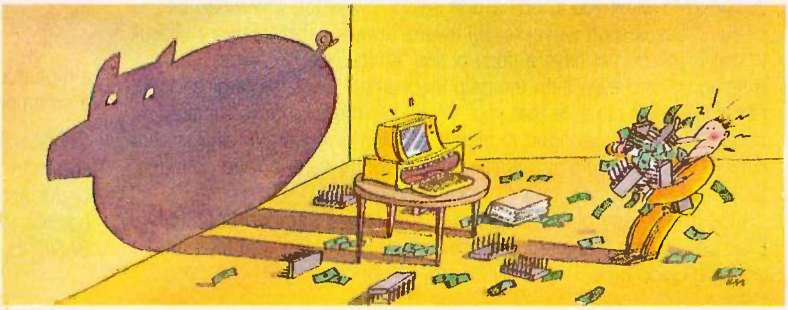

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SOFTLOGIC
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BIX is the BYTE Information Exchange, BYTE's ongoing electronic conference. Each month, this section attempts to give readers a glimpse into this constantly evolving, rapidly growing exchange of ideas and information. This month, the conferences covered are Amiga, Atari ST, IBM PC (and clones), Macintosh, and Pascal.
For information on joining BIX, see page 357.

AMIGA

Once again the Amiga conference has come in as one of the busiest on BIX. This month's selections begin and end with problems, the first concerning a missing text file and the last with troublesome C libraries. In between, there are two discussions on different aspects of using the Amiga for its musical capabilities and a request for advice on making the programming leap from C to assembler.

DISK SECTOR SURGERY

amiga/main #3080, from dcoulter [Derek Coulter]

Help! I've destroyed one of my most important text files by accidentally OPENing the file for output in Amiga BASIC. As you know, OPENing an existing file erases its contents.

Am I right in assuming that the sectors containing what was in the file were not deliberately wiped clean (i.e., zeroed out) by DOS when I OPENed the file? If I am, I wonder if it's possible to look at individual disk sectors directly? If I could do that, I could search each one until I found the text.

I'd be *very* appreciative if someone would recommend a program (preferably in the public domain that I could download from BIX) that would allow me to read sectors. Or even suggest how a BASIC-bound non-developer Amiga enthusiast like me could do it from Amiga BASIC.

amiga/main #3093, from rankin [John Rankin]
a comment to message 3080

Yes, there is a program that you can use to do just that. It is called DiskEd and can be found in the "c" directory of some disks. It is designed to allow you to edit a disk sector by sector, which can be useful in cases such as yours. Be aware, however, that it is very difficult to use if you do not have a copy of the "AmigaDOS Technical Reference," and even then the help the manual gives is marginal. If you have patience I am sure that your efforts will prevail. I have repaired several disks that belonged to friends of mine who were in similar situations. It just takes time and a little know-how; be sure to read as much as you can before you start to use this program.

I found my copy of this program on the Amiga Cambridge LISP Disk, so I'm sure that there is probably one available if you look hard enough. Good luck.

amiga/main #3095, from fnf [Fred Fish]
a comment to message 3093

There is a very nice little public domain disk salvager (called DiskSalv) that has appeared on Usenet and is on my library disk number 20. I believe there is also something similar in the AmigaDOS 1.2 alpha/beta releases.

amiga/main #3097, from jdow [Joanne Dow]
a comment to message 3093

DiskDoctor is coming in version 1.2. I don't know if it will recover erased data, but it will generally clean up a disk.

amiga/main #3098, from langeveld [William Langeveld]
a comment to message 3093

DiskEd is not on any standard disk that I know of. It is supposedly a program for developers. Developers are privileged people who get a lot more software from Commodore-Amiga than us common mortals.

amiga/main #3099, from langeveld
a comment to message 3095

The program that will be released with 1.2 is called DiskDoctor. It supposedly comes on a disk called "The Toolbox" and will initially be handed out only to developers. Later on it might be available for the rest of us, but it is not clear whether that pleasure will be, er, for free.

amiga/main #3102, from demo9 [Pat Harrington]
a comment to message 3095

I have an alpha of version 1.2 of the OS and hope DiskDoctor will be generally available despite messages here to the contrary. I used it to recover a disk that crashed on me (it contained files I had downloaded on-line) that I couldn't even format. I got the message "Hard error cylinder 0 . . . Format abandoned" before fixing it with DiskDoctor. In other words, it sure seemed to do the trick for me.

amiga/main #3109, from duck [Dale Luck, Commodore-Amiga]

It will probably be available only to registered developers. That's one of the reasons to become a registered developer; you get some of these goodies. Please remember that there is a world of difference between something we hacked up to do a quick job and something that is ready as a supportable product. DiskDoctor is once again written in unsupportable (to Americans) BCPL.

amiga/main #3113, from lnoland [Les Noland]
a comment to message 3098

I got a copy of DiskEd with my Amiga Pascal but I certainly wouldn't suggest anyone buy it just to get a copy of DiskEd. That's especially true given the fact that DiskEd is about as much fun to use as receiving a heavy wooden mallet on the cranium.

amiga/main #3118, from jdow
a comment to message 3080

On reflecting, I don't know how from BASIC, but the trackdisk interface shown in one of the Fred Fish support files (#5 disk) shows individual sector access. With that I bet a modest effort could generate a sector patcher routine. Now, I suspect this might be very hard to do from BASIC, but access is possible.

amiga/main #3251, from langeveld
a comment to message 3080

Even though your message is two weeks old, you still may want to know that on fishdisk 20 there is a program called DiskSalv, which is supposed to not only fix broken disks but also retrieve deleted files. If you don't have it but still want it, I might be persuaded to upload it to Listings.

[Editor's note: DiskSalv is now available for downloading from the Amiga library in the Listings section of BIX. Information concerning the fishdisks (public domain software for the Amiga) mentioned above may be obtained by sending a SASE (57 cents postage) to: Fred Fish, 345 Scottsdale Rd., Pleasant Hills, CA 94523.]

SOUND SAMPLER

amiga/main #3025, from jsan [Jez San]

Does anyone know of a sound sampler unit for the Amiga that is actually *shipping*? I need one *very* quickly (i.e., tomorrow)!

FutureSound is about 5 weeks away (so the lady on the phone says), which, translated into *real* terms means 10 weeks. And there are others advertised but I haven't tracked any down.

If not, does anyone know of a decent sampler unit for any other machine, or even a stand-alone synthesizer with sample capability that has provision for uploading and downloading the samples to another host, possibly down the serial port?

amiga/main #3036/3037, from langeveld
a comment to message 3025

Call Mimetics. They were selling a sound sampler at the last FAUG meeting (a week ago).

The address of Mimetics is

Mimetics Inc.
P.O. Box 60238 Station A
Palo Alto, CA 94306
Tel. (408) 741-0117

Their sound sampler is around $100. The MicroForge unit should also be shipping, but it is around $350. I have not actually seen that one, though.

amiga/main #3039, from lnoland
a comment to message 3025

This is speculative, but you might check it out. I don't know of any sound-sampling devices for the Amiga that are shipping right now, but there is a very reasonably priced sampling keyboard made by Ensoniq, called the Mirage (when I say reasonably priced, I mean for a sampling keyboard, not for just a sampling device—I believe the price is $1695). I don't know how possible or easy it would be to transfer those samples to the Amiga but you might want to check it out. They do store the samples on 3½-inch disks but I don't know what format they're in. They also advertise that there are sound-editing programs available "for all major personal computers." I doubt that that includes the Amiga at present but who knows?

Ensoniq's particulars: Ensoniq Corp., 263 Great Valley Parkway, Malvern, PA 19355.

In Canada: 6969 Trans Canada Hwy., Suite 123, St. Laurent, Que. H4T 1V8.

In Europe: Ensoniq Europe, 65 Ave. de Stalingrad, 1000 Brussels.

In Japan: Sakata Shokai Ltd., Minami Morimachi—Chu-O Building, 6-2 Higashi-Tenma, 2-Chome, Kita-Ku, Osaka 503.

amiga/main #3124, from grogers [Steve Mueller]
a comment to message 3039

Actually, the Ensoniq (like the Prophet 2000, Emulator 2, Roland SP units, and the Yamaha samplers) dumps sample data over MIDI (so compatible disk format is no object, *n'est-ce pas?*) in a quasi-compatible format. You can't quite read one sample file from another synthesizer (*yet*). Advantage of Ensoniq? Not much; it uses 8-bit samples. Prophet 2000 uses 16-bit samples. You could probably make an Ensoniq clone with the Amiga, a minimal amount of hardware, and a *lot* of software.

amiga/main #3147, from cmcmanis [Chuck McManis]

For those of you who are music buffs and are going to be hooking up

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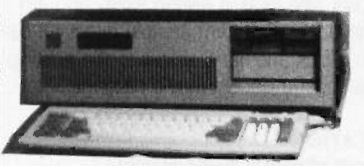
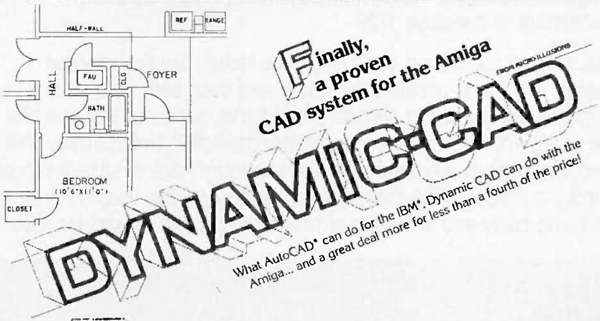




synthesizers to your Amiga even though it already has the best sound capabilities on the market, may I suggest you look at the Yamaha DX-100. I just got one at a recent sale here in Silicon Valley and am quite pleased. It was $350 and although it can't sample directly it can play back sampled waveforms. Adds another 8 voices to the existing 4 of the Amiga. Now if I could just get a decent music package . . . .

SOUND CHANNEL ALLOCATION

amiga/softw.devlpmt #1779, from cheath [Charlie Heath]

I've been dealing with putting together three separate audio device users (speech, a canned music driver, and a custom sound-effects driver), and have found it difficult to deal with channel allocation. It seems that there is a missing link—once an audio channel has been "stolen" from a user, the user has to explicitly test to find out that that has happened and then must reallocate it.

It seems to me that there should be a "borrow" channel command, which would take the channel when a higher-priority request is made but would automatically restore ownership to the prior owner. Sort of like prioritized multitasking, except it would never time-slice; you would own the channel until a higher-priority request occurs, and you would get the channel back when the higher-priority user released it.

Has anyone else found this to be true? It seems to me that people are now dealing with this in one of four ways: set the priority to MAX, so nobody else can get the channel; ignore the problem—if the channel is allocated by another user, it is never reallocated; test to find out if the channel has been stolen every time an audio command is issued, with a considerable performance penalty and a lot of overhead; test only at convenient places in the code (like at the start of a song or sound effect, etc.).

amiga/softw.devlpmt #1803, from sbennett [Steven Bennett]
a comment to message 1779

Alas, we're stuck. Sound channels, once stolen, are not returned. I suspect that this is because the driver was designed more so that the programs using it would allocate the channel, send out a sound (like one note), and deallocate it immediately thereafter. Unfortunately, this does cost a bit in overhead, and I suspect (will have to write a program to test it someday RSN) this overhead is too costly to use. In my stuff, I am being nasty and allocating at maximum priority, at least for now.

I do suspect, however, that simply checking to see if the channel has been stolen for each audio driver call is not too much overhead. If you are running asynchronously (which is generally best for this kind of stuff, unless you like waiting for sounds to finish) then all you have to do is check the error return of the call, which will tell you that the channel requested is not available immediately. Not exactly the nicest method to the driver, but it works.

Once you have discovered your loss, it is up to you to do anything you need to. Usually, this means preceding any call to output to that channel by an attempt to allocate it.

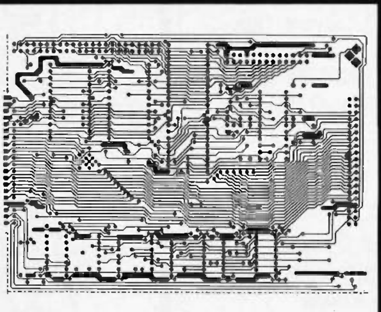
One final note. The list of suggested priorities in the RKM ("ROM Kernal Manual") could be shuffled around a bit but otherwise makes some sense if you really want to be nice to other programs running. Eventually, I'm going to have to see if I can change my program to handle this stuff correctly. But if it is too much time and trouble (and this especially includes overhead), I am going to be nasty and hog the channels anyway, under the assumption that the user is unlikely to run two audio-intensive programs simultaneously. Better that than to have a program that produces less than quality sound.

amiga/softw.devlpmt #1804, from cheath
a comment to message 1803

That seems to concur pretty much with what I'd thought. The problem comes when you want to combine two audio drivers into one program, say for digitized sound effects and music. That might not be such a problem if there is a single arbitrator in the program, but unfortunately I've been working with a canned music driver for which I don't even have access to the source code—so I can't build such arbitration in.

amiga/softw.devlpmt #1809, from jdow
a comment to message 1804

Only thing I could imagine using sound channels in both of two programs for would be ^G character in a program—check for sound allocation and flash screen as an alternative—or accompanying music with speech commentary. But then the sync would want to exist between the music and the speech. Hence they'd have to be in the same program.



MOVING TO ASSEMBLER

amiga/softw.devlpmt #1792, from pjohnston [Dale Kuethe]

Can any of you programming geniuses help me out? I am making a transition from C to assembler for reasons of size and speed. (As put in the movie "Top Gun," "I feel the need. The need for *speed*!") I cannot afford Tech Manuals yet and I learn best from examples anyhow. What I am looking for is the Intuition functions and animation stuff. I have done it all in C before but it is just too bulky and slow. Also, if you have a few seconds (and are feeling very, very generous) it'd be nice if you uploaded your *best* 3D graphic routines . . .

amiga/softw.devlpmt #1794, from jdow
a comment to message 1792

Probably the quickest trick from Lattice C is to run OMD (Object Module Disassembler) on the object code and feed the result to an editor to make it something the assembler would really like. Then start hand-optimizing the results. Of course, the OMD route is moot for Aztec, as it has an assembler stage in the compile. Take that output and again hand-optimize.

amiga/softw.devlpmt #1795, from cheath
a comment to message 1794

The Manx output is really easy to convert to assembler, since you can just put in "#asm" statements after compiling a "C" function to assembly source. That makes it easy to get function arguments and structure offsets correct. However, the current version of Manx's assembler is not very good for "stand-alone" development. It was really designed to accept the compiler's assembler source output, and not much else. I understand Manx is making some improvements in the assembler for the next update, though.

AZTEC C LIBRARIES

amiga/softw.devlpmt #1780, from mikeduffy [Mike Duffy]

Problem: Basically, I get a working program with individual .o files and a non-working program with the same files in a library. No errors on link, just a different-sized program that loads, begins to execute, and then software-error task held. For more info, see "manx.aztec/amiga." Thanks for any help you can offer.

amiga/softw.devlpmt #1782, from fnf
a comment to message 1780

This one bit me once a long time ago. Seems that there are some latent problems in the librarian program, the end result of which is a corrupted executable.

amiga/softw.devlpmt #1784, from langeveld
a comment to message 1780

That's right, the librarian with 3.20a is next to useless. What does work is to join the .o's together with the DOS command "join." That does mean, however, that all .o's are linked in.

amiga/softw.devlpmt #1789, from cheath
a comment to message 1784

Are you sure about that, Willy? I thought that only worked for ALink-style libraries, not with Manx. Haven't tried it, though.

amiga/softw.devlpmt #1791, from langeveld
a comment to message 1789

Yup, have tried it myself. Besides, somewhere in manx.aztec/amiga.c jgoodnow says that it will work the way I described.

amiga/softw.devlpmt #1812, from mikeduffy

Aztec users might want to see manx.aztec/amiga #115 if they are creating programs with large (>64K) data segments for a linker bug that bit me. By the way, rumor has it that Aegis developed its stuff with Aztec. Can w.volkaegis confirm or deny this? Since the Aegis products are fairly big, have you encountered any problems when stretching your tools (e.g., Aztec/Lattice/etc.) to the limits?

amiga/softw.devlpmt #1820, from w.volkaegis [William Volk, Aegis Software]
a comment to message 1812

Draw is a big program (150K object) but has a smaller than 64K data segment (almost everything is allocated on the fly). I believe you have to use a linker option (or compile option) to go to the "large data

(continued)

model." Aztec default is to use 16-bit offsets from a register (fast and compact). I recommend eliminating global data wherever possible (style consideration).

amiga/softw.devlpmt #1822, from mikeduffy
a comment to message 1820

Most of the nonallocated data is 0x6000 bytes of chess openings in encoded format, so it's not something I'd like to allocate and read off of disk (yet another file for the user to accidentally lose). Incidentally, the large data model does not necessarily mean what you think. You can mix large and small and (in theory) the linker will notify you when a piece of small data cannot be reached (page cc.11 of the Aztec manual).

amiga/softw.devlpmt #1823, from cheath
a comment to message 1822

Sounds like that big array could easily be accessed from only one file using long pointer addressing. Question is, though, is all the Data put in front of all the UData with the current linker? (Have you thought about putting the chess openings into a "comment" hunk, which would be ignored by the loader but which you could go back to and read explicitly as a file?)

amiga/softw.devlpmt #1824, from mikeduffy
a comment to message 1823

Yeah, from the link map, Data and UData are both in segment 0 (code in 1) with Data first. Thanks for the "comment" hunk suggestion. I can see I am following where others have already worn a trail.

amiga/softw.devlpmt #1825, from cheath
a comment to message 1824

Actually, I haven't tried the comment hunk deal—but I'd like to know if it works. I've got these nasty data files all over the disk!

amiga/softw.devlpmt #1826, from mikeduffy
a comment to message 1825

Any suggestions for hiding data files and/or determining where all the application-related files live? Somehow, these problems are never fixed until the third or fourth release of the OS (witness MS-DOS, which has yet to get it quite right), but they're quite important for developing robust applications.

amiga/softw.devlpmt #1827, from cheath
a comment to message 1826

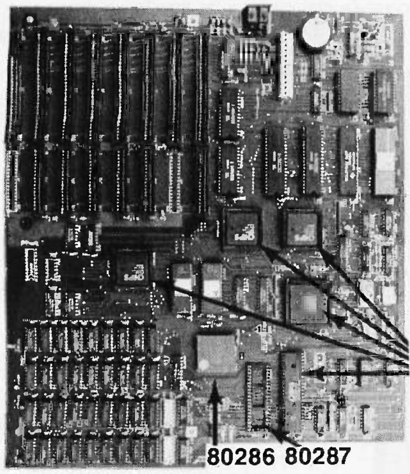
I was hoping to get by with an "assign" and use a pseudo device name within the program. That puts the burden on the user, but what the heck. If the user has put a floppy in with the volume name, it will get accessed automatically; if the user copies it to another disk or hard disk, they gots to include an "assign" in the startup sequence, or something.

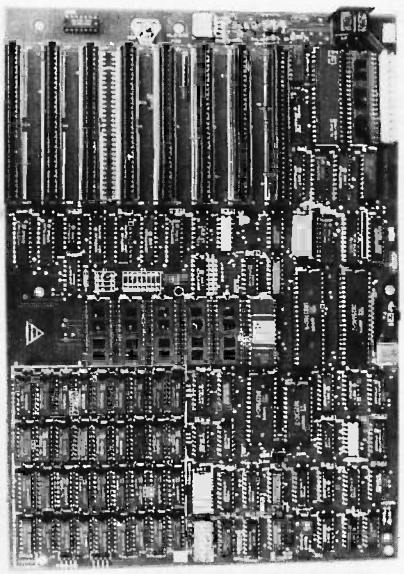
REGISTER A6 AS A FRAME POINTER

amiga/softw.devlpmt #1913, from jgoodnow [Jim Goodnow]

I've been doing some looking and thinking about this whole thing with using A6 as the frame pointer. When I originally decided to use A5, I

(continued)





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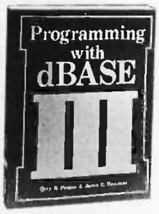

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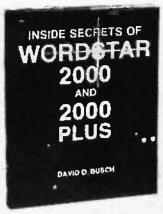

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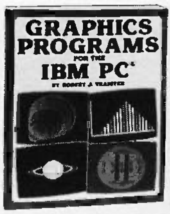

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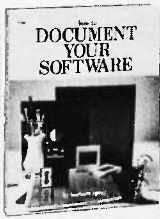

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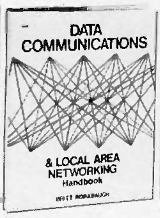

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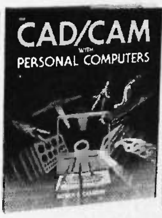

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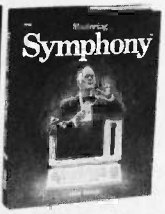

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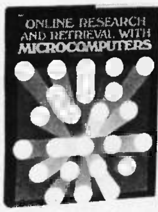

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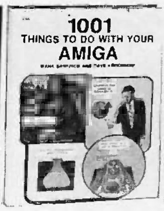

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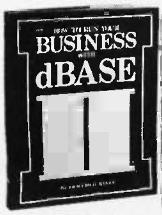

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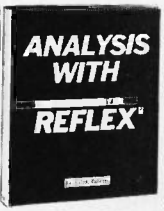

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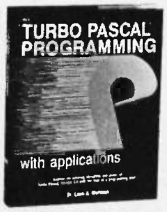

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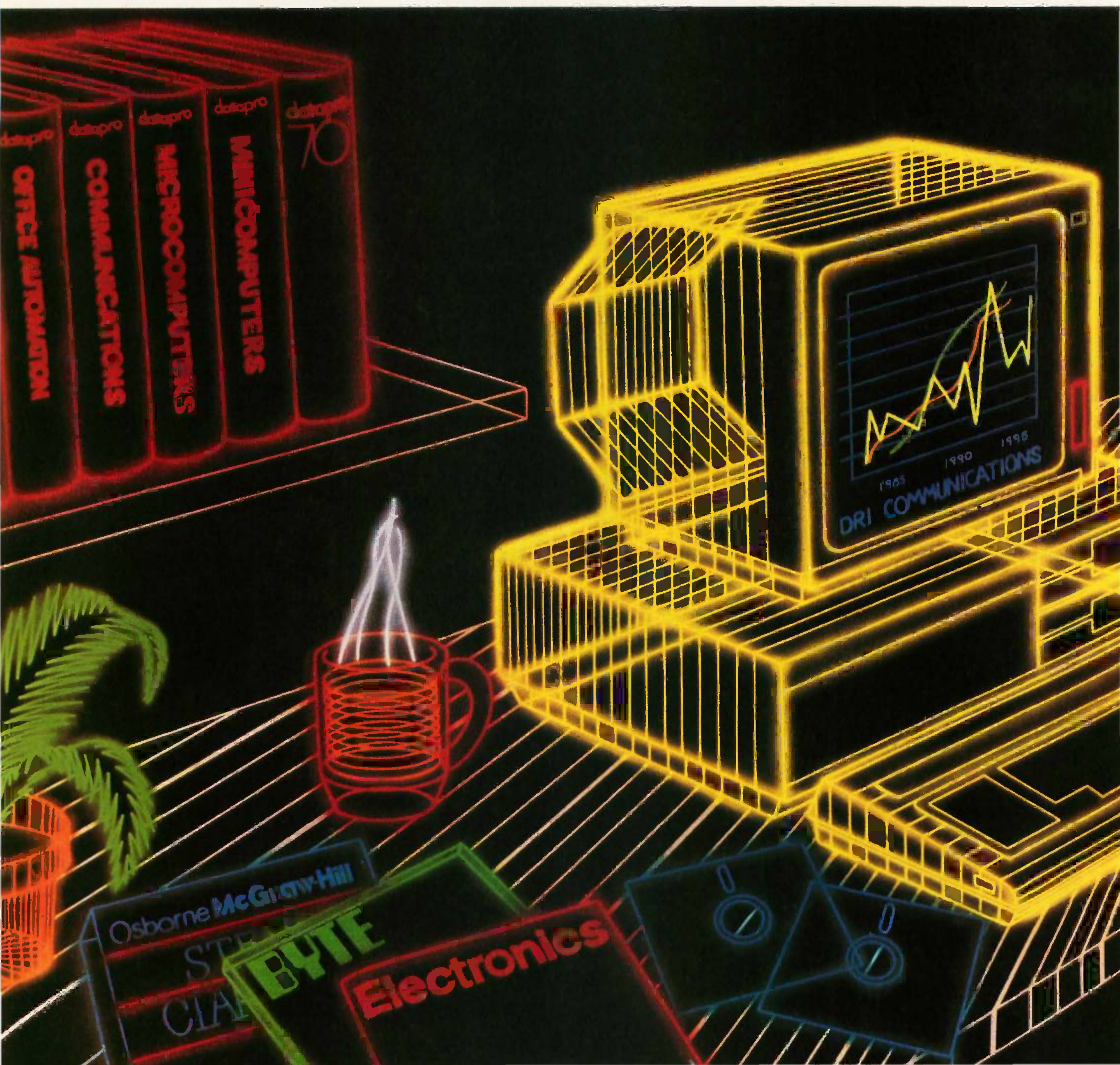

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was operating pretty much on my own with no feedback. Now, however, with all youse useful people here, let me put it to you. The question really comes down to speed. Size was originally an issue, but I now have a way of cutting the size down even with A6 being the frame.

To recap the question for those unfamiliar with it, when a C program makes a call to one of the resident libraries, it has to load A6 with the base of the library before calling the function. If A6 is used as the frame, it has to be saved and restored. The difference in code looks something like this:

```
move.l  a6,-(sp)         vs.    move.l  _DosBase,a6
move.l  _DosBase,a6             jmp     _LVOInput(a6)
jsr     _LVOInput(a6)
move.l  (sp)+,a6
rts
```

A difference of about 51 cycles. There is also an obvious size difference, but there are other ways around that. The question is whether the 50 to 60 cycle difference is worth the incompatibility problems. Obviously, for most DOS and EXEC calls this is not a problem, but what about GRAPHICS, LAYERS, and INTUITION?? I look forward to any and all comments, since I have to make a decision in the next few days. Thank you.

amiga/softw.devlpmt #1914, from langeveld
a comment to message 1913

I have a prejudice toward A6 for the frame pointer. Reason: I have both the Aztec C compiler (commercial version) and Absoft FORTRAN. I occasionally want to call C functions from FORTRAN, but Absoft insists that the frame pointer be A6.

Is it possible to make this a switch in the compiler (he asks in full naivete, not really knowing what's involved)?

amiga/softw.devlpmt #1915, from jgoodnow
a comment to message 1914

A switch would be easy, but the problem is what about all those libraries that were compiled with the switch set to A5, and the assembly language glue routines that have to have one or the other hard-coded in. Part of the problem at the moment is that there are too many choices: near/far code, near/far data, 16/32-bit ints, A5/A6 frame ptr.

Whoops! Almost forgot, FFP/IEEE/68881, which makes for 16 regular libraries and 48 math libraries. I like giving people a choice, but that's a lot of disks. Unfortunately, my nice-guy nature gets me in these jams! (grumble grumble try to be nice to everybody . . .)

amiga/softw.devlpmt #1916, from cheath
a comment to message 1913

Jim—The compatibility issue isn't too important for me, because I don't tend to port a lot of stuff between the compilers. I could see it being a problem for some folks that want to be able to put together object code modules from both compilers—and it sounds like, since your new linker supports the ALink format, that would become a practical possibility RSN.

The only reason I would want A6 to be the frame pointer would be to get an extra register address variable. But I think it's still a win, because if I really need an extra address register I'd be writing in assembler.

Know what else I'd like? With function prototypes, the ability to pass function arguments in registers. But that's a different subject. . . .

amiga/softw.devlpmt #1917, from cheath
a comment to message 1915

Willy—Prolly your best solution would be to write special binding routines in assembler for the functions you want to call from FORTRAN. That could get a bit sticky if you do much modification (and forget to do a binding and crash and get mad at Jim), but if you have just a few shared routines it oughta work. That assumes, though, that there are no name conflicts between FORTRAN and C library functions. . . .

amiga/softw.devlpmt #1919, from duck
a comment to message 1913

Graphics and layers use a compiler that has A5 as a frame pointer. However, the C compiler is also modified so that it never uses A6.

I think using A5 as a frame pointer makes sense, but to be strictly compatible you will still need to preserve/restore A6 if it is used.

(continued)

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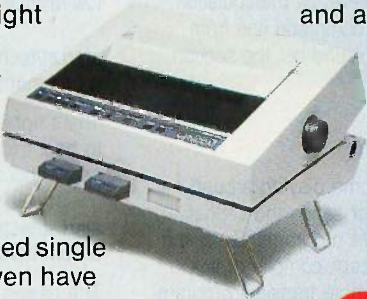

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amiga/softw.devlpmt #1920, from duck
a comment to message 1916

If you make heavy use of exec calls or graphics calls, you could preload A6 with the vector pointer and get rid of the interface library.

If the compiler itself knows the register calling sequence, maybe by use of the "prototyping" in new standard C, you could generate in-line code to call the library routines.

amiga/softw.devlpmt #1921, from jgoodnow
a comment to message 1919

If I preserve A6 in the library interface routines, then I might as well use it as the frame pointer. The problem is Aztec C calls Lattice C, which calls Aztec C glue routine. Even if the C functions save A6, so that Lattice C calling Aztec C works, there is still the problem with the glue routines. As pointed out, the problem exists with other languages as well.

amiga/softw.devlpmt #1922, from w.volkaegis
a comment to message 1921

I'd opt for less T-States. . . .

BTW, does the IEEE support include an option for the 68881? I'm surprised at the number of calls we get on the subject.

amiga/softw.devlpmt #1928, from sdb [Scott Ballantyne]
a comment to message 1913

Jim, having A6 used as the frame pointer would incredibly ease ports from UNIX (PPC) compilers. (It is no fun wading through 3000+ lines of 68K code and dealing with register/frame differences.) In fact, as the compiler is currently set up, it may not be possible to do a port without a complete rewrite (having A4 as a register variable would ease that). I don't know how many others have problems like this, however. On the other hand, for original applications, the current solution seems the best (A5 = frame pointer).

Speaking for myself, and attempting to take advantage of your nice-guy nature, I would love to see yet another switch (yas, indeed) for this. I do think there is more at issue than simply porting code from Amiga C by Lattice and Manx back and forth, or using modules created by one compiler with another.

ATARI ST

Software seemed to be on the minds of most of the participants in the Atari ST conference this month. The first thread begins as a case of missing memory and evolves into trying to "fool" the GEM graphics mode. The second thread picks up the general topic of graphics, but from a rather different point of view, that of low-level bit manipulation. Accessing BIOS from interrupts, accessing the command line from Modula-2 and making your ST act like a VT52 round out the section.

MEMORY MAP

atari.st/tech #169, from sprung [Ron Sprunger]

I am trying to use TDI M2 from C-Shell, and some playing around has revealed interesting problems. Dave Beckemeyer sends the C-Shell in two versions, one of which doesn't support GEM programs. Since the TDI compiler and linker are GEM programs, I can't compile or link under that one, but it lets me have about 62K more transient programming area to work with.

The memory is important, because I need a minimum 600K RAM disk to carry all the standard library modules, plus compiler, linker, and MicroEMACS. If I put the non-GEM C-Shell in AUTO and boot, MDISK tells me it can give me a 702K RAM disk, meaning 298K not available. MDISK is the MichTron RAM disk program. MDISK reserves 128K for TPA, and C-Shell program size is about 67K, leaving 105K unaccounted for, unless C-Shell reserves a bunch.

If I come up on the desktop, MDISK offers me 709K, which seems to be its maximum, even though the docs say 800K. Now GEM programs are supported, and if I go into the GEM C-Shell, MDISK offers only 640K, meaning that the GEM-supporting version of C-Shell seems to need an extra 62K for something.

The reason I mention the details is that if you make yourself too big a RAM disk, then run C-Shell, things seem to be OK, but you are prone to nasty crashes with no error messages.

Now for a (nearly) undocumented feature of C-Shell. The docs on the disk for the non-GEM C-Shell mention that it does not support the "gem" command. The "gem" command is mentioned nowhere else, either in the manual or in the disk docs. Before discovering this, I was running Modula and Linker from C-Shell by simply typing in the program name "modula," etc. I would then come into Modula with a slightly shrunken window and with or without a mouse (by some whim I could not discern). Entering a GEM program without the mouse can mean hangup time if you haven't a valid file on the logged disk, as you can't get to the CANCEL command without a mouse. Anyway, if you want to run a GEM program from C-Shell, type "gem progname" and you're in fine shape.

The MDISK program is not without fault—it requires an extra 15K for each RAM disk it sets up, and it insists on copying any .ACC files plus the desktop.inf file to the created RAM disk, where they haven't the slightest business being.

Can someone tell me where the 90K mentioned above is going?

atari.st/tech #288, from jerryb [Jeremy Brown]
a comment to message 169

Ron, MDISK copies the .ACC files because you should be using the MDISK in an AUTO folder, where it would copy the files and load them much quicker than from floppy. A better RAM disk is HippoRAMdisk (much better than I hear their C is/was). It *allows* use in an AUTO folder and accesses a text file where you have the RAM disk size plus a list of all the files you want to automatically copy into the RAM disk. There is a special function to create this file, and you can edit this file later if you wish. In the file copy list, wildcards are supported (as are folders). Whether you can use this special feature from outside an AUTO folder I do not know. I recommend that you look into it. I have also used MDISK and would rather go without. Note: The HippoRAMdisk I am referring to is a post-updated one from before TOS ROMs.

atari.st/tech #289, from sak [Sal Magnone]
a comment to message 288

Doesn't any program running in the AUTO folder boot into that blasted low-resolution mode? What a bug!

atari.st/tech #291, from swestrup [Stirling Westrup]
a comment to message 289

That's right, and I've never found a way around it! If anyone knows how to boot into an AUTO folder program in medium resolution, *I want to know about it!*

atari.st/tech #292, from jtittsler [Jim Tittsler, Atari Corp.]
a comment to message 291

The easiest way is to have a program in your AUTO folder ahead of the program you want in medium res that does nothing more than go into medium resolution and then terminate. Remember that programs will

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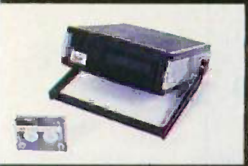

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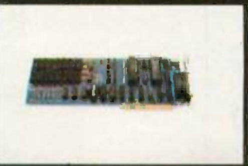

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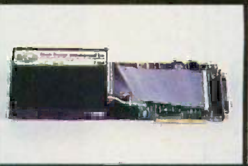

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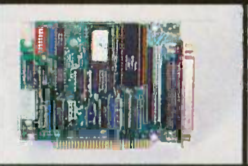

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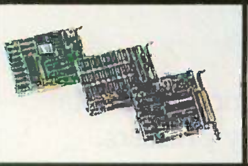

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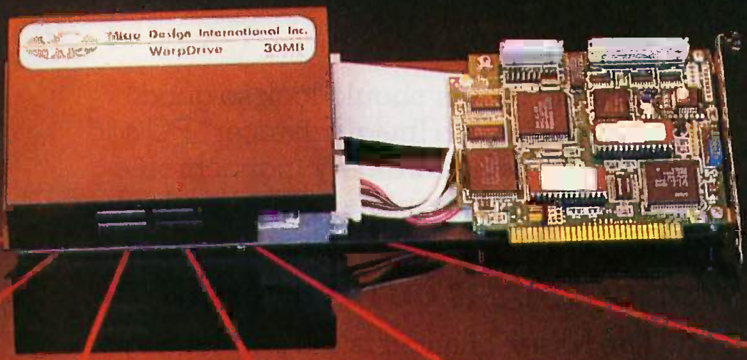

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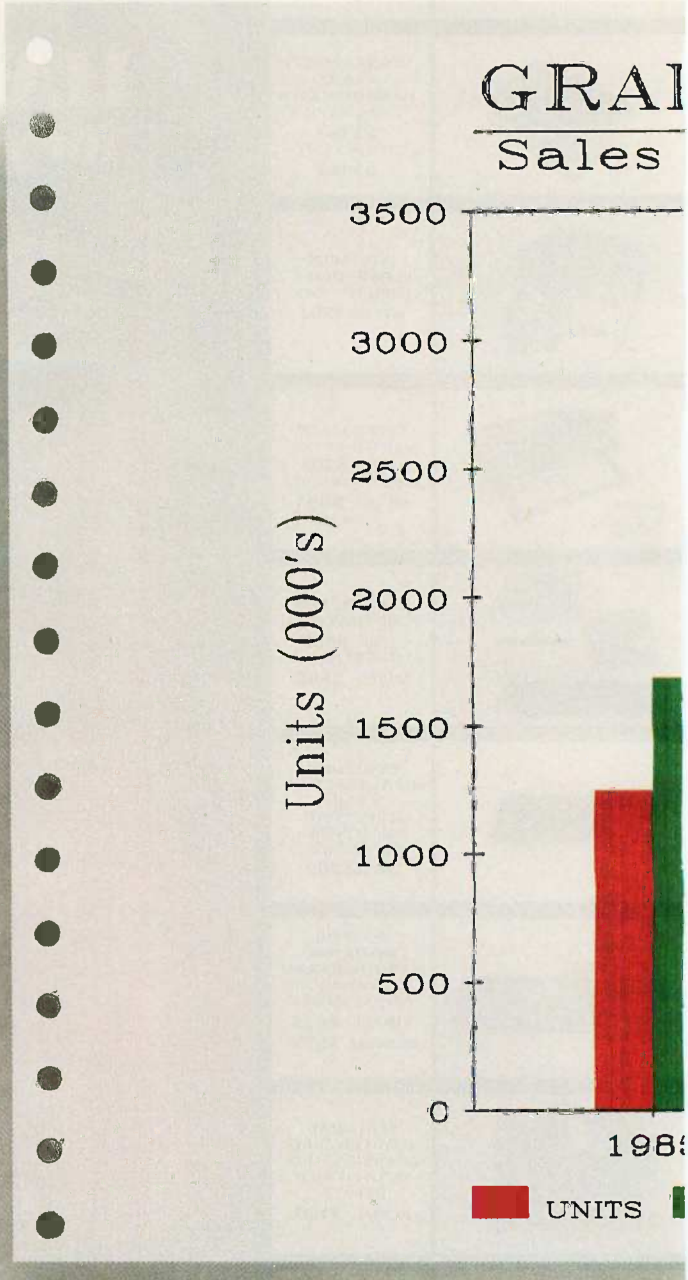

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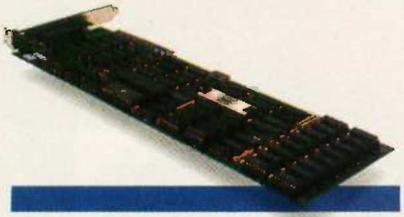

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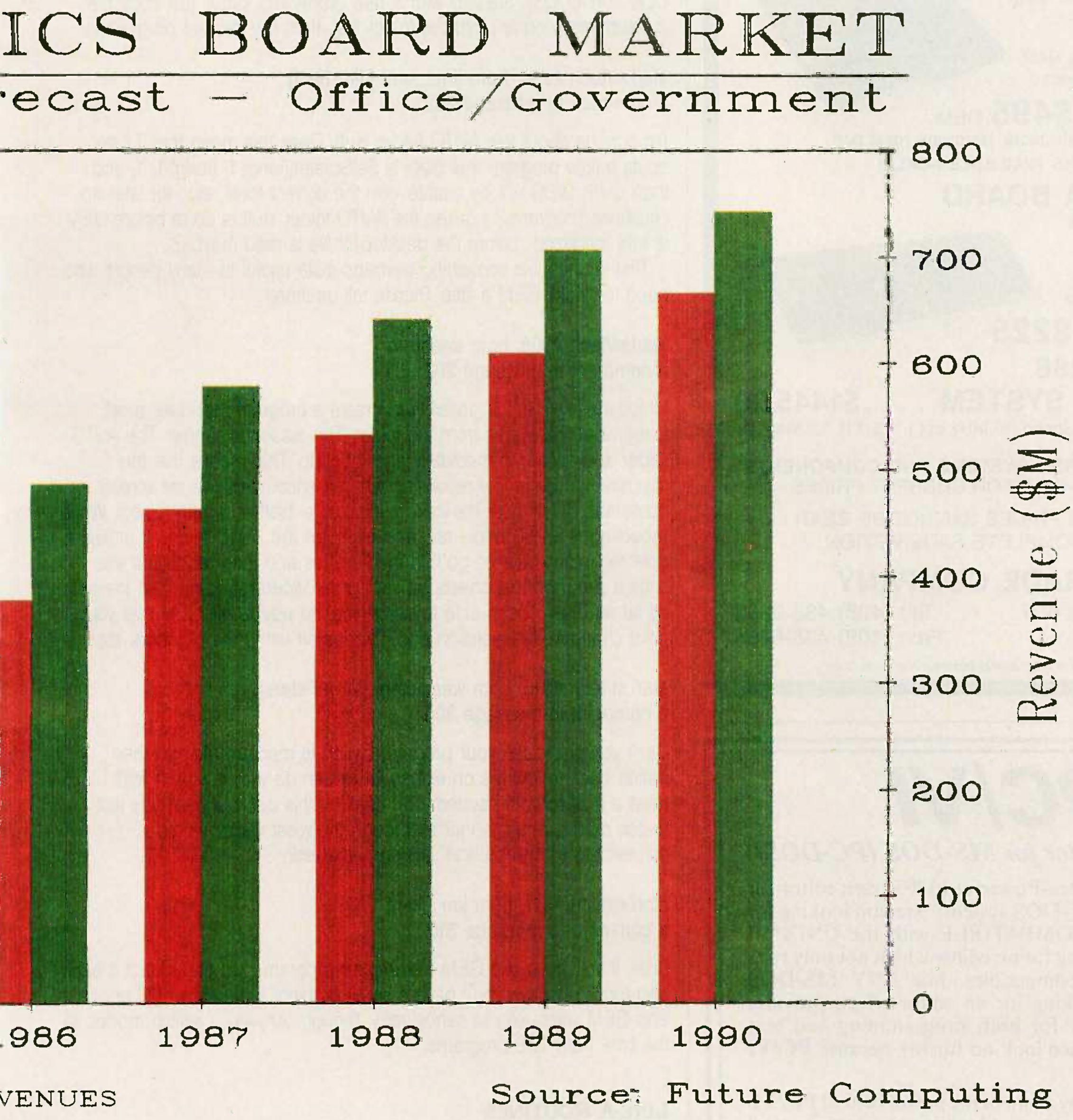

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be executed in the same order that low resolution will display them (in COMMAND.TOS). Starting with a new disk/AUTO folder, just copy the medium-res program into the folder first, then the desired program(s).

atari.st/tech #294, from jim_kent [Jim Kent]
a comment to message 292

I'm curious about this AUTO folder stuff. Does this mean that if I execute a little program that does a SetScreen((long)-1, (long)-1, 1) and then quits, GEM will be usable with the correct fonts, etc., for later applications programs? I guess the AUTO folder stuff is done before GEM is fully initialized, before the desktop.inf file is read maybe?

This sounds like something perhaps quite useful to many people who need to "trick" GEM a little. Please tell us more!

atari.st/tech #306, from swestrup
a comment to message 292

Unfortunately, it is *not* possible to create a program that does a set screen call that works from the folder. The reason is simple: The AUTO folder is executed immediately after boot-up. That means that the machine will be in low resolution when it encounters the set screen command. It will note the new resolution to itself and then reboot. While rebooting, it is still in low res and executes the AUTO folder. It makes a note reminding itself to go into medium res and then reboots. If you write a program that cheats by setting the video registers, then there is, as far as I have been able to determine, *no way* to tell GEM that you have changed its resolution and it keeps on using the old fonts, etc.

atari.st/tech #310, from wes.peters [Wes Peters]
a comment to message 306

Can't you just make your program switch to medium res and then switch back to low res on exit so GEM can do with it what it will? I have a monochrome system so I can't try this out, but can't you just switch modes and then jump through the reset vector stored somewhere in the "biblical" system variables?

atari.st/tech #311, from jim_kent
a comment to message 310

Sure, if you don't use GEM inside your program, you can switch it back and forth. I believe you'll have a small problem if there's an I/O error and GEM wants you to cancel/retry, though. Anyway, I switch modes all the time from TOS programs.

LINE-A ROUTINES

atari.st/tech #229, from chriskuku [Christoph Kukulies]

I am stuck in a problem due to lack of documentation of the $1007 (bitblt) (read $a007). It says in the Line-A document that A6 points to a block of parameters. Maybe someone can give me a layout on these parameter blocks. I wanted to switch the logical screen base with Setscreen( ), then draw something hidden with VDI calls, and then perform a vro_cpyfm(. . .) with source_mfdb and dest_mfdb set (not equal to zero). vro_cpyfm does not work (!), so I turned, like so very often before, to Line-A. Who can help me?

atari.st/tech #232, from jim_kent
a comment to message 229

Chris, this is well documented if you have the developer's kit on pages 6 and 7 of the Line-A document. It looks something like:

```
struct blit_block
  {
  short b_wd, b_ht;
```

(continued)

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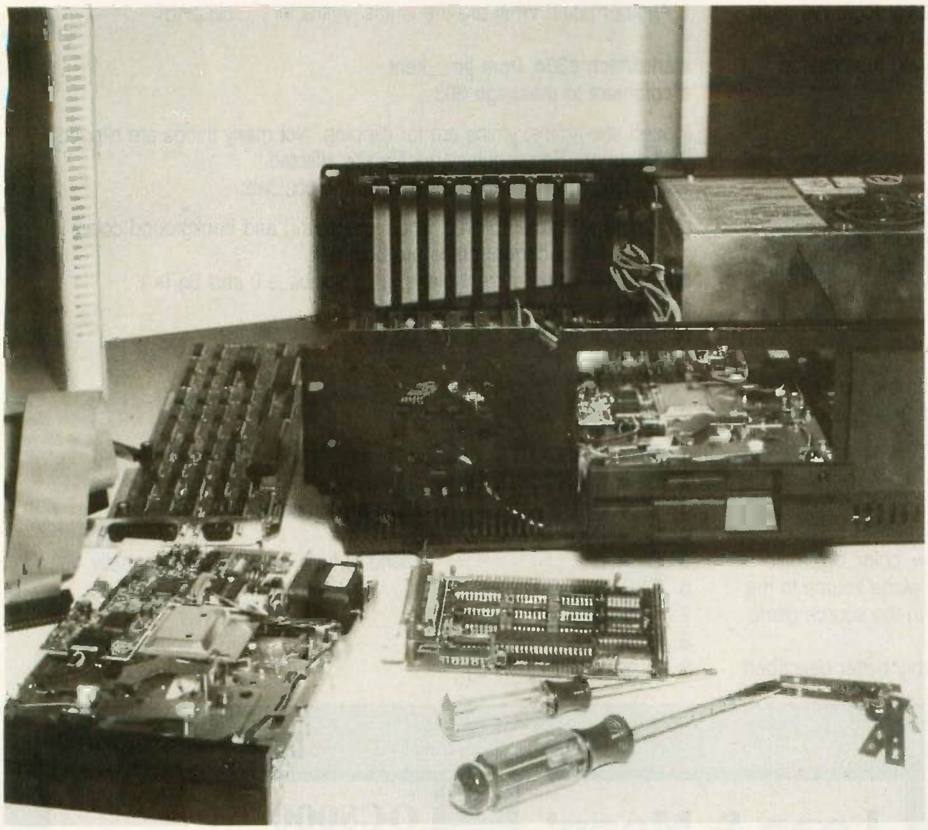

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```
 short plane_ct;
 short fg_col, bg_color;
 char op_tab[4];
 short s_xmin, s_ymin;
 short *s_form; /*pointer to the source pixels */
 short s_nxwd, s_nxln, s_nxpl; /*offsets to next word, line, plane */
 short d_xmin, d_ymin;
 short *dform;
 short d_nxwd, d_nxln, d_nxpl;
 short *p_addr; /* == NULL for no pattern */
 short p_nxln, p_nxpl;
 short p_msk;
 char pad[24];
 }
```

The op_tab is one of the more cryptic bits of raster logic I've seen. It works with the fg_color and bg_color. If you tell me more specifically what you want to do, maybe I can tell you the color/op combinations to try.

atari.st/tech #234, from alexl. [Alex Leavens]
a comment to message 229

Check over in the GEM conference for commented C source code on using the bit-blit routines from C. The parameter blocks are identical to what you need for the Line-A stuff. The files in question are in gem/listings.st and are CRABS.C and MULTBALL.C.

atari.st/tech #296, from chriskuku

Now I'm at the point where I need to know more on the op_tab[ ] parameters. Where can I get this Line-A Document (which is obviously more detailed than where my information came from)?

atari.st/tech #299, from jim_kent
a comment to message 296

Try making the op_tab = {4, 4, 7, 7}, fg_color = color, bg_color = anything, and s_nxpl = 0. This will take a single plane source to the dest, making the dest color where there are ones in the source plane, and leaving the dest alone elsewhere.

However, the op/color combination stuff is probably better described in the GEM VDI manual (chapter 6) than in the Line-A bit.

I got what documentation I have from Atari. $300 for the developer's kit . . . the dread Alcyon compiler, etc., and some documentation.

atari.st/tech #303, from chriskuku
a comment to message 299

Thank you, Jim, for the quick answer. However, I still require additional information on the meaning of the op_tab. It seems that the raster-op table in the GEM VDI manual does not correspond to the bit combinations I found. Could you or alexl. be so kind as to send me the necessary information to make bit-block transfers "by hand," that is, any source, any destination, any mode, preferably for monochrome but color wouldn't do any harm. Until I get the Line-A document from Atari you are my only hope.

Another point: What are the xmins, ymins for . . . clipping?

atari.st/tech #304, from jim_kent
a comment to message 303

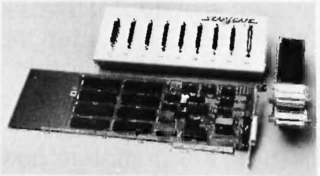
Indeed, the xmins, ymins are for clipping. Not many things are clipped by it, though. Rectangular area fills are affected.

OK, OK, here's some more stuff on the op_tab:

op_tab[0]—logic employed when foreground and background colors for current plane are both 0.
op_tab[1]—when current plane fg_color bit is 0 and bg is 1.
op_tab[2]—when fg is 1 and bg 0.
op_tab[3]—when fg is 1 and bg is 1.

Now for the logic . . .

```
0  D' = 0
1  D' = S AND D
2  D' = S AND [NOT D]
3  D' = S                    /*just a plain copy */
4  D' = [NOT S] AND D
5  D' = D                    /*kind of futile waste of time normally */
6  D' = S XOR D
7  D' = S OR D
8  D' = NOT [S or D]
9  D' = NOT [S XOR D]
```



10 D' = NOT D
11 D' = S OR [NOT D]
12 D' = NOT S
13 D' = [NOT S] OR D
14 D' = NOT [S and D]
15 D' = 1

So this is the official stuff, but what does it mean? Another example: If you want the (new) destination to be a copy of the source, set op_tab[0] = op_tab[1] = op_tab[2] = op_tab[3] = 3 bg_color = fg_color = anything.

USING BIOS FROM INTERRUPTS

atari.st/tech #266, from rchecketts [Rick Checketts]

Has anyone tried calling the Atari ST BIOS from an interrupt routine? I was trying to use the serial I/O routines from within an interrupt, saving registers and using a private stack space, etc., and while the program ran for a while, it bombed for no apparent reason. Any ideas?

atari.st/tech #269, from davjon [David Jones]
a comment to message 266

I don't know if this is any help, but I was having similar problems—I was calling some of the sound-oriented BIOS calls in an interrupt routine and kept getting *lots* of bombs after a while of correct operation. I solved the problem by disabling all interrupts at the start of the routine and enabling them again afterwards. My best guess is that the BIOS re-entrancy rule (no more than 9 levels, I believe) is being violated or something.

atari.st/tech #271, from jim_kent
a comment to message 269

No more than 3 levels of re-entrancy, I believe.

atari.st/tech #273, from sak
a comment to message 271

Plus, aren't there 3 or 4 routines that cannot be called during system processing at all? I don't have the guide handy, but I do remember something about using the printer during a BIOS interrupt. (Excuse me, TRAP! Old habits die hard.)

atari.st/tech #278, from rchecketts
a comment to message 273

The guide does say something about the printer but my routines didn't try talking to the printer. I did try blocking interrupts, and while this had some effect, it did not cure the problem. I did notice that the crash usually occurred during evnt_multi, so I tried flagging that evnt_multi was active and skipping the interrupt routine and again this helped; that is, the program ran a bit longer and then bombed. I've worked around it for now by leaving the interrupt just doing timing, etc., and leaving the rest to a fake interrupt that's just called as often as possible. Not an ideal solution. I'd still like to do it right!

atari.st/tech #279, from jtittsler
a comment to message 278

Here are some notes on using a BIOS function within an interrupt handler:

Nested Traps and Interrupts

Occasionally it may be necessary to make "nested" BIOS calls (for instance, to get keyboard input from a critical-error handler). The BIOS is re-entrant to three levels; the total number of standard and extended BIOS calls may not exceed three. Exceeding this limit will cause the

(continued)

system to crash.

It is possible to call the BIOS from an interrupt routine. The basic problem is to get around a non-atomicity bug in the BIOS trap handler. Before the interrupt routine can call the BIOS, it must decrement the system variable "savptr" [$4a2 long] by 46; after the trap, "savptr" must be restored to its original value. The interrupt code is responsible for its own mutual exclusion. This interrupt "level" does not count as one of the three nested BIOS calls.

Applications should not attempt disk or printer I/O from critical-error or interrupt handlers.

COMMAND LINE

atari.st/questions #205, from sprung

Can someone give me a quick rundown on the command line? I need to pick it up from Modula. Where is it and what's the format? It must be in these docs somewhere.

atari.st/questions #222, from alexl.
a comment to message 205

Ron, the command line is a simple little thing that sort of allows you to do MS-DOS-like things (like passing parameters to a program). Don't bother with it. Buy Beckemeyer's C-Shell.

atari.st/questions #223, from sprung
a comment to message 222

Thanks Alex—I know *what* the command line is. I need it for my own utilities in M2. I have C-Shell, and I talked with David Beckemeyer about the command line, but he didn't know how I could get it either. All I really need is a simple way to pick up the base page address at run time.

According to the review in May "Antic," Personal Pascal provides the command line, but no sign of it in M2.

atari.st/questions #224, from jtittsler
a comment to message 223

Well, I don't know how to do it from M2, but when a program is invoked, a pointer to the base page of that program is available under the long on the top of the stack. In code (which is a bit easier for me to deal with than English):

```
start: move. 4(a7),a0 * a0 now points to the base page
       move.l a0,__base * put the pointer in the C
                        * external
```

It is quite possible that the M2 run-time library does something similar.

atari.st/questions #225, from sprung
a comment to message 224

"under the long . . . "—What exactly is in A7? And what does the 4 do to that number? I can pick up the A7 register (or any other), but I'm not clear on how to make that into the base page address.

atari.st/questions #226, from cheath [Charlie Heath]
a comment to message 225

```
    move.l          4(a7),__base
```

will take the address that was the last thing put on the stack into "__base," which you can reference within the language (assuming M2 has the same underscore convention as C).

atari.st/questions #227, from sak
a comment to message 226

Yeah, but isn't that assuming the M2 run-time library hasn't used the stack already?

atari.st/questions #228, from sprung
a comment to message 227

That seems to be the case—I've been playing around with it and have managed to pick up and reference the address off the stack, but it does not contain the base page address by the time I get it. Sigh. I'll have to pursue it with TDI. Thanks, guys.

atari.st/questions #229, from jtittsler
a comment to message 225

A7 is the stack pointer. It is a very reasonable thing for the run-time library to squirrel away that pointer before it does anything else. For example, in the developer's C compiler that I use, that function is the first thing done in the startup module (GEMS, GEMSTART, MYGEMS, etc.).

SCREEN ESCAPE CODES

atari.st/questions #236, from sprung

Can someone tell me where, in the DevPak or elsewhere, to find all the screen and cursor control sequences for the monochrome monitor? Or exactly what it emulates, as I have the VDT book by Stephens. If VT52, my book lacks cursor on and off (which I got from Steve Tether's code) and reverse video.

atari.st/questions #237, from alexl.
a comment to message 236

The screen codes are in the "Hitchhiker's Guide to the BIOS."

atari.st/questions #239, from jruley [Jonathan Ruley]
a comment to message 236

Get the abacus "internals" book—it has a pretty good rundown. The emulation is incomplete VT52.

atari.st/questions #243, from jtittsler
a comment to message 236

The screen escape codes are an (improper) superset of those in the VT52, with a few additions from the H/Z-19 (and a couple more that provide similar functions but are accessible in a 2-character sequence instead of 3). Specifically, for the ones you asked about:

ESC e	Enable cursor
ESC f	Disable cursor
ESC p	Enter reverse-video mode
ESC q	Exit reverse-video mode

Also, someone was asking about wrap/nowrap:

ESC v	Wrap at end of line
ESC w	Discard at end of line

One shortcut to erase home is

ESC e	Clear screen and home cursor (same as ESC h ESC j)

IBM PC AND COMPATIBLES

The majority of this month's IBM PC section is taken up with an involved exploration for the answer to a seemingly simple question. A query concerning a single interrupt provokes lengthy discussion culminating in the dissection of PRINT. In addition to being informative from a systems point of view, this example shows the real nature of online conferencing, which allows running discussion without constraints of time or location. This central discussion is bracketed by a short thread on interfacing an Apple color monitor with a PC compatible, and a more involved thread on the intricacies of calling C language subroutines from inside a BASIC program.

APPLE MONITOR TO PC CONNECTION

ibm.pc/pc.hardware #806, from rjackson [Robert Jackson]

I have an interesting project that no one around here can help me with. I have an Apple RGB Color Monitor 100 that I would like to hook up to my Z-150 (IBM compatible). My first problem is that I can't find anyone who can tell me if it will work in the first place, much less help me build the necessary cable. If anyone can help, I would appreciate it. I use both computers every day and really miss the color on my Zenith.

ibm.pc/pc.hardware #807, from dmick [Dan Mick]
a comment to message 806

Do you have docs on IBM-compatible video output (or Zenith's docs for their board; same thing) and docs on the input connector for the Apple monitor? There are so few signal lines that it seems from examining these docs you could glean what you need, even if you're not an EE.

ibm.pc/pc.hardware #808, from barryn [Barry Nance]
a comment to message 806

I haven't the slightest idea of what the connector for the Apple RGB monitor looks like, but here's what the TTL output of a standard IBM Color Graphics Adapter looks like:

```
              <------  Ground  ------> 1
              <------  Ground  ------> 2
 TTL Adapter  <--------  Red  --------> 3   Color Graphics
    RGBI      <-------  Green  -------> 4     RGB Output
   Monitor    <--------  Blue  --------> 5   9-Pin D-Shell
              <------ Intensity ------> 6     Connector
              <------ Reserved ------> 7
              <----- Horiz. Drive -----> 8
              <-----  Vert. Drive  -----> 9
```

ibm.pc/pc.hardware #809, from rjackson
a comment to message 808

Thanks for the IBM pinouts. I now have two problems. First, I can't get anyone to tell me for sure if the monitor (frequency- and scan-rate-wise) will really work on an IBM. Second, Apple wasn't kind enough to supply the pinouts for their monitor. That shouldn't be too hard to get, considering the available technical information on the Apple II. If anyone knows whether or not the Apple RGB monitor will work, I'd really appreciate a yea or nay.

ibm.pc/pc.hardware #817, from mfg [Marc Greenfield]
a comment to message 809

I have converted an Acorn color monitor to work on my IBM by simply attaching a DIN-9 connector to the circular plug that would normally have attached to an Apple. I think that based on this your monitor should work on your IBM, that is, unless it is a special brand that may work with a special controller. If the pin configuration matches that listed in one of the comments above, then it should work OK.

INTERRUPT 28H

ibm.pc/pc.software #999, from jcummins [John Cummins]

Anyone know what INT 0x28 does?

ibm.pc/pc.software #1002, from jrobie [Jonathan Robie]
a comment to message 999

It isn't used by BIOS, according to my IBM PC Tech Ref manual.

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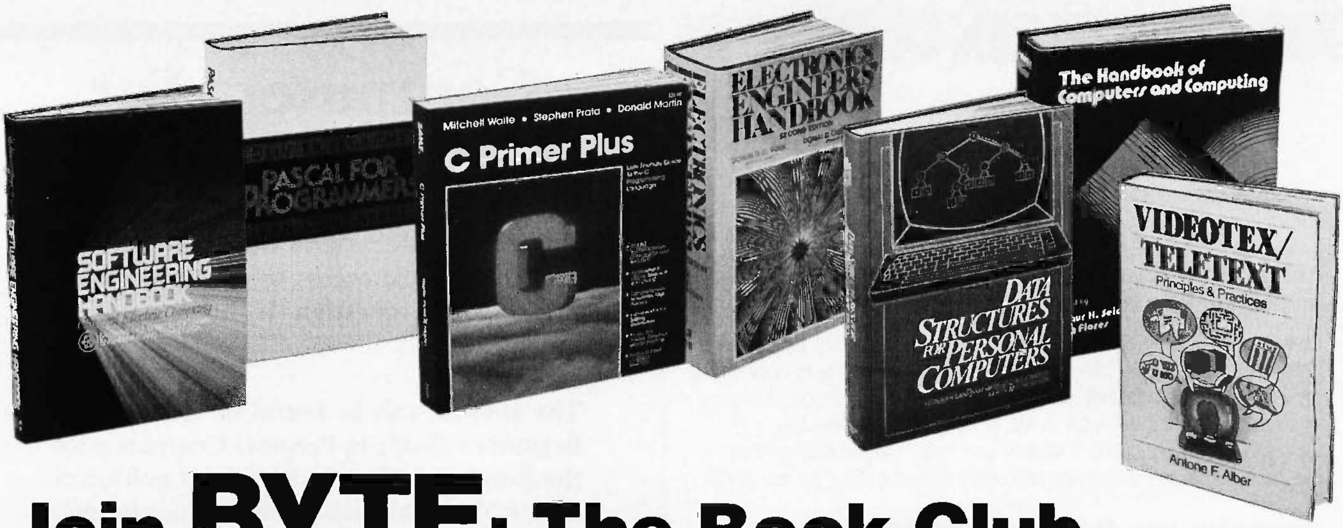

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Where is this interrupt used?

ibm.pc/pc.software #1007, from dmick
a comment to message 999

My impressions are, from looking at its code and the code for the "transient loader" in DOS 2.1, that it is the loader for COMMAND.COM to initialize the system. Once I have DOS loaded, there's not a single INT 28H to be found anywhere in memory, DOS's or otherwise, which leads me (also) to that suspicion. You might snoop at IBMDOS.COM and see if it's called in that code.

ibm.pc/pc.software #1008, from mjk [Martin Kochanski]
a comment to message 999

INT 28 is called by DOS repeatedly whenever it gets bored, that is, waiting for the user to type something at the keyboard. INT 28 does nothing whatsoever. But if you have the standard print spooler PRINT.COM installed, then it intercepts INT 28 and copies a little text to the printer before returning to DOS (which tests the keyboard and calls INT 28 again if there's still nothing). It *may* follow that you can use INT 28 for some background purposes of your own, and even that you can call DOS disk routines from within it, but I'm not sure.

ibm.pc/pc.software #1009, from dmick
a comment to message 1008

Yeah, I was thinking of INT 2EH, which someone asked about earlier. INT 28H does exactly nothing (IRET) on the IBM XT and Zenith Z-150, that's right. However, I couldn't find *any* calls, including DOS calls, to it either. I'll look again on both, I guess, and examine PRINT.COM, too. I always thought PRINT used the timer interrupt.

ibm.pc/pc.software #1010, from barryn
a comment to message 1009

>thought PRINT used the timer interrupt.

I think PRINT uses IRQ7 (hardware interrupt F, at addresses 3C-3F) to tell it when it can send the next character to the printer via INT 17.

ibm.pc/pc.software #1011, from dmick
a comment to message 1010

That would seem to make any other process (the foreground task) be awfully slow; that is, the CPU is tied up printing chars as fast as it can. OK, OK . . . I'm ripping PRINT apart tomorrow. You guys just won't let me get disinterested in whatever you bring up!

ibm.pc/pc.software #1012, from barryn
a comment to message 1011

Don't bother tearing it apart . . . just try this experiment: Tell PRINT to print a fairly long file, something that will give you time to do some telecommunications while it's printing. Then, while the print is occurring, use your communications software to log onto a bulletin board somewhere. Watch closely to see if some of the communications characters are dropped. Then hit the button on the printer that deselects it and watch for the dropped-characters problem to go away.

The missing communications characters are a result of the PRINT program tying up the PC's interrupt processor for too long a time.

ibm.pc/pc.software #1016, from rschnapp [Russell Schnapp]
a comment to message 1010

I seriously doubt that any IBM/MS software uses IRQ7. It was poorly implemented on early monochrome adapters, and the bad design was copied by too many board makers. The INT 28 hook to PRINT sounds right.

ibm.pc/pc.software #1017, from suer [Sue Rosenberg]
a comment to message 1016

The following information about INT 28 came from the NBS bulletin board and was posted by Ross M. Greenberg:

INT 28: Internal routine for MS-DOS

This interrupt is called from inside the "get input from *keyboard*" routine in DOS if, and only if, it is safe to use INT 21 to access the disk at that time. It is used primarily by the PRINT.COM routines, but any number of other routines could be chained to it by saving the original vector and calling it with a FAR call (or just JMPing to it) at the end of the new routine.

Until PRINT.COM installs its own routine, this interrupt vector simply points to an IRET op code.

ibm.pc/pc.software #1018, from dmick
a comment to message 1017

Thanks, Sue! Timely for sure! And thanks for trying to save me the time, Barry, but if it's not obvious by now, I'm kind of obsessive. I'll investigate and find out what all of you are telling me, I guess, although there still seems to be some controversy over INT 28H software call or hardware interrupt.

ibm.pc/pc.software #1021, from dmick
a comment to message 1012

But if PRINT used IRQ7 like you say, the communications ports (IRQ2 and 3) would take precedence, right? What I mean is, wouldn't the serial interrupt interrupt the IRQ7 service routine? Or does the 8237 mask out all eight while it services one interrupt? I forget and don't have my hardware docs handy.

ibm.pc/pc.software #1022, from barryn
a comment to message 1021

Good question. Did you have a chance yet to trace through PRINT.COM to see exactly what's going on?

ibm.pc/pc.software #1024, from dmick
a comment to message 1022

No, but you can bet I will. I did look at my reference for the interrupt controller, though, which is (contrary to what I said before) an 8259A (I've been having problems with my DMA chip, too). Anyway, if a lower-level interrupt comes in while a higher level is being serviced, the 8259A passes the IRQ to the CPU, which will respond *if* the interrupt mask is enabled (STI). So, if PRINT's hypothetical ISR for IRQ7 does an STI, the comm ISR should execute in the midst of PRINT. I should just shut up until I get to PRINT.

ibm.pc/pc.software #1028, from dmick
a comment to message 1024

ACK! <---Bill the Cat
Gad! PRINT takes over the following vectors:
28: Called once from within DOS. I can believe it's from the KB handlers. Just before an exit from the routine, whatever it is.
2F: Documented. Unused except by the PRINT system.
13: Disk access (!). Seems to be a sort of "isolation" call . . . don't print characters while disking, maybe?
17: Printer. Obvious reasons.
05: Print screen. Can't start one unless no print files going. Reasonable.
14: Communications (!). Pretty complex. I'll look a little further. I suspect this is to add buffering (and maybe has a bug, Barry).
1C: Timer tick. I'll bet this is what does the actual bground/fground context switch to send some chars to printer. Looks that way.

There's a million variables/semaphores involved with this (surprisingly big and complex) routine. I think just for my own information about context switching, I'll probe further . . . but not tonight.

Who asked about this, anyway? Have we answered your question yet?

ibm.pc/pc.software #1030, from barryn
a comment to message 1028

It's past the point of caring who asked about this. It's reached the point of raw, unadulterated curiosity . . . .

Let's see. First off, I notice INT F isn't on the list. There goes my original theory out the window.

INT 13? PRINT.COM *does* print from the disk, unlike other spooler programs. I can see why PRINT would need to be "protectionist" about the disk. I wonder if it releases (restores) the previous INT 13 vector when it finishes?

INT 05 . . . I've replaced that one on occasion myself. If PRINT did things by the book, it wouldn't replace the interrupt vector; it would just set the print screen flag (at 0050:0000) to a nonzero value. This is supposed to tell the print screen routine that something is in progress and it had better not dump the screen at this time.

INT 14? Maybe it has to do with being able to redirect parallel output to a printer connected to a serial port. It can't be for buffering purposes . . . the INT 14 routines don't provide any buffering and are pretty useless for communications purposes, except perhaps for setting baud rate and communications parameters. INT 14 should *never* be used for actual send/receive operations.

ibm.pc/pc.software #1040, from dmick
a comment to message 1030

Yeah, INT 14 probably has to do with serial printers. But I meant it *might* be adding the buffering to the ISR that should've been in the BIOS from the beginning, since things are just that much more critical when you've got a PRINT process hogging CPU time. About your comments on INT 05 (print screen) . . . seems like that flag is defined as "there's a screen print" in progress or "error during screen print," which may or may not be generally applicable to printer activity in general. Do any popular applications or languages allow you to interrupt a print procedure with a print screen request? Hmmm . . . guess I've got *another* thing to investigate.

ibm.pc/pc.software #1042, from barryn
a comment to message 1040

If the INT 05 routine leaves a value of 255 in the print screen flag, it's signaling that it ran into an error. However, if the flag has a value of 1 when the Shift/PrtSc keys are pressed, the INT 05 routine will just exit (no action taken). Or if INT 05 is invoked from within an application and the flag is already a 1, it just exits.

ibm.pc/pc.software #1044, from dmick
a comment to message 1042

Yeah, right, but it's set/read by the INT 05 routine; that was my only point. (Actually my point was that it was defined to be set/read by that guy. Whether or not he's the only one allowed, I don't know.)

ibm.pc/pc.software #1045, from barryn
a comment to message 1044

Well, if I wrote a payroll application that printed checks, I'd be sure to stick a "1" in the print screen flag while I was printing checks. Whether programmers actually go to that extent or not I don't know. I understand a great deal of IBM's "application software" (such as the Assistant series) was ported from System/23 BASIC to the PC, and I doubt if much effort was put into any of the peculiarities of the PC.

ibm.pc/pc.software #1046, from dmick
a comment to message 1045

I know what you mean . . . I'd either set the flag and hope it worked in the next BIOS release or take the INT 05 vector and use my own flag. By the way, WordStar, Lotus 1A, and my favorite program editor *all* allow print screens while printing.

(continued)

LINKING BASIC AND C

ibm.pc/pc.software #1141, from pcl [Peter Cleary]

Hello. . . .

I'd like to know if anyone here has tried to make a patch to link C and BASCOM. I have an application that now has to use files to communicate data back from C. I really don't know why they decided not to support BASIC. Many existing BASIC programs could use some optimizing. Meaning C subroutines. If any .ASM wizard has done it, could he/she let me know about it? Thank you.

ibm.pc/pc.software #1142, from gperfect [George Perfect]
a comment to message 1141

I hooked Microsoft BASIC (compiled) into some Texas Instruments speech driver routines written in Lattice (I think) some years ago. The TI code was designed as standard C libraries so the code should remain sound. Basically, you need to convert arguments passed by BASIC's "CALL func(args)" facility into the format expected by your C compiler. BASIC passes *all* arguments as pointers. Version 5.3 of the Microsoft compiler (and later) passes them on the stack. Where the called C function expects (say) an INT *value*, your conversion routine must push the value *pointed at* by the BASIC argument onto the stack.

On return from C, you must remember to pass back the returned value, if any. I did this by passing an extra argument via BASIC's CALL and stored the result in that.

A couple of ground rules:

- *Never* allow C to modify a BASIC string—at least not its length. BASIC strings are stored with two bytes (an INT) describing the length immediately followed by the string itself. C has no length field but stores a NULL (zero) byte at the end of the string.
- If you pass a BASIC string to the C routine (say, a filename) BASIC actually passes a pointer to its length field. You must increment this pointer by two bytes before passing it on to C.
- Some C routines use quite a lot of stack space; ensure the stack in your main program is adequate or switch to a separate stack (the approach I adopted) before calling C.
- Be wary of calling C functions that allocate memory or perform I/O on standard devices (stdin, stdout, etc.), as these are normally initialized by the C program's startup routine, which will *not* have been called. Some C functions call these routines as side effects; if in doubt, read your library manual.

I hope this helps. If you need any more info, let me know. If necessary, I'll dig out the assembler I wrote to do the job and post it in long.messages.

ibm.pc/pc.software #1144, from btonkin [Bruce Tonkin]
a comment to message 1142

BASIC strings are passed as a pointer to the string descriptor. On 8-bit versions of BASIC, the first byte pointed to is the string length, and the next two bytes are the location of the actual string. On 16-bit versions (compiled), the first *two* bytes are the length as a signed integer, and the next two are a pointer to the string in the current data segment. Neither the length nor the pointer may be modified except in very special circumstances.

ibm.pc/pc.software #1145, from barryn
a comment to message 1144

What circumstances, Bruce? I thought it was absolutely forbidden to touch the string descriptor from within an assembler subroutine. If there's a way to do it, I'd sure like to know.

ibm.pc/pc.software #1146, from btonkin
a comment to message 1145

If the string descriptor points to a file buffer, then the length of the string or the location of the string may be changed *if* the length can be entirely contained within the file buffer and *if* the string is still within the file buffer after the change. I did it routinely with the CP/M compiler and it'll work in the MS-DOS compiler, too. But be careful! Point it to the buffer *before* you fiddle with it! Also, on the MS-DOS stuff, there's something called a "string back pointer" which can mess things up, though I don't know what it's supposed to do.

If you do garbage collection before you call your routines, and if you save all pointers before you fiddle with the string and restore them before you return, you can get away with fiddling, too. Have fun!

ibm.pc/pc.software #1147, from barryn
a comment to message 1146

Sounds like walking into the Black Lagoon in the dead of night. . . .

ibm.pc/pc.software #1148, from dmick
a comment to message 1146

Um . . . the back pointer points backward somehow. I figured this out once, but I believe it's a pointer to the string right behind (earlier defined, or higher in string memory) the one to which it belongs. I forget where it is, though. Seems like it's the last item in the string area (after the actual string data) or before it. I thought it was added to help garbage collection. . . seems like I read this somewhere.

ibm.pc/pc.software #1150, from gperfect
a comment to message 1144

Apologies, apologies, apologies!

Bruce is quite correct in his description of BASIC string descriptors and I was quite wrong. You can see how long it is since I did any serious work in BASIC. I hope nobody spent any time trying to produce working code with my earlier descriptions. The remaining info is still valid, however.

ibm.pc/pc.software #1152, from gperfect
a comment to message 1144

I just looked up the correct description for Microsoft BASIC strings in the V5.35 compiler manual. Page 97, paragraph 8 says, "If the argument is a string, the parameter's offset points to four bytes called the string descriptor. Bytes 0 and 1 of the string descriptor contain the length of the string (0 to 32767). Bytes 2 and 3 respectively are the lower and upper eight bits of the string starting address in string space.

"The string start address points to a two-byte flag and a two-byte back pointer (for efficient garbage collection), followed by the actual string. *The compiler string space should not be tampered with, or a 'String Space Corrupt' error may result*" (their emphasis). This is maybe where Dan saw the reference to back pointers and garbage collection.

MACINTOSH

Confusion over the effects that any of the various upgrades can have on your system has dominated the Macintosh conference, a dominance that is reflected in the selections here. In the midst of the confusion, there is a discussion on the philosophical considerations of compiler design. With this brief exception, the section concerns itself with upgrades, giving attention to (among others) disk formats, cooling fans, and power supplies.

UPGRADE OBSERVATIONS

macintosh/mac.plus #35, from dpallen [David Allen]

I just upgraded my 512K Mac with the addition of internal and external drives and new ROMs. I have not upgraded the logic board yet because I need the power from the unupgraded communications port to drive my Macvision and Penmouse+ pad. (Besides which, my dealer doesn't have any right now.)

I have the System Installation disk that was provided with the February 1986 update to "Inside Macintosh." This disk provides system 3.1.1 and an install program that does not work. It gets the wrong date from the 3.1.1 and throws up. Apparently the install program was date-sensitive to either the 3.0 or 3.1 version and Apple forgot to change the date for 3.1.1. If anyone has a quick fix for that one I would appreciate it. Meanwhile, I am using the known buggy 3.0 that comes with the disk drives because I don't want to take the time to reinstall my desk accessories into all my boot disks, which I would have to do if I brute-force-substitute 3.1.1 for the old system file.

In olden days I could remove the Finder from the boot disk when necessary for disk space considerations and just specify the boot program to use. It appears that one must retain the Finder on any boot disk, even when one does not want to use it. At least I am unable to get a boot from a systems file that does not contain the Finder in the same window/folder. Is this true? If so, it is really a step backward. I wanted to reduce the size of the RAM disk folder so that everything would fit inside a 339K RAM disk. This I have done with the old system. I can't do it with this one because the Finder insists on coming for the ride even though I told him to stay home and mind the kids.

Is there any way to force the system to find a file outside the current window? It's a pain to have things bollixed up just because the system can't find a file that is really there.

Although there is some improvement in disk speed operations, I do not see the whiz-bang speedup that some of my friends with Pluses are remarking about. Is this because I don't have the new logic board yet? I had hoped that things would be faster than they are.

Joe Miller of Koala tells me that the cable/power supply cobbled up by the Thunderscan people will also work for Macvision. Koala plans to provide the self-same cable arrangement as a product in the next couple of weeks. Also coming is a new Morevision program, since the old one will not work with the new ROMs. The older desk accessory software for Macvision *does* work OK with the new ROMs though, so I am not completely out of business with Macvision. Koala is going to add more capability to Morevision when they re-release it to fix the ROM compatibility problem. Look for even better performance from Macvision with this new software. Apparently there has been some hidden capability in the Macvision box that the older software has not addressed.

The folks at Kurta are coming up with a new connector and internal circuit board so that the Penmouse+ tablet will continue to work from the communications port of the Mac Plus. They claim to be able to make their tablet work from the Mac Plus communications port even though the voltages previously available there have been removed. They are also going to drastically improve their Macintosh software to make it much more friendly. (Much needed.) Meanwhile, the Mousepad+ is definitely *the* Macintosh/Amiga/IBM PC mouse. It uses a cordless stylus with internal battery supply and works really well.

I see that Apple is continuing the charade that great disasters will immediately befall all who attempt to use single-sided disks initialized for two sides. In all the time I have used both sides of single-sided disks with the Apple II (hundreds of disks) I have never had even *one* disk failure from the use of the "other" side. The only disk failures I have witnessed were on the "front" side! As one manufacturer explained to me off the record, they don't even know which side of the disk will be the "front" side when the inspection takes place, so they have to be equally careful with *both* sides of the magnetic material. Apparently the only virtue in buying "double-sided" disks is that if you have a failure on the "back" side they will replace the disk under the warranty (big deal), while they won't with a single-sided disk "misused" as a double-

(continued)

sided disk. It isn't that they didn't inspect it. . .they just won't warranty it unless you pay the double-sided price.

Any comments on these observations will be appreciated.

macintosh/mac.plus #36, from bbayer [Barry Bayer]
a comment to message 35
Re: single-sided 5¼-inch disks:

Not only that but Apple uses the *bottom* of the disk, while (I have been told) Tandy uses the *top* (models 1 thru 4, at least). But most catalogs show the SS disk for both.

macintosh/mac.plus #38, from lloeb [Larry Loeb]
a comment to message 35

As was previously stated in another section, to get the installer to work, open it with ResEdit, and open the INSC resource. Change the date string from 9A740CF6 to 9A8B6777 and it should work. See TN76.txt in mac.supplmnt if all else fails.

macintosh/mac.plus #40, from mcgath [Gary McGath]
a comment to message 35

Just got my Mac upgraded today, and updated one of my Finder-less disks by temporarily removing an application to make room (having copied it), running the update, removing the Finder (but using the Minifinder), and then copying the application back. No problem.

macintosh/mac.plus #41, from dpallen
a comment to message 38

Installer script for Mac Plus update has INSC ID=0, which I opened. The only close strings I found were "9A740FF4" and "9874081D." I looked and found that I do not have tech note #76. Any further suggestions, Larry?

macintosh/mac.plus #43, from lloeb
a comment to message 41

TN76.txt is in Listings under mac.supplmnt. Is there a INSC resource in the System you want to update to? If so, change to that string.
Keep me posted.

macintosh/mac.plus #45, from hedges [Tom Hedges]
a comment to message 35

Although Apple's comments about single-sided disks being used on both sides are a little like a press release by disk manufacturers, I have had more than a few single-sided disks that failed disk initialization for double-sided and one that passed, wrote OK, and failed to read immediately thereafter (that one was the disaster just like Apple predicted). So watch out.

macintosh/mac.plus #46, from dpallen
a comment to message 45

I, too, have had a couple of failures in initializing disks with the new drives; however, they were accompanied by a peculiar mechanical squealing near the end of the initialization and the initialization failed. The disks would not initialize as single-sided after that either, even when I bulk-erased them.

macintosh/mac.plus #47, from hedges
a comment to message 46

My failure mode was not so dramatic. It got through the format and into the verify pass, then just said it couldn't initialize. If you try again at double-sided, no go; try at single-sided and all will be OK.

macintosh/mac.plus #48, from scottmac [Scott MacGregor]
a comment to message 47

I haven't had failures with single-sided disks yet, although I bought DD/DS when I upgraded. Somewhere I heard a comment that if a single-sided disk had been used a lot, that the other (unused) side had the pressure pad rubbing on it, and this was the most likely reason for not using it as a DS disk. I guess the moral is when using a single-sided as a double-sided, make sure it is relatively new!

macintosh/mac.plus #49, from lloeb
a comment to message 48

That rings true to me and would account for the horror stories one hears. If the pressure pad stuff hits the top head—bad news.

DECEMBER 1985 UPDATE

macintosh/tech.talk #183, from rschnapp [Russell Schnapp]

I know, I'm probably the last one to have bought the "December '85" Mac Software Supplement Additions.

I just tried to use the Installer on the System Installation disk to update a copy of my Paradise MAC 10 boot disk. There was no trouble installing the "External Disk" script. The "Mac Plus" script, though, fails before I can click Install. It says the System file's *date is incompatible* with the one in the script.

Do I really have to install System 3.1.1 the hard way (i.e., via ResEdit)?

macintosh/tech.talk #184, from lloeb
a comment to message 183

Yup. Change the INSC resource to 9A8B6777 from 9A740CF6. If I had a Plus, I'd verify a script and upload it. . .but I don't.

macintosh/tech.talk #185, from rschnapp
a comment to message 184

First, is that INSC resource in the script? I assume that's what you mean.

Second, I don't have a Plus, either. Their documentation said that you must perform the Mac Plus update to obtain the new System, Hard Disk 20, etc., even on a 512K Mac.

macintosh/tech.talk #186, from lloeb
a comment to message 185

First, yes. There should be a resource-type INSC in the script.

Second, do you currently have an HD20 file on your startup? Does it load HFS into RAM? The installer is based on purging RAM-based HFS. If you *have* to have RAM-based HFS (because you don't have the new ROMs) I'm not sure the newest system will be of much use to you. Comments?

macintosh/tech.talk #187, from rschnapp
a comment to message 186

Thanks, Larry. I tweaked the INSC resource and the installation worked. Yes, I have the Hard Disk 20 file in my startup. I updated a copy of my MAC 10 boot floppy and booted with mouse button held down (declining auto-mount of the hard disk and System). I then explicitly mounted the hard disk. Voila. It all works. After some investigation, though, I agree that Finder 5.2/System 3.1.1 doesn't really gain me much. I was hoping for the zoom boxes in the Finder, but I guess that is only if you get the 128K ROMs. Most of the really good stuff seems to be only in the ROMs, like menu sorting.

After hearing about the Red Ryder problems with RAM HFS and the new System, I think I'll hold off until I upgrade my ROM/disk. Red Ryder 7.0 still works just fine with 2.1/5.0 RAM HFS.

COMPILER QUALITIES

[Editor's note: The messages leading up to #316 dwell on the reputed speed of a not-yet-released compiler.]

macintosh/software #316, from hedges
a comment to message 306

As a developer I can't understand why everyone is so concerned with compilation speed. Freedom from bugs, quality of code, support for embedded MDS-compatible assembly language in-line all seem to be more important to me. A too-fast compiler may be nice if your marketing strategy is to lure away BASIC hackers to a compiled language (i.e., Turbo Pascal), but a developer on the Mac has to be far beyond that stage. If saving development time is the real objective, then everyone would be demanding a high-quality source-level debugger, because one certainly spends more time debugging than waiting for a slow compiler.

macintosh/software #317, from paul.hoffman [Paul Hoffman]
a comment to message 316

I agree, hedges. More good compilers will get us more good software from lower-level people. I never saw the "greater good" of Turbo Pascal on the IBM PC until I talked to two people who had bought it for nerdy fun and ended up releasing very good utilities into the public domain. It will probably happen here, too.

macintosh/software #318, from dwiner [Dave Winer, Living VideoText]
a comment to message 316

Hey—I want a good debugging environment, too! But fast compile speed is important because it makes it easier to make small tune-ups to your program and test them individually, instead of lumping a lot together. It makes it easier to trap bugs also—because if you changed your otherwise-debugged program in only one place, you should have a pretty good idea where to look for the problem!

Ideally, you should have your source code in one window and the running program in another—and such a fast compile time that you can tune up a program the same way a painter tunes up a painting!

macintosh/software #319, from bwebster [Bruce Webster, Consulting Editor, BYTE]
a comment to message 316

"...one certainly spends more time debugging than waiting for a slow compiler."

It's exactly the time spent compiling—adding code, increment by increment—that makes fast compilers appealing. You know the old "code-and-go" approach of BASIC hackers? And, of course, I design stuff right the first time, so I spend more time compiling than debugging (...trying to keep a straight face...).

macintosh/software #321, from jbaker [John Baker]
a comment to message 316

I agree; a fast compiler is nice, but given the choice between a fast compiler that generated mediocre code vs. a slow optimizing compiler that generated superior, high-performance objects, I would take the optimizer any day. The comment about a source-level debugger is also right on. The recently released native code Modula-2 compiler

(continued)

MacMETH has such a debugger, the best tool in the package, and I can assure you that a good debugger is far more useful than a fast compiler with a poor or (in the case of many Mac systems) nonexistent source-level debugger.

MACINTOSH PLUS POWER SUPPLIES

macintosh/soapbox #575, from hansen [Allan Hansen]

Since I had my 512K Mac upgraded to a Plus, I have had the power supply changed 3 (three!) times. Is that common (is the power supply not able to handle the new drive?) or was I just unlucky? I also had to have the focus redone after the last change. I thought my eyes were going bad.

macintosh/soapbox #576, from bwebster
a comment to message 575

Ouch. And my condolences.

macintosh/soapbox #578, from lloeb
a comment to message 575

I've had mine replaced because of voltage regulator/flyback transformer problems in the sweep circuit. Now I have an inexpensive Radio Shack 3-inch fan sitting in the central depression of the case. No heat problems now! Unless you have AppleCare, may I recommend same?

macintosh/soapbox #581, from hedges
a comment to message 575

I've had one Mac for almost two years and another for 15 months. Neither has ever failed (knock on wood) except a 64K memory chip died (of fright, I think) the night before I got up the nerve to put a Dr. Dobb's-style 512K memory upgrade into it myself. That upgraded 128K machine has since been upgraded with 1MB of memory, an SCSI adapter, and a homebrew 12-bit audio DAC, all of which use lots of power (and it will still drive a MacNifty Audio Digitizer that sucks more juice from the serial port). I guess I've got a good power supply board.

macintosh/soapbox #587, from mdelugg [Michael Delugg]
a comment to message 578

Larry,
Hate sounding *really* dumb, but is the fan set up to pull hot air up and out?? (I would assume, but have learned not to.)

macintosh/soapbox #588, from lloeb
a comment to message 587

The fan I have (3-inch RS #273-242) sucks air through the Mac and pushes it out. That is, the exhaust is away from the Mac. Sitting in the handle, it pulls air through the vent that is sometimes blocked by people putting their keyboard "into" the main body of the Mac. (Go look under the lip on the front. See that vent there?) I prop the whole thing up so one edge of the fan is resting on the top of the Mac and the other on the base of the indentation. It rests on a taped-down tongue depressor (hey, use the materials at hand, right?) so that the vibration isn't transmitted to the case. What I *should* do is make up some triangular rests for a fan and sell them through the back pages of BYTE for a 4000% profit. . .oh well, another business opportunity lost.

My message wasn't at all clear on the how of the fan, so I don't think it was a dumb question at *all*.

MACINTOSH PLUS QUESTIONS

macintosh/mac.plus #108, from jamurphy [Joe Murphy]

I just heard that my Mac Plus upgrade came in (I ordered it through my university consortium about 7 weeks ago) and in a couple days I am having my Mac upgraded. For those of you who have a Mac Plus or have had their Mac upgraded, I have a few questions:

1) I am using a Hayes Smartmodem. Will that adapter cable work as it should and make my modem usable?

2) Is there a cable available from Apple for use with the Mac Plus and the Imagewriter I?

3) Can I re-initialize my single-sided disks as double-sided?

4) I have heard that many people who have upgraded have quickly had their power supplies fail; anyone have this happen? And if so, did you have one of the original Macs with the bad power supply?

Thanks in advance.

macintosh/mac.plus #109, from lloeb
a comment to message 108

1) Probably.

3) Only if they are relatively new and the stuff from the pressure pad that wipes off on one side of the disk won't foul up the second head. Single-siders have this pressure pad where the new head wants to be.

4) My original 100-day analog board failed because the flyback transformer went, not because of the power supply part. (Mine had dark paper on the side that goes next to the case; the newer ones are white.)

macintosh/mac.plus #110, from jruley [John Ruley]
a comment to message 109

And make sure that you get the latest revision of the software tools (v. 3.0 I think) or you may have some *very* strange problems!

macintosh/mac.plus #111, from lloeb
a comment to message 110

Ummm. . .do you mean System/Finder? 3.1.1/5.2 is latest semi-stable.

macintosh/mac.plus #112, from jruley
a comment to message 111

Oh, sorry. Yes, the Finder. And I should have said v. 3.2—which we just got. 3.1 has problems with Multiplan (*out of memory ?!*).

macintosh/mac.plus #113, from lloeb
a comment to message 112

3.2/5.3 is frozen and out; you're right.

macintosh/mac.plus #114, from jamurphy
a comment to message 113

Yeah, really? When do you think the masses might get their paws on it? Is this version three-quarters done as opposed to 3.1.1, which seemed to be about half done?

macintosh/mac.plus #115, from jruley
a comment to message 114

I checked—version 3.2 is what I've got. It clears up the memory errors in Multiplan nicely—definitely better than 3.1.1 Try your dealer—ours had it but did not burst the packaging and put it in, so we got 3.1.1 in the box.

Which is a long-winded way of saying you have to ask for it!

macintosh/mac.plus #116, from erosenbaum [Ed Rosenbaum]

This is a weird comment about startup screens. First, you convert the straight MacPaint pics with something like "ScreenMaker" by Bill. Then, you stick the screen into the System Folder. Should work fine!

macintosh/mac.plus #117, from lloeb
a comment to message 114

It's going to be distributed to all registered developers by Apple.

macintosh/mac.plus #119, from paul.hoffman
a comment to message 117

Any idea when it will be sent out? And why only to registered developers? Certified developers need it just as much.

macintosh/mac.plus #122, from jruley
a comment to message 119

As do us mere users. . . .

macintosh/mac.plus #123, from lloeb
a comment to message 119

Registered developers pay $800. They gotta get *something*.

PASCAL

The Pascal conference (one of several language-specific conferences on BIX) provides a forum for the exchange of information and opinions about programming. In the messages below, Dave Winer, president of Living Videotext, shares some of what he and other programmers have learned about trying to write "well-behaved" Terminate and Stay Resident ("pop-up") programs. Then there is a short discussion of checking for printer activity from a printer spooler.

RULES FOR TSR (TERMINATE AND STAY RESIDENT)

pascal/source #25, from dwiner [Dave Winer, Living Videotext]

Part one

There is a very active group of programmers working on Borland's SIG on CompuServe, studying the technology of resident software. They're also working on a generic "shell" for residency—they include Bela Lubkin, Neil Rubenking, and Kim Kokkonen.

Bob Bierman, an LVT staffer, gave a presentation at the Software Entrepreneur's Forum, discussing the resident technology in Ready!. Mr. Kokkonen attended the meeting and took detailed notes on the presentation. With our permission, those notes were posted on the Borland SIG on CompuServe.

I thought this document would be of interest, so I am forwarding it, with Mr. Kokkonen's permission.

Part two

The following is a summary of a talk given by Bob Bierman of Living Videotext. Bob is the chief programmer for Ready!, the memory-resident outline processor. The talk was given on February 11, 1986, at the IBM Special Interest Group of the Software Entrepreneur's Forum in the San Francisco Bay Area. Bob described many of the techniques used to develop a "machine-friendly" memory-resident program. Any confusion in the following is due to the summarizer and not based on any problem of Bob's.

Ready! takes several steps beyond those of earlier memory-resident programs (TSRs). Perhaps most importantly, it allows the bulk of the TSR to reside in expanded memory (LIM EMS). A single version of Ready! self-configures to use EMS or not, depending on its presence in the system. When EMS is used, the kernel of the TSR in normal memory uses only 4K bytes. The rest of the code and data in expanded memory use about 175K bytes.

When the Ready! hot key is pressed, the first step is to determine whether it is safe to interrupt DOS or the application at that time. We will return to this important issue below. Assuming it is safe, Ready! remaps the EMS page window to access one section of the EMS code. Control is transferred to the EMS page window. Then a 16K page window is used to swap whatever is in the top 160K bytes of normal memory into EMS, while pulling the rest of Ready!'s code and data into the normal memory formally owned by the swapped area. Control is then transferred into normal memory and Ready! executes from there.

The swapping process takes about 1 second on a PC and negligible time on an AT. This swap time is apparently not bothersome to the users of Ready!, who are most happy to get their normal memory back.

The swap of Ready!'s code is made into high memory of the PC to hopefully avoid overwriting other memory-resident programs at the lower end of memory. This would be disastrous since a programmed keyboard interrupt ("hot key") for those other programs would jump into Ready!'s code at some undetermined point. Ready! checks other interrupts at invocation to help avoid this possibility.

The choice of the full swap from EMS to normal memory was not made lightly, according to Bob. The full swap was the weakest of several possibilities considered, but it had the advantage of working on schedule. The swap approach is also the least likely to cause problems when other TSRs take advantage of EMS. Bob pointed out three additional difficulties with executing directly from expanded memory—if the code and data are larger than the 64K window of EMS, the program needs to have a well-defined overlay structure allowing 16K chunks to be pulled in and out of the EMS page window; the disk transfer area (DTA) used by the TSR cannot reside in the EMS page window when an EMS RAM disk is in use; the stack of the TSR should not reside in EMS due to some stack-swapping problems when EMS functions are called.

Ready! also breaks new ground in the way it de-installs itself. Many TSRs will de-install whenever the user asks for it. This may leave holes in DOS's memory allocation structure, leading to problems. Ready! will not de-install itself until it senses that all memory above itself is free. When the user requests de-installation, Ready! sets a flag and then awaits the appropriate time for de-installation. EMS memory is freed up immediately after the request is made.

The trickiest portion of writing the TSR is determining when DOS or the application is interruptible. DOS provides no clean services to make this determination. Bob recommends checking several different monitors before allowing the "pop-up" to occur.

The first step in popping up is detecting the application's hot key. In Ready!, INT 9 is used because they also want to detect some of the keystrokes (like Ctrl-UpArrow) that the BIOS doesn't report. When the hot key is detected by INT 9, a flag inside Ready! is set, but Ready! is not activated.

DOS provides two hooks that should normally allow safe pop-ups. INT 21 function 34 returns a pointer to the InDOS flag in ES:BX. If the byte pointed to is 0, DOS is not active and therefore any DOS call can be made safely. However, function 34 itself cannot be called at any time. This function does a stack switch before returning its result and, apparently due to an oversight of its programmer, it does the stack switch with interrupts enabled. This opens the possibility for function 34 to mess itself up if it is called at the wrong time.

Bob also noted that the InDOS flag is not simply a binary value. It represents a count of "recursions" into DOS.

DOS can also be interrupted at certain times even when the InDOS flag is not 0. While DOS is waiting for keyboard input, the InDOS flag is set to (usually) 1, but at the same time, DOS also continually calls INT 28. Apparently, INT 28 was created specifically to allow the DOS PRINT command to run in the background. In any case, if the TSR watches for INT 28 calls, it is safe to use any DOS function above 9 during the INT 28.

Other monitors must also be checked before invocation. Because

(continued)

many programs use the BIOS calls without going through DOS, it is necessary to check whether the BIOS disk calls (at least) are active. This is done simply by taking over the disk interrupt (INT 13) and setting a flag (within Ready!'s data area) upon entry to the interrupt, and resetting it upon exit from the interrupt. Before popping up based on some other interrupt, Ready! checks its own "InINT13" flag to make sure that no disk access is in progress. Ready! follows the same scheme for several other interrupts.

Looking at the DOS memory map after installing Ready!, it becomes apparent that all of the following vectors are taken over by the program:

8	Timer
9	Hardware Keyboard
10	Video
13	Disk
16	BIOS Keyboard
20	Program Terminate
21	DOS
25	Absolute Disk Read
26	Absolute Disk Write
27	TSR
28	Background Process

In all likelihood, 8, 13, 21, 25, 26, and 28 are taken over specifically to allow safe pop-ups without disturbing the system. INT 16 is used by Ready!'s "key transfer" scheme to pass keystrokes into DOS or an application (like the cut and paste of SuperKey and SideKick). INT 9 is used to supply special keystrokes and to aid in the pop-up process. INT 10 is used to keep track of the video mode of the system (Ready! turns off the hardware cursor and maintains its own flashing reverse-video block). INT 20 and INT 27 are most likely used to aid in the deinstallation process.

This author's guess of the overall pop-up scheme is as follows:

INT 9 is used to set a flag that the hot key (Ctrl-Keypad5) has been pressed or released. On each timer tick, the hot-key flag is checked. If set, the Ready!-maintained inINTxx flags are checked for safeness.

If the INT 21 flag is set or if another "dangerous" BIOS or DOS interrupt is active, activation does not occur at the timer tick.

On each INT 28 call, the hot-key flag is checked. If set, DOS function 34 is also checked to be not greater than 1.

Without actually implementing this, it is a bit hazy but hopefully gets the idea across.

Bob emphasized that while "de-invoking" the pop-up it is just as critical that the safeness flags be monitored as while invoking it.

Ready! keeps no files opened between invocations. Files are opened only when an outline is read or written from memory, and then immediately closed. If all DOS handles are in use, Ready! will not be able to access the disk.

Ready! fully chains all interrupts that it takes over. This means that all interrupt handlers installed before and after it get their chance at the interrupt. Bob recommended that for chaining INT 16, the chaining process use the INT instruction rather than a CALL FAR instruction. By using INT rather than CALL FAR, handlers installed *after* Ready! get another chance at the interrupt. This obviously requires that some flags be set inside Ready! to avoid an infinite recursion, and it is not necessary for most of the interrupts. It is particularly important, however, for INT 16 (keyboard), where macro processors may need to be invoked. It also plays a role in the delaying mechanisms used when passing keystrokes into other applications.

Ready! does not take any special pains to work with programs (such as XyWrite) that take over the keyboard without chaining. Bob believes that any tricks to make these work will cause more problems than they solve. In particular, the SideKick trick of "stealing back" the hardware keyboard interrupt on each timer tick would be a disaster if other programs attempted to do the same thing. Living Videotext is working with other publishers to get their programs cleaned up and compatible in this sense. They are also trying to set a standard for the scan codes returned for keystrokes not supported by the BIOS.

A few general pointers: According to Bob, the "memory-resident interface code" of Ready! amounts to 12,000 lines of assembly language. Writing a bulletproof and machine-friendly TSR is obviously no job for the weekend hacker! The rest of Ready! is written in Pascal (probably Microsoft, but definitely a linked version of Pascal).

Ready! includes its own "relocator," which fixes up the EXE image of the program when it is relocated from EMS to normal memory.

The resident portion of Ready! could not have been developed on schedule without the ATRON hardware debugger, said Bob. This $1500 piece of hardware allows you to continue from hard crashes and to investigate the state of the machine to determine what happened. If you can't afford this, at least get an NMI reset card. The "AT Technical Reference—Options and Adapters" is an invaluable guide that many developers do not have.

The PC Network is a disaster for memory-resident programs. It takes over interrupts in a very unfriendly way, and Ready! will not work with it.

A number of the major vendors of TSRs are currently meeting informally to reach some agreement on behavioral standards for TSRs. Watch for some announcements this year. Microsoft is decidedly against TSRs, and as versions of DOS roll by, support for TSRs (such as it is) will wane, while support for true multitasking will improve.

SUMMARIZED BY KIM KOKKONEN

pascal/source #26, from dwiner
a comment to message 25

A list of TSR problem areas (to BIX/Pascal/Source)

Compiled by Living Videotext Inc.
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(415) 964-6300

Background

This list of problem areas in both resident and nonresident software was compiled during the development of Ready! and describes a policy for writing resident and nonresident software that would eliminate a lot of the problems that users have in running resident software reliably.

In each case, we describe a problem, suggest a solution, and provide an example of program(s) that illustrate the problem area.

- Use of INT 16H (get a keystroke). When an application is running, it should issue an INT 16H to get a keystroke and *should not* just call the vector installed before the application. This allows every program in the chain to see the key request and to take any and all actions that are required [e.g., Word Finder].
- Using a stack in an interrupt routine. Don't set up your own stack in an interrupt routine. This prevents it from being re-entrant and will prevent any routine from invoking at the point your stack is active.

  Instead, set your stack *only* when you need it *and* when interrupts are off, or in an area that is "protected" from re-entrancy [e.g., Keyworks].
- Don't take control of INT 9 (the hardware keyboard interrupt). There is no reason to, and no program should ever take complete control over the keyboard. If your program wants to use keystrokes that the BIOS does not generate, such as Ctrl-UpArrow, the program should install a routine that chains into the interrupt and generates a new scan code for that keystroke, placing it into the system keyboard buffer just as the BIOS does. If there is just a single keystroke you are looking for to do an invocation (such as a resident program, being activated by a hot key), you should just chain to the interrupt, looking for the keystroke, and when found, it should only set a flag and continue through the in-

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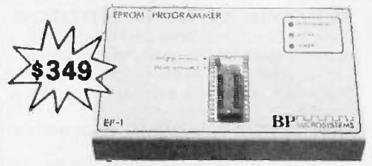

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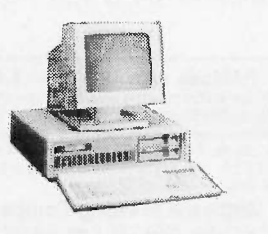

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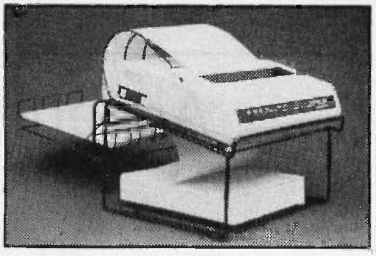

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terrupt chain [e.g., XyWrite, Samna Word III, Leading Edge Word Processor, Hayes Smartcom].

- Don't grab an interrupt vector more than once. Do not set a timer trap to re-grab an interrupt vector that your program initially installed. It must not be critical that your program be the last vector in the chain. You must trust that the chain will not be broken [e.g., SideKick].
- Changing video modes. Use the BIOS whenever possible, but if there is some reason your program directly changes modes, it must also set *all* the CRT values in the BIOS data area, addresses 0040:0049 through 0040:0066. See the CRT BIOS listing for more details [e.g., Lotus 1-2-3 version 1A, switching from text to graphics].
- Don't jump from a DOS critical-error routine. Instead, set a global error flag that your disk routines check with the error code that the critical-error handler gives you. Then issue an IGNORE response and do an IRET back through DOS so that the DOS stacks are cleaned up [e.g., Lotus 1-2-3 version 1A].
- Setting the high-order attribute bit to be used as background intensity rather than blinking. This is a value sent out port 3D8H (the mode control register). Whenever a program sets this port, the value should also be stored in the BIOS data area at address 0040:0065 (CRT_MODE_SET) [e.g., Framework version 1.1, Superwriter, and SuperCalc].
- Maintain the hardware cursor. If your program does not want to use the hardware cursor but instead uses its own software cursor, the cursor position should still be reflected in the BIOS data area at addresses 0040:0050-0040:005F depending on which video page you have in use [e.g., ThinkTank and Ready!].
- Changing the color palette by toggling the color burst bit. This is a common way of obtaining different colors from a monitor. Whenever a program sends a value through port 3D8H (the mode control register), it should also set the value in the BIOS data area at port; the value should also be stored in the BIOS data area at address 0040:0065 (CRT_MODE_SET).
- Changing the palette on an EGA board. If a program changes the EGA palette directly rather than using the BIOS function, it should copy the values modified to the save area defined by the EGA BIOS, the second double-word off the "save pointer" located at address 0040:00A8. See the EGA BIOS listing for more details [e.g., Microsoft Word].

CHECKING FOR PRINTER STATUS

pascal/turbo #696, from larryjudy [Lawrence Judy]

Printer, Are You There?
Jim, or Barry, or Joanne, earlier in about message 630 or so I had requested help with determining if the printer was turned on before my program tried to print. My main problem is unfamiliarity with 8086/8 assembly and the complexity of MS-/PC-DOS, but I did jiggle your various answers to come up with the subsequent short function (posted as a message), which worked great on my AT&T 6300. Unfortunately, it did not work on the IBM PC at work. The short program below will work on the IBM, but not on the AT&T without the additional line at the end of the function. I don't know if the last line will work on the IBM. Is this a difference of MS- vs. PC-DOS, or of printers (Toshiba 1340 at home, Panasonic at work)? Could someone tell me if the program will work on their IBM machine?

```
program Intr17n2__pas; var ch : char; Function PrinterIsReady :
Boolean; Type
  RegisterSet = record ax,bx,cx,dx,bp,di,se,ds,es,flags:integer;end; Var
  Regs : RegisterSet; Begin
  PrinterIsReady := false;
  FillChar (Regs, sizeof(Regs), 00);
  With Regs Do
  Begin
    ax := $0200; {request status}
    dx := 0; {lpt1 = 0, lpt2 = 1}
  End;
  Intr ($17, Regs) If((regs.ax and $4000 = 0)) then
  begin
    if regs.ax and $1000 < > 0 then PrinterIsReady:= true
  end; if regs.ax and $8000 = 0 then PrinterIsReady := false end;
begin
  repeat
  read(kbd,ch);
  if PrinterIsReady then
  begin
  clrscr;
  writeln('The printer is ready.')
  end
  else
  begin
  clrscr;
  writeln('The printer is not ready.')
  end;
  until ch in [7'q','Q'];
  end.
```

pascal/turbo #699, from jrobie [Jonathan Robie]
a comment to message 696

Larry, scanning your PrinterIsReady function, I notice that structure is something like this:

```
PrinterIsReady := false;
Inquire if printer is ready;
If (regs.ax and $4000) = 0 then { if printer does not acknowledge }
  begin
  if (regs.ax and $1000) < > 0 then PrinterIsReady:=true {selected}
  end;
If (regs.ax and $8000) = 0 { if printer is busy }
then PrinterIsReady := false;
```

If the printer does acknowledge, then the PrinterIsReady returns false. Not all printers send an acknowledge signal, so if you test for acknowledge then you can't assume that the acknowledge signal is present.

You also may want to check to see if you are out of paper. You are out of paper if (regs.ax and $2000) = 1. This test doesn't seem to work with my Zenith Z-150 and a C. Itoh Prowriter printer, though.

pascal/turbo #707, from jimkeo [Jim Keohane]

Larry, mebbe what you should is write a little quick-and-dirty program that issues INTR $17 repeatedly and writes out the value of r.ax until keypressed. Display the values bit by bit like:

```
repeat {set reg and issue INTR call} for i:=1 to 16 do
  begin
  if r.ax and $8000 = 0 then write('0') else write('1');
  r.ax:=r.ax shl 1;
  end; writeln; until keypressed;
```

This should show you all the status settings that are set as you turn printer on/off, select/deselect, remove paper, unplug cable, etc.

You can now see if there is one test that will suffice for both the IBM PC and the AT&T 6300. Keep in mind there may be differences with other printers too, so try to keep your test to the minimum.

pascal/turbo #708, from wheelock [Bruce Wheelock]
a comment to message 707

With a spooler?
I can't see a way to check printer status with a print spooler installed. Anyone else? I thought not. ■

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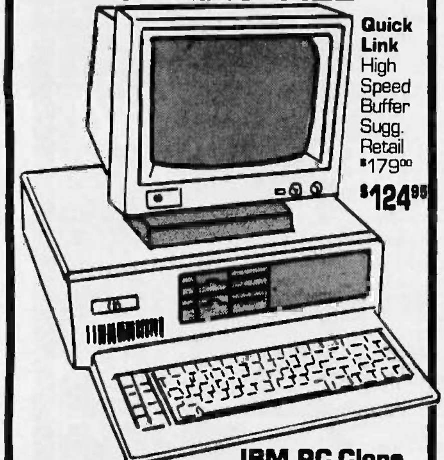

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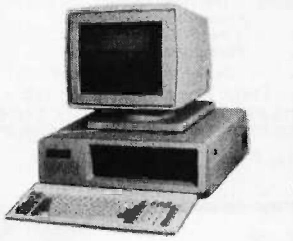

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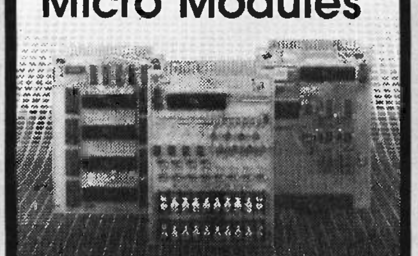

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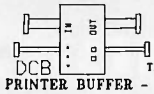

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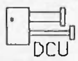

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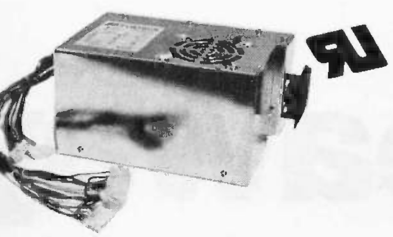

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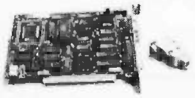

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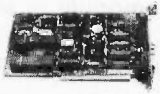

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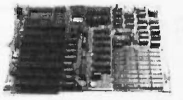

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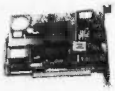

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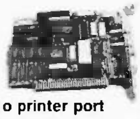

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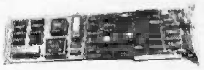

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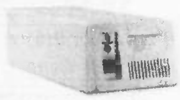

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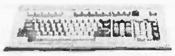

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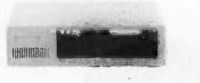

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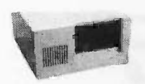

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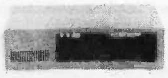

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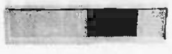

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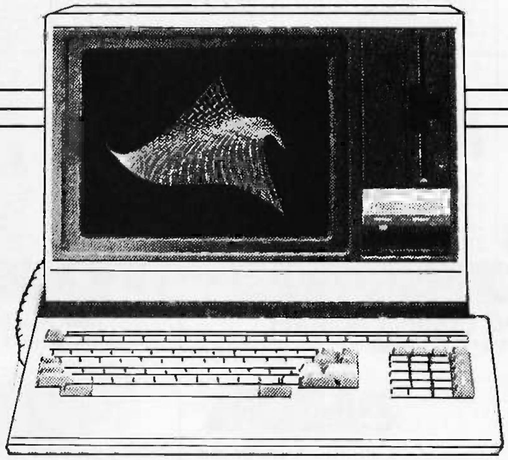

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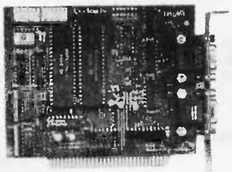

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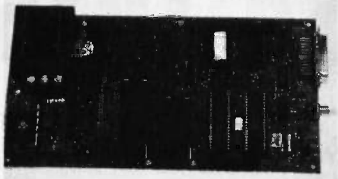

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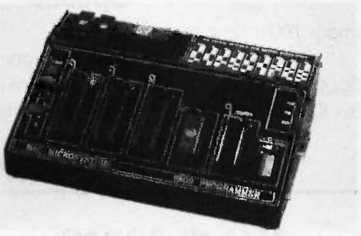

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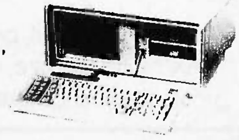

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Graphwriter Combo	319	Carbon Copy	117
Harvard Pres. Graphics	229	Fastback	99
Generic Cad	75	Inset	87
In*A*Vision	255	Norton Commander	44
Microsoft Chart 2	179	Pop-Up Deskset	45
ProDesign II	169	SQZ	56
Dr. Halo II w/Mouse	109	Xtree	31
Fontrix	91	Statgraphics	449

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SOFTWARE FOR
ONLY $6 A DISK

OVER 500 DISKS FULL
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USER SUPPORTED PROGRAMS

LONE STAR
SOFTWARE

Recently a Customer Wrote . . .

". . . I'm SICK! Friday afternoon I bought a $300.00 data base manager from my local computer dealer. When I got home I found out my neighbor bought the same kind of program from you last week for six dollars. What's worse, I like your program better! Please send me your disk directory and the following disks . . ."

What can we say? Isn't it really about time you discovered that spending big bucks for all of those "glamorous-name" software products doesn't necessarily guarantee you anything but a thin pocketbook and a fancy copy protection scheme?

No . . . Computerland won't tell you about us or our great software. But why make a $300.00 mistake? Many of our $6.00 packages will actually do everything better and faster than the great "Starword-dplus-4.5.6", and you can keep the difference.

Here is just a sample of our library by category.

WORD PROCESSORS

PC-Write 2.6 (#78) A full featured word processor that is faster than Wordstar.
DICTIONARY (#378) Dictionary type spelling checker.
IV-ED (#415) Word processor - editor.
LETTERWRITER (#415) controls letter processing.
PC TYPE (#455) Jim Button's contribution to a full fledged word processor.

SCREEN EDITORS

FOIL EDIT (#347) Full screen editor. Top to bottom and left to right.

TEXT PROCESSING TOOLS

FOGFIND (#378) reverses writing complexity using the "Fog Index".
WORDSTAR AIDS (#379) collection of the most useful utilities for the Wordstar user.
PC OUTLINE (#414) Create and collapse and outline. Great for plans, essays, etc.

DATABASE PROGRAMS

PC FILE III (#5) most popular database program from Jim Button.
U-MIND (#133) Fast hashing makes this a dandy database. (Intelligent database)
NEWBASE (#233) Menu driven database for the beginner.
PC-DBMS (#383) A relational database management system that provides on-line help and screen editing functions.
ELSIE EXPERT SYSTEM (#398) Artificial intelligence shell to build a custom knowledge-base.
PDS*BASE (#396) Complete hierarchical data base system master/detail or mother/daughter type.
CREATOR (#339) create, report, and sort makes this a super database management system.

DATABASES

BOBCAT (#247) Small business database. Excellent!
MFIND (#311) Database of over 2000 movies that can be searched in any category, or you can add your own.

SPREADSHEETS

PC-CALC (#199) Fabulous 123 work-a-like from the author of PC-File.
PC-PAD (#406) Spreadsheet and address book program written in basic.

SPREADSHEET TEMPLATES

LOTUS 1-2-3 TEMPLATES AND MACROS (#140, 141, 165, 257, 289, 301-304, 406, 414) Why spend hours of writing your macros when these are ready made? Modify them yourself.
SYMPHONY WORKSHEETS (#305, 306)

FINANCIAL PROGRAMS

PC-CHECK MANAGER (#275) Keeps multiple checkbooks in balance.
TAX FILE DBS (#295) Tax record keeping system that saves you money on April 15.
SAGE TRADER (#242) Analyzes commodity trades. Don't "short" this one!
PORTSWORTH PACKAGE (#101) Evaluates your ever changing stock portfolios.
FINANCE (#164, 227) Determine present and compound values, interest rates, etc.
HOME FINANCE (#406) Lotus 1-2-3 Macros for real life applications.
PC-GENERAL LEDGER 1.2 (#237) An exceptional accounting system. Used by some CPA's.
TIME AND MONEY (#251) Financial record keeping and analist system.
LOAN AMORTIZATION (#399) For output to screen or printer. Lots of on-line help.
BASIK CHECKBOOK (#271) Keep track of checkbook and personal finances.
ACCU-TAX 1985 (#479) You can't buy a better "commercial" program.
MR. BILL (#469, 470) Prepare invoices, client report, audit trail, etc.
ANALYTIC CALC (#430-432) 3 disk set. Complete spreadsheet, database, graphics, word processor - fassst!

COMMUNICATIONS

QMODEM (#310) The best and fastest communications programs you can buy at any price, bar none!
PC-TALK (#16) The classic "Freeware" communication program.
PC-VT (#286) VT-100 Emulation.
SYSCOMM (#338) Menu driven system allowing unattended file transfer.
RBBS 12.2 (#212) Become a SYSOP and start a bulletin board.
FIDO NET (#333) Bulletin Board System. Perhaps the easiest to run.

MATH AND STATISTICS

EPISTAT 3.1 (#88) Statistical analysis of small to medium-signed data samples.

LANGUAGES

CHASM 2.13 (#10) Cheap assembler with tutorial.
XLISP 1.4 (#148) Lisp language interpreter.
MVP-FORTH (#31, 32) Two disk set of Mountain Valley Press Forth.
3 FORTHS (#352) To modify or expand your own forth language. MVPFORTH, FORTH-H and SEATTLE Computer's Forth.
PROLOG & UNIFORTH (#417) Complete with editor and documentation.
SNOCREST BASIC (#409, 410) two disk set. Real basic interpreter with manual. Can be used with a multi-user system.
ESIE (#398) Build and generate an expert system in a flash.
PASCAL COMPILER (#424) Written in Turbo Pascal.
P-BASIC (#381) BASICA work-a-like for clones, etc.

UTILITIES

DISKCAT 4.0 (#106) Catalog all your disk files in a hurry.
GINACO (#66) 54 polished routines written in basic for any beginner or experts. We love it!
ULTRA-UTILITIES 4.0 (#133, 245) Recover lost files, modify sectors, etc. Like Nortons.
SYSMENU (#250) Build a menu driven menu system. Excellent for hard disks.
LOAD-US (#284) Allows Lotus and Symphony to be used on a hard disk.
PC-DESKMATES (#405) Better than Sidekick and all of the rest of the memory resident desktop utilities.
ALIGN 1.6 (#217) Disk alignment tool.
TOP UTILITIES (#273) All of the most requested utilities on one disk.
NUMZAP (#284) Removes line numbers from BASIC programs.
HARD DISK UTILITIES (#478) A collection of the best in the library.
UNPROTECT (#414) Various routines to disconnect protection schemes.
PATCHES (#376) make back up copies of some of the most popular commercial programs with this collection.

PRINTER UTILITIES

SP 3.4 (#186, 275) Printer buffer that partitions your data so you can use your computer and print at the same time.
SIDEWAYS (#265, 411) Prints text sideways on an Epson printer.
SETPRTR (#79) Sets up Epson printer from a menu.
SLIDE (#244) produce medium resolution slides and overhead transparencies.
PRINTER UTILITIES (#411) Sorgasboard of utilities and tools.
EPSON PRINTER UTILITIES (#326) Spool, set up routines all designed for Epson codes.
BANNER (#386) make long banners *with* large letters. Includes MS-FORTRAN source codes.

EDUCATION

EQUATOR (#249) A teaching tool for math, science and finance.
PC-TUTORIAL (#403) A first course in computer usage covering various aspects of MS-DOS. Good!
PC-PROFESSOR (#105) Learn Basic the easy way. One of the best tutorials on BASIC.
PC-DOS HELP (#254) type "help" for the DOS command you forgot.
FLASH CARDS (#367-370) 4-disk set. Vocabulary builder, spelling teacher.
TOUCH-TYPE (#320) Advanced type tutor.

GAMES

TOP GAMES (#274) The most requested arcade type games.
ARCADE GAMES (#293) Another goodie bag of top Arcade games.
TRIVIA GAMES (#327-329) Lots of files and documentation for hours of fun. Will not work on PC JR.
PC JR GAMES (#354) Games that will work only on PC JR. Combat, dungeons and dragons, Global Thermonuclear War.
MISC. GAMES (#390) Good selection of educational, adventure, and arcade games.
BIG FOUR GAMES (#272) Texas most popular, STARGATE, ZAXXON, AIRTRAX, and DND

MUSIC

PC-MUSICIAN (#127) Compose music on your PC, save and play again.
PIANO MAN (#279) Play your PC keyboard like a piano.

APPLICATIONS

GENEALOGY ON DISPLAY 3.0 (#90)
GENEALOGY - FT 1.25 (#240) from Pine Cone software.
LABELMAKER (#146) Our favorite label file and maker. Menu driven.
PC-FLY "Fliteplan" 2.1 (#261) Pilots prepare and file your flight plans.
RECIPE 83 (#281) Recipe index for use with PC File III (#5)
FAMILY HISTORY (#361) Family history, ancestor and decendant charts. Sample programs.
FORM LETTERS (#388) LOTS of samples of the most commonly used business letters. Modify!
HAM RADIO (#436, 437) Electronic goodies, design antennas, great circle, etc.

GRAPHICS

PC-KEY DRAW (#344-345) A small CAD system. Lots of demonstration files.
PC-PICTURE GRAPHICS (#136) Drawing package allows you to zoom, color, and store pictures.
PC-GRAPH (#418) Allows user to create graphics from PC-File report files.
ORIGAMI (#408) Japanese art of paper folding. Graphics required.
DRAFTSMAN (#400) Easy to use presentation quality. Mouse or keys.

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TOTAL #________ x $6 = ________
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TEXAS RESIDENTS ADD 6⅛% TAX = ________
SHIPPING & HANDLING = ________
(1 @ $1.00 and .50 for each additional disk)
TOTAL ________

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CARD NO. ______________________________
EXPIRATION DATE ______________________________
SIGNATURE ______________________________

PLEASE ENCLOSE CHECK WITH ORDER

CIRCLE DISK NUMBER DESIRED:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
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481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500

Inquiry 209

An end to diskette lies!

Super Star™ Diskettes are of equal or *higher* quality than 3M, Maxell, TDK and many other "famous" brand names.

They simply cost about half as much!

Super Star™ diskettes are manufactured to equal or exceed the same specifications as 3M, Maxell, TDK and many other "famous" brand name products.

They are designed for 60% or higher clipping levels, not the 40% used in IBM and ANSI standards. Each is guaranteed for ten million read/write passes. Every Super Star™ diskette is 100% verified and carries a LIFETIME WARRANTY!

Yet Super Star™ diskettes cost only about half as much...

How can we deliver Super Star™ diskettes of such high quality at such a low price?

Simple...we don't make fools out of our customers.

We bargain hard with the same people who turn out many of the "famous name" brands. Their manufacturing capacity far exceeds their capability to sell everything they make. So, as large scale purchasers, we are able to obtain significantly lower prices than others for ***high-quality*** diskettes.

For example, we pay one of the big name manufacturers 98¢ for their "famous name" diskette in a pretty box. In an unequalled display of favoritism, that same manufacturer sells the same diskette in the same fancy box to a major corporation for 42¢ each. Finally, a software duplicator can buy the same diskette *without* the box for 37¢!

A 265% price difference: for what?

In the example above, that's a difference of 265% in price for the very same diskette!

So you see, paying for a "famous name" on a diskette doesn't guaranty you that you're getting any more for the money.

You may be paying for some big corporation's fleet of aircraft and their executive retreats in Minnesota and Canada, but you are not paying for any more quality.

You're simply getting rooked out of money you could have in your own pocket.

There are four kinds of diskettes: And Super Star™ is right up there with the best.

As you leaf through the pages of this magazine, you will see diskettes advertised at prices as low as 33¢. Every one, of course, claims to be the "best".

It's simply not true.

Here are the only kinds of diskettes you can buy:

High-Clip Product: this is what you get when you buy Super Star™, 3M™, Maxell™, TDK™ or any number of other famous and not so famous name diskettes. They have clipping rates of 60% or more, are certified for ten million read/write passes or more and are simply the best diskettes available. You can expect perhaps 1 out of 100,000 to fail...and that will usually be the result of dirty or misaligned drives.

ANSI Spec Product: These are "okay" diskettes. They have a clipping level of 40%. Usually they are the fall-out from a manufacturer's "high-clip" product line. You can expect about 1 out 20 to fail in normal use. (But that failure rate has more to do with the disk *drive* rather than the diskette.) The price difference between an ANSI-spec disk and a High-Clip product is only a few cents. But the failure rate of ANSI product is 50,000 times higher!

Duplicator Product: This is a catch-all category. Some of it may be High-Clip Product, some ANSI spec, some cosmetically blemished, some garbage. Usually anyone who buys product in this class justifiably anticipates that 20 out of every 100 diskettes will not format properly.

Floor Sweepings: This is just plain "garbage". For example, the 5.25" SSSD diskettes that you see advertised for 39¢ are exactly that: garbage. No decent manufacturer has sold any 5.25" SSSD diskettes in several years. SSSD is the absolute bottom of the line in terms of quality. Most of the discount diskettes you see advertised are "floor sweepings"...bought up by brokers and passed on to the unsuspecting public by unscrupulous merchants who are simply out to make a fast buck.

When every bit counts, you can count on Super Star™!

Well, I wish we had more space, but we don't.

So, here's the message in a nutshell:

1. Super Star™ diskettes are high-clip product, 100% certified, tested to 60% or higher clip levels and not less than ten million read/write passes.
2. Super Star™ diskettes carry a LIFETIME WARRANTY.
3. Super Star™ diskettes equal or exceed the published specifications of such "famous" brand names as 3M, Maxell, TDK, etc.
4. Super Star™ diskettes give you this quality *at about half the price of the big names!*

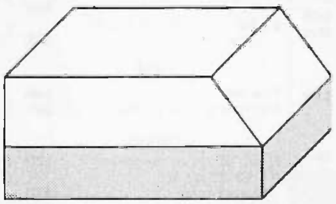
Save your money: buy Super Star™ diskettes!

That's the message:

Super Star™ diskettes mean the highest quality at about half the price!

SUPER STAR SPECIAL!

Your choice of storage for $ 4.95!



Buy 50 Super Star™ diskettes of either size and you can get a nice plastic storage case for only $ 4.95 (shipping included!).

These are durable plastic cases with dividers.

The 5.25" unit holds 50 diskettes and the 3.50" unit holds 40 diskettes.

5.25" Storage Unit (P/N3100) $ 4.95ea.
3.50" Storage Unit (P/N3102) $ 4.95ea.

Super Star™ 5.25"

SSDD	(P/N3800)	**.38ea.**
DSDD	(P/N3801)	**.38ea.**
SSDD96	(P/N3802)	**.68ea.**
DSDD96	(P/N3803)	**.71ea.**
DSDDHD	(P/N3804)	**$ 1.36ea.**

ORDER IN MULTIPLES OF 50 ONLY!

All Super Star 5.25" Diskettes are poly-bagged in lots of 25 with Tyvec sleeves, write-protect tabs and user ID labels

QUANTITY DISCOUNTS: 350-500 diskettes, deduct 3%. 550-700 diskettes, deduct 6%. 750-1,000 diskettes, deduct 9%. 1,050+ diskettes, deduct 12%

Super Star™ 3.50"

SSDD	(P/N3805)	**$ 1.39ea.**
DSDD	(P/N3806)	**$ 1.45ea.**

ORDER IN MULTIPLES OF 50 ONLY!

Super Star 3.50" diskettes are packaged in boxes of 50 with user ID labels.

QUANTITY DISCOUNTS: 350-500 diskettes, deduct 1.5%. 550-700 diskettes, deduct 3%. 750-1,000 diskettes, deduct 4.5%. 1,050+ diskettes, deduct 6%.

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(In Illinois: 1-312-256-7140)
INQUIRIES:
1-312-256-7140

FOR FASTEST SERVICE, USE NO-COST MCI MAIL. Our address is DISKORDER. It's a FREE MCI MAIL letter. No charge to you. (Situation permitting, we'll ship these orders in 24 hours or less.) **SHIPPING:** 5.25" & 3.50" DISKETTES-Add $ 3.00 per each 100 or fewer diskettes. **OTHER ITEMS:** Add shipping charges as shown in addition to other shipping charges. **PAYMENT:** VISA, MASTERCARD and Prepaid orders accepted. **COD ORDERS:** Add $ 5.00 special handling charge. **APO, FPO, AK, HI & PR ORDERS:** Include shipping charges as shown and additional 5% of total order amount to cover PAL and insurance. We ship only to United States addresses, except as shown above. **TAXES:** Illinois residents add 7% sales tax.

MINIMUM ORDER: $ 35.00

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ND 04DEG *(half height 5¼" 360K grey face plate)*	$111
ND 08DEG *(half height 5¾" 1.2MB grey face plate*	$149

Control Data

Half height *5¼" 360K black face plate floppy*	$85

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Seagate

ST225 *20MB half height 65MLS with controller card*	$429
ST225 *20MB half height 65MLS no controller card*	$345
NEW* **ST238 *30MB half height 65MLS with controller card*	$529
ST4026 *20MB full height 30MLS no controller*	$545
ST4038 *30MB full height 30MLS no controller*	$645
ST4051 *40MB full height 30MLS no controller*	$745
Western Digital *controller card*	$125

Control Data

9415-86 *86MB full height 30MLS no controller*	$1495
Disk Manager Software *for formatting past DOS (33MB)*	$100

TAPE BACKUPS

Irwin Magnetics

10MB *INTERNAL TAPE DRIVE half height unit uses floppy controller*	$499
20MB *INTERNAL TAPE DRIVE for 286 COMPAQ and AT*	$599

Everex

20MB *INTERNAL TAPE DRIVE half height with controller*	$573
60MB *INTERNAL TAPE DRIVE half height with controller*	$724

Alloy

60MB *EXTERNAL TAPE DRIVE software, cables and controller*	$741

Tape Cartidges/Scotch 3M

DC-600A *cartridge tape (up to 60MB capacity)*	$26
DC-1000 *cartridge tape for Irwin tape drive*	$19

MEMORY MULTIFUNCTION BOARDS

AST

SIXPACK PREMIUM *512 to 2MB*	$356
Advantage *w/128K (expandable to 3MB, S2,G for AT)*	$356
RAMPAGE PC *256 to 2MB (EMS board w/deskview windowing software)*	$234
RAMPAGE AT *512 to 2MB (EMS board 8MHz)*	$445

PCA (XT COMPATIBLE)

640K, 4.77MHz, 2 floppies, monochrome graphics, P, TTL monitor, FCC app.............. **$775**

ANI TURBO XT COMPATIBLE

640K, one floppy, 20MB, P, S,S,G,C, 4.77 or 8MHz switchable, FCC app........... **$995**

IBM PC

w/256K, one floppy, 4.77MHz........................ **$1150**

IBM AT

w/512K, 1.2MB floppy 6MKZ, 20MB.................. **$3295**

w/640K, 1.2MB floppy 8MHZ, 30 MB............ **$4290**

MULTITECH AT COMPATIBLE,

w/512K, keyboard, up to 5 half-height internal drives, 10 or 6 MHz Switchable, slots, 192 W supply, MS-DOS 3.1 FCC Approved. 1.2MB floppy, one year warranty... **$1550**

Alloy network compatible

COMPAQ DESK PRO 286

Model 2 with 30MB hard drive, 6 or 8 MHz swtichable, 512K, 1.2 MB floppy, color/mono card, parallel/serial port........... **$3,650**

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JRAM AT *w/OK (Parallel 2MB capacity)*	$190
JRAM 3 AT *w/OK (EMS board, up to 2MB capacity)*	$239

Clone

6 PACK compatible *w/S, P, C, G. w/OK (up to 384K) w/software*	$99

MULTIFUNCTION I/O BOARDS

DISK I/O *operates 2 floppies, and G, S, P, C*	$95
AT I/O, *Parallel, Serial*	$95

MODEMS

Hayes

SMARTMODEM 1200B *INTERNAL (1200/300 baud w/Smartcomll)*	$384
SMARTMODEM 1200 *External (1200/300 baud)*	$479
SMARTMODEM 2400 *External (2400)*	$630

Everex

EVERCOM Modem *(1200/300 baud w/software)*	$150

US Robotics

COURIER 2400 *Baud Internal or External*	$491

NETWORKS MULTI-USER

Alloy

PC-SLAVE/16 *16 BIT SLAVE BOARD 8088-2 (8MHz Processor, 2 serial ports, 1 Mb Ram)*	$895
12 Slot Expansion Chassis *225 Watt power supply*	$1135
20' RS-232 Slave Cable	$39
ATNX *ALLOY TERMINAL NETWORK EXECUTIVE SOFTWARE*	$295
LINK *RS-323 ASCII Terminal IBM Keyboard*	$625

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Citizen (Epson & IBM Compatible)

MSP-10 *160/40 cps dot matrix narrow carriage*	$307
MSP-15 *160/40 cps dot matrix-wide carriage*	$414
MSP-20 *200/50 cps dot matrix-narrow carriage*	$347
MPS-25 *200/50 cps dot matrix-wide carriage*	$520

Epson

FX-85 *160 cps, narrow carriage NLQ*	$434
FX-286 *200 cps, wide carriage NLQ*	$624
LQ 1000 *24 Pin, 180 cps NLQ 60 wide carriage*	$830
LQ 800 *24 Pin, 180 cps, NLQ 60 narrow carriage*	$630

IBM

Proprinter	$445
Proprinter XL *Wide Carriage*	$661

Okidata

ML182 *120 cps narrow carriage*	$228
ML 192 *160 cps NLQ narrow carriage*	$327
ML 193 *160 cps NLQ wide carriage*	$529
ML 292 *200 cps 100 NLQ narrow carriage color*	$614
ML 293 *Dual 9 pin, 200 NLQ wide carriage color*	$803
2410/P/IBM *350 cps 175/85/wide*	$1850

Toshiba

P-351 *24 pin 288 cps wide carriage*	$1025
P-341 *24 pin 216 cps wide carriage 180 NLQ*	$727
P-321 *24 pin 216 cps narrow carriage*	$442
P-351 *C Color printer*	$1178

Panasonic

KXP1091 *120 cps, NLQ 29 cps*	$270
KXP1092 *180 cps, NLQ 33 cps*	$348
KX1592 *wide carriage, 180 CPS, NLQ 38 cps*	$480

N E C

P-5XL24 *pin, 290 cps, 100 NLQ color*	$1071
P-6, P-7, *24 pin*	$477/667

LASER PRINTERS

Hewlett-Packard

LASER JET PROFESSIONAL *8 pages per minute*	$2357
LASER JET PLUS *DPI graphics/S/P interface*	$3053

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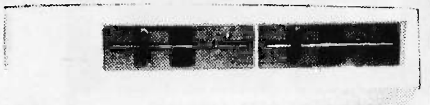

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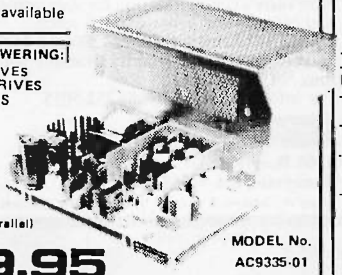

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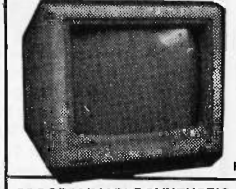

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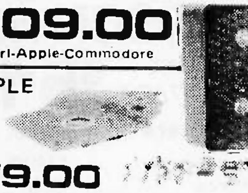

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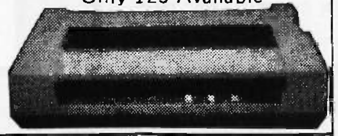

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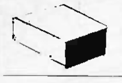

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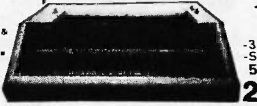

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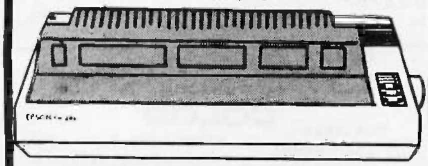

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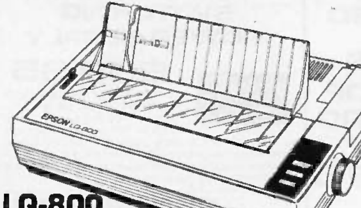

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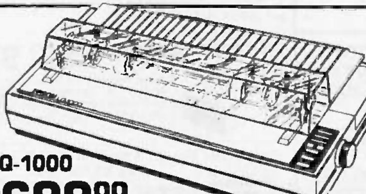

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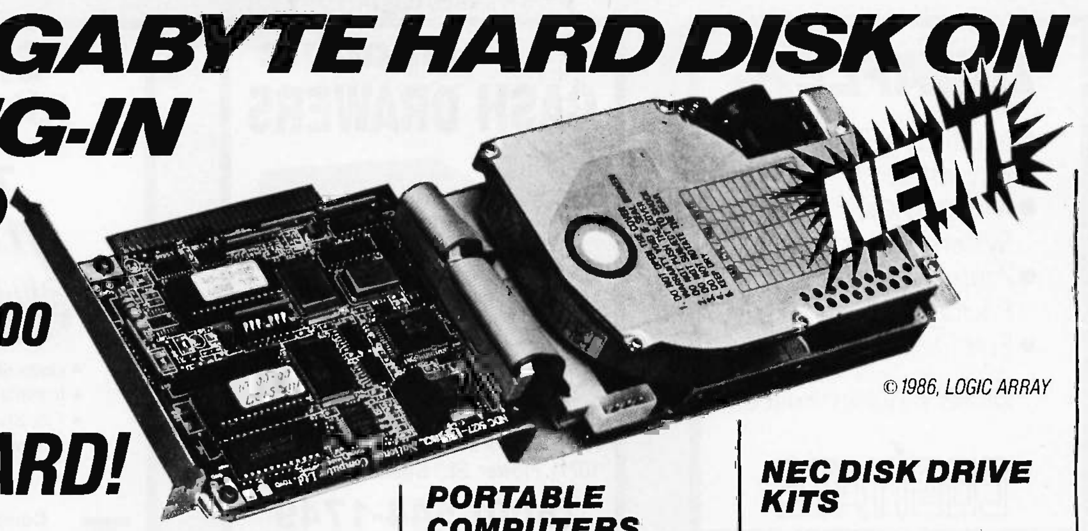

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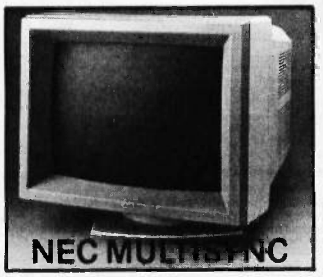

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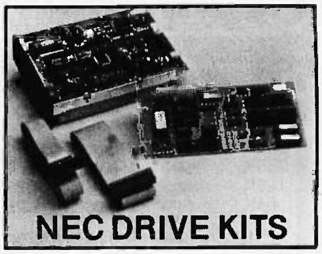

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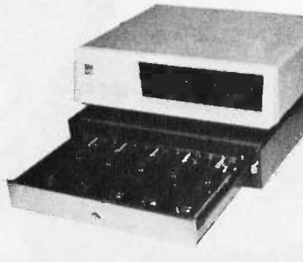

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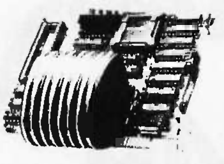

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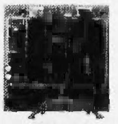

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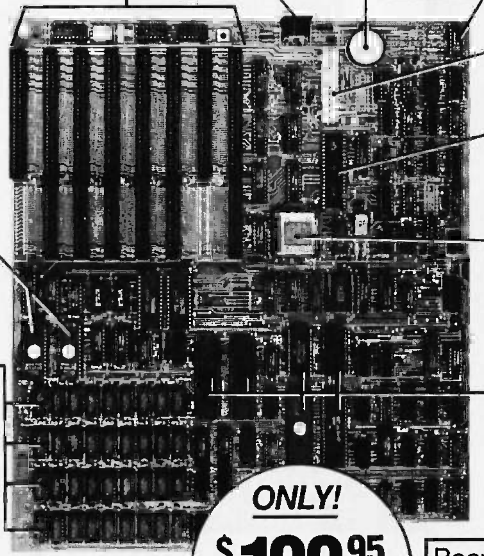

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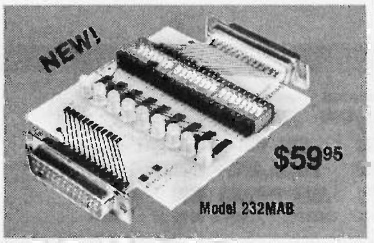

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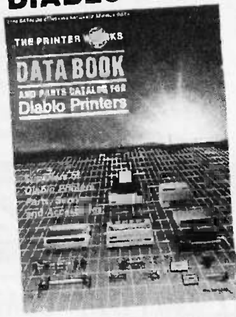

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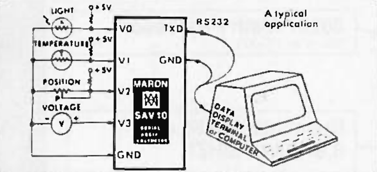

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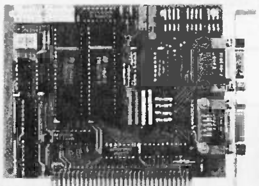

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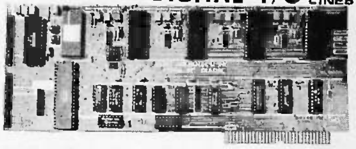

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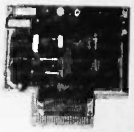

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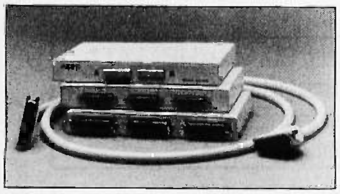

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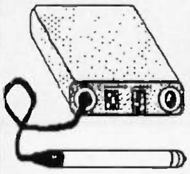

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Inquiry 274

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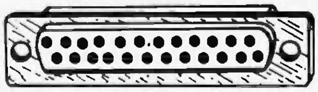

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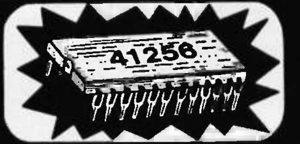

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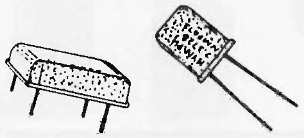

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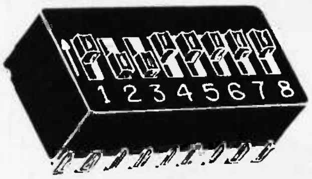

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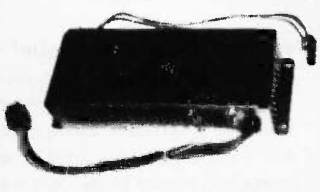

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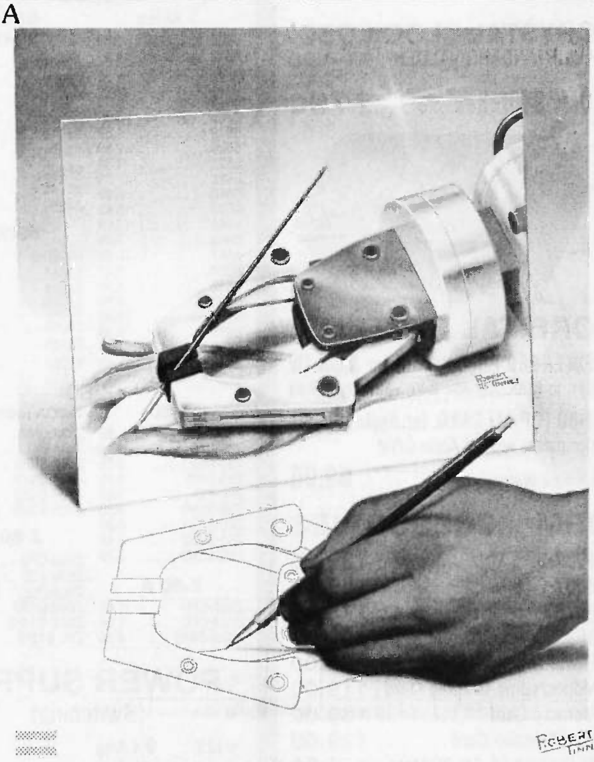

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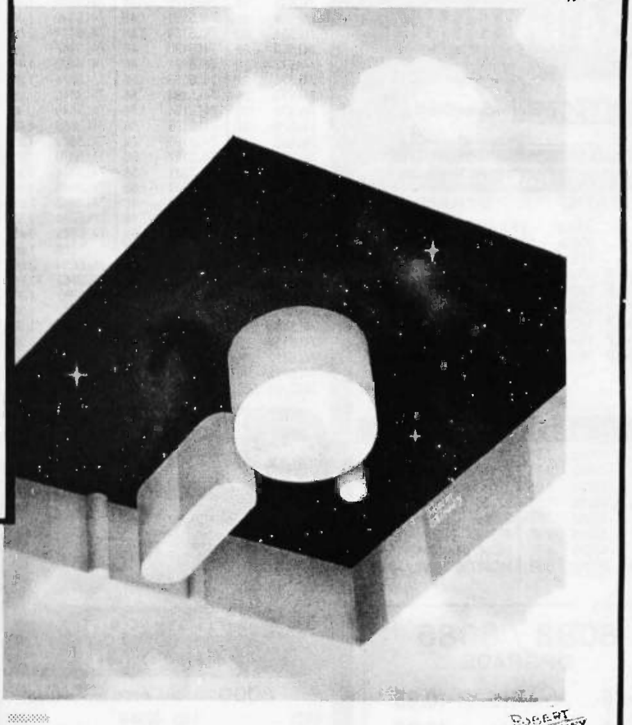

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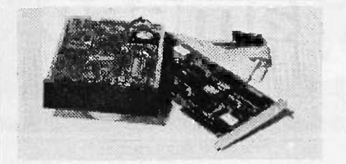

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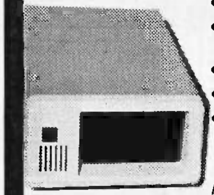

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74LS05	.25	74LS174	.39
74LS06	.99	74LS175	.39
74LS07	.99	74LS189	3.95
74LS08	.19	74LS191	.49
74LS10	.19	74LS193	.69
74LS14	.39	74LS221	.59
74LS27	.25	74LS240	.69
74LS30	.19	74LS243	.69
74LS32	.25	74LS244	.69
74LS42	.39	74LS245	.79
74LS47	.89	74LS259	1.19
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74LS74	.25	74LS279	.39
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74LS90	.39	74LS368	.39
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74LS123	.49	74LS374	.79
74LS125	.39	74LS393	.79
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CD4013	.35	CD4093	.39
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CD4017	.49	CD40103	2.95
CD4018	.69	CD4503	.49
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CD4027	.39	CD4515	1.39
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CD4040	.65	CD4520	.79
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8118	16,384 x 1	(120ns)	.69
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2114N-L	1024 x 4	(450ns) L.P.	1.09
2114N-2	1024 x 4	(200ns)	1.05
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HM6264P-15	8192 x 8	(150ns) CMOS	3.29
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2716-1	2048 x 8	(350ns) 25V	4.95
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2732	4096 x 8	(450ns)	3.75
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2732A-25	4096 x 8	(250ns) 21V	3.49
2732A-45	4096 x 8	(450ns) 21V	3.29
27C32	4096 x 8	CMOS	6.49
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27C64	8192 x 8	CMOS 21V	4.95
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74HC30	.39	74HC259	1.19
74HC32	.45	74HC273	1.79
74HC74	.45	74HC373	1.49
74HC75	.69	74HC374	1.49
74HC76	.69	74HC393	1.19
74HC85	1.19	74HC595	1.95
74HC86	.59	74HC688	1.95
74HC123	1.19	74HC4040	1.19
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74HC139	.79	74HC4511	1.95
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74C10	.29	74C244	1.59
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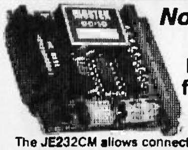

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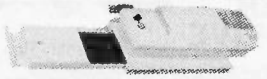

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30013	Zilog Data Book (85).	$14.95
30032	National Linear Supplement (84).	$ 6.95
210830	Intel Memory Handbook (86).	$17.95
230843	Intel Microsystem Hndbk. Set (86). . . .	$24.95

MUFFIN/SPRITE-STYLE FANS

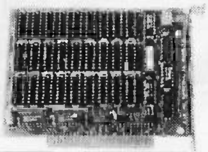
MUF60 (SPN3-15-2462). . . . Howard Industries (4.68" sq.. 60 cfm)	$9.95
SU2C7. . . . . EG&G Rotron (3.125" square, 20 cfm)	$9.95

NEW PRODUCTS!

DISK DRIVE SALE!

MPI52S	Double-sided 48TPI. . . *IBM PC/XT Compatible!* . .	**$89.95**
TM100-4	Double-sided 96TPI. . . *QUAD Drive!*	**$59.95**

ZUCKERBOARD

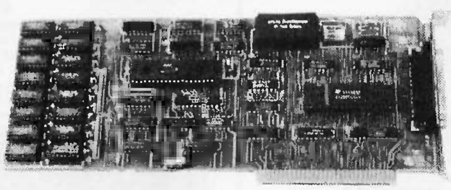


Expansion Memory Half-Card for IBM-PC, XT, Portable, Tandy 1200 and Compatible Computers

Expand your computer to its full capacity of 640K. It will accept either 64K memory chips (4164) or 256K memory chips (41256).

EM-100	Expansion Memory Half Card with 0K RAM . . .	**$59.95**
EM-D	RAM Disk and Printer Spooler Software. . . .	**$39.95**

ZUCKERBOARD



Multifunction Board with Clock Calendar for the Tandy 1000

The **Zuckerboard Multifunction Board** allows you to expand the memory on your Tandy 1000 to as much as 640K. The Multifunction Board comes complete with an RS232 port for your serial expansion needs, a clock/calendar and RAM Disk Printer Spooler. The Zuckerboard Multifunction Board is made in the U.S.A. and comes with a standard 2 year warranty.

MTAN-256K	Includes 256K RAM and Manual.	**$199.95**
MTAN-512K	Includes 512K RAM and Manual.	**$239.95**

Expansion Memory Half-Card and Clock/Calendar for the Tandy 1000 – *DMA Controller Chip on board!*

TAN-EM256K	Includes 256K RAM and Manual.	**$ 99.95**
TAN-EM512K	Includes 512K RAM and Manual.	**$139.95**

Options for TAN-EM256K/512K

TAN-C	Includes Plug-in Clock Option Chip (only).	**$39.95**
TAN-D	Includes RAM Disk Spooler Software (only).	**$39.95**

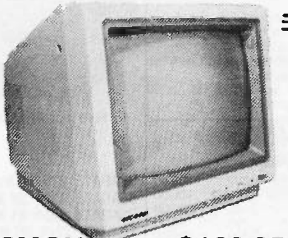
3.5" Micro Floppy Disk Drive for Tandy 100 & 200, NEC8201A, IBM PC, XT, AT and Compatible Computers

Now your IBM PC or compatible can read and write the same disks as your portable!

FD-103	Includes 3.5" Disk Drive, Cable, AC Adapter, Blank Diskette and Documentation. . . .	**$179.95**

Software for the FD-103 Disk Drive (Software needed for operation)

TS1	Tandy 100 TSDOS Disk Operating System Software.	$49.95
TS2	Tandy 200 TSDOS Disk Operating System Software.	$49.95
TSN	NEC PC8201A Disk Operating System Software.	$49.95
LAPDOS	IBM PC, XT, AT and Compatible LAPDOS Disk Operating System Software.	$79.95



bui 13" Color Composite Monitor
for VIC-20 and C-64
Also compatible with other computers with composite output (i.e. Apple II, II+, *//e)**

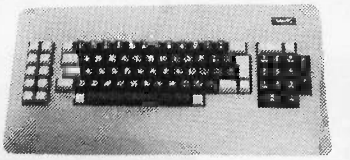
Ideal for color graphics and games
· Resolution: 260H x 300V · Recommended Display Character Number: 960 Characters (40 Characters x 24 Rows on 5x7 Dot Matrix) · CRT: 13" diagonal · Size: 14.6"W x 13.5"H x 15.5"D · Weight: 25.3 lbs.

CMON. . . . . . $129.95 each or 2/$219.95

RCA-3-DIN (Universal Computer to Monitor Cables for Atari, Commodore & TI). . . . **$3.49**

IBM® COMPATIBLE ACCESSORIES

83-KEY KEYBOARD



· Identical layout as original IBM PC Keyboard · Highly desirable case with palm rest · Complete with cable and data · *JUST PLUG IN!*

KB83. . . . . . *SALE* $29.95

Build an IBM PC/XT™ Compatible!

IBM-64K(2)	64K RAM Chips (18).	**$ 24.98**
KB-83	83-Key Keyboard.	**$ 29.95**
IBM-FCC	Floppy Controller Card. . . .	**$ 49.95**
IBM-Case	Case.	**$ 49.95**
IBM-MCC	Monochrome Card.	**$ 79.95**
IBM-PS	Power Supply.	**$ 79.95**
FD55B	Disk Drive.	**$119.95**
IBM-MON	Monochrome Monitor. . . .	**$ 99.95**
IBM-MB	Motherboard.	**$139.95**
	Regular List	***$674.58***
IBM™-Special (Incl. 9 items above). .		**$599.95**

Additional Add-Ons Available!

IBM-KB	83-Key Keyboard.	**$ 69.95**
IBM-ENH	Enhanced Keyboard.	**$ 99.95**
IBM-ICB	Integrated Color Board . . .	**$ 99.95**
IBM-EGA	Enhd. Graphics 256K RAM . .	**$299.95**
IBM-20MBK	20MB Hard Disk Drive. . . .	**$499.95**

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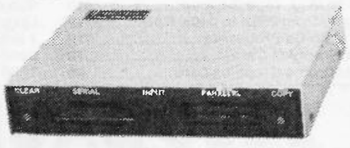
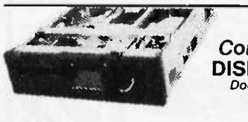
NEW! Universal 64K/256K Printer Buffer NEW!

JOHNATHON FREEMAN DESIGNS



The **UBUFFER Universal Printer Buffer** is a hi-speed data buffer that accepts data at a high rate, and then outputs this data to your printer. You save valuable computer time. The UBUFFER can be connected to practically any computer or printer. There are four possible combinations: 1) Serial to Serial, 2) Serial to Parallel, 3) Parallel to Parallel, 4) Parallel to Serial. Manual included. Size: 9-1/3"L x 4⅛"W x 1½"H

UBUFFER-64K . . . $199.95
UBUFFER-256K . . $229.95



IBM Compatible!
DISK DRIVES
Documentation Included

FD55B	Teac 5¼" DS ½-Height.	**$119.95**
SA455	Shugart 5¼" DS ½-Height.	**$119.95**
TM100-2	Tandon 5¼" DS Full-Height. . . .	**$109.95**

JMR 5¼" DISK DRIVE ENCLOSURES

Complete with power supply, switch, power cord, fuseholder and connectors.

DDE-1FH. . . . . Houses 1 Full-Height 5¼" Floppy Drive.	**$69.95**
DDE-2HH. . . . . Houses 2 Half-Height 5¼" Floppy Drives – Vertical	**$79.95**
HDDE-1FH. . . . . Houses 1 Hard Disk Drive	**$199.95**

$20 Minimum Order – U.S. Funds Only
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IBM Compatible Computer

- 256K Expandable to 640K on Motherboard
- Double Sided Double Density Disk Drive
- IBM Type Keyboard (with LED indicators)
- Floppy Controller Card
- Eight Expansion Slots
- 135 Watt Power Supply

The Eclipse 16 is an outstanding value in IBM Compatible Computers. After careful research and evaluation we found it to be the most reliable unit.

Our computer includes some of the newest features available, such as the 4.7MHz, multi-layer motherboard with 256K of RAM upgradable on board to 640K. A generous eight expansion slots and 135 Watt power supply give you ample room and power for add-on boards. The enclosure has an easy-access flip top lid making upgrades a breeze. And our floppy controller supports up to four drives, so as many as three additional drives can be used. Finally, each computer is configured and fully tested before sending it to you.

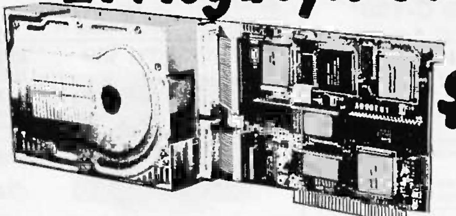
Satisfaction Guaranteed! We're really excited about this new unit, and so sure you will be too... that you may return the Eclipse 16 for a full credit towards an IBM PC if you are not completely satisfied.

OPTIONS

20MB Hard Drive w/Controller	$495
Additional Drive-Installed	99
Irwin 10 Meg. Tape Back up	489
Upgrade from 256K to 640K RAM	79
8087 Math Co Processor	119
Color Graphics Card	79
Monochrome Graphics Card	99

RGB Color Monitor	199
TTL Monochrome Monitor	139
Microsoft Mouse	139
Upgrade from Floppy Controller to Disk I/O 2 drive controller, clock/cal., software parallel, serial, and game ports	79
1200 Baud Internal Modem w/Software	179

21 Megabyte Gold Card



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The fastest, lowest powered, longest warrantied, most durable, highest capacity, most reliable, lowest priced HARD-DISK-ON-A CARD available in the world today.

• 65ms Access Time - *Fastest Available* • Automatic Head Unloading - *Protects Heads and Media* • 2K Sector Buffer - *Increases System Throughput* • High Reliability: 28,000 hr. MTBF - *No one else even close* • 15.5 Watt Power Consumption - *Lowest Available* • 2 Year Warranty - *Longest Available*

WERE $695... GET 'EM WHILE THEY LAST FOR JUST ~~$559~~$419

NOW YOUR COMPUTER CAN READ!!

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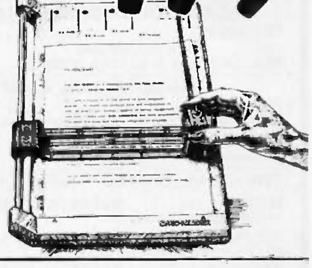
Omni-Reader... the first optical character reader **designed and priced for the small computer**

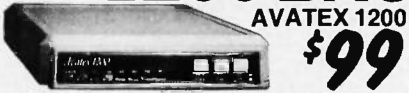


COPY:
- Manuscripts
- Contracts
- Articles
- Forms
- Invoices

APPLICATIONS:
- Mailing Lists
- Editing
- Data Base Management
- Transfering information between incompatible systems

Uses a standard RS-232 serial port hookup to interface eaisily with your computer.

1200 BAUD MODEMS



AVATEX 1200

$99

This 300/1200 baud modem matches the design specs of the Bell 212A, feature by feature, bringing you reliability, impeccable transmission and easy operation. Hayes Compatible, except for "S" register. Communication software included.

The AVATEX 1200, at $99, is a steal!

SMARTEAM 1200

$159

The Team 212A offers all the features of the Hayes Smart Modem 1200 for a fraction of the price. Now is your opportunity to purchase a 1200 baud modem at the price of a 300 baud modem.

SIGNALMAN 300 BAUD MARK VI

$49

The Anchor Automation Mark VI is a 300 baud direct connect modem that plugs into any slot of your IBM/PC. This modem supports auto answer and auto dial capabilities. Other features include telephone number storage, send / receive text files, single key-stroke dialing along with many other functions provided on disk. The *Mark VI* was originally priced at over $300.

ECLIPSE 2400

BAUD MODEM

$299

- Hayes & Bell 212A/103 Compatible
- CCITT V.22. V.22 bis

The **ECLIPSE 2400** modem is a microprocessor-based full or half-duplex modem incorporating the latest in high speed data communications capabilities. It also accomodates computers and terminals equipped with an RS-232 port allowing communication with other computers or timeshar-ing systems either locally or remotely. Compatibility, Versitility and Performance are yours in a configuration designed to provide years of reliable operation.

MODEMS

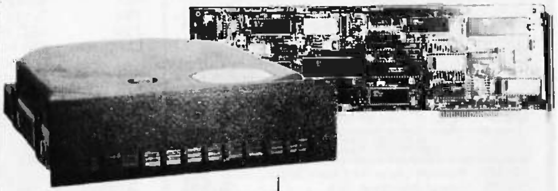
Eclipse 1200 100% Hayes, with status lamps.	EDP-1200	149.00
Eclipse 1200B Internal with software	EDP-1200B	139.00
Eclipse 2400 External, Hayes Compatiple	EDP-2400	299.00
Avatex 1200 baud external, Hayes	AVA-1200	99.00
Hayes Smartmodem 2400 baud modem	HYS-2400	599.00
Fujitsu 2400/1200 baud auto everything.	FUJ-1935D	459.00
Team 1200 Hayes Compatible, 300/1200 baud.	TEM-1200	159.00
Smarteam 1200B IBM 1200 baud card	TEM-1200B	159.00
UltraLink 1200 data and voice on same line.	UTL-1200A	99.00
CTS 212AH 1200 baud, auto dial	CTS-212AH	179.00
Prometheus 1200 super features	PRM-P1200	289.00
Prometheus 1200B internal PC	PRM-P1200B	279.00
Signalman Mark VI, 300 baud internal PC	SGL-MK6	49.00
Hayes Smart Modem 1200 baud, auto dial	HYS-212AD	369.00
Hayes 1200B for use with the IBM/PC, 1200 baud.	HYS-1200B	299.00
Hayes Smartmodem, 300 baud only, auto dial	HYS-103AD	199.00
Hayes Chronograph, time & date	HYS-CHR232	199.00

Seagate

$299

20 MEGABYTE WINCHESTER HARD DISK DRIVE

Quantity Two



Five Inch Winchester Disk Drives

	each	two+
SEAGATE 225 20 Meg. ½ Ht.	329	299
SEAGATE 4026 26 M. 35mS.	759	729
SEAGATE 4051 51 M. 35mS.	995	959
FUJITSU 2242 55 M. 35mS.	1599	1529
FUJITSU 2243 86 M. 35mS.	2095	2019
RODIME RO-202E 27 Meg.	659	629
RODIME RO-203E 40 Meg.	995	959
RODIME RO-204E 53 Meg.	995	959
CONTROL DATA 94155-86 M.	1829	1779
MAXTOR XT1140 140 Meg.	2995	2929
HONEYWELL 85M. 27 mS.	1795	1695
TOSHIBA MK56 70 M. 30mS.	1789	1729
TANDON 502 10 Meg.	419	379

• Winchester Controllers for IBM/PC •

XEBEC 1220 with floppy controller	229
NATIONAL COMPUTER 5004	129
DTC 5150BX	139
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WESTERN DIGITAL WD/1002	139

• SCSI/SASI Winchester Controllers •

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Winchester enclosure and supply	139
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Advanced 286 AT Compatible

$1495

Phoenix BIOS ● 200 Watt Power Supply
MS-DOS 3.2 ● GW Basic ● 6/8 Mhz. Selectable

***The Advanced AT* is everything you ever wanted in an IBM/ATCompatible.** Complete with 640 k/byte of memory, (expandable to 1 Meg.) 1.2 M/Byte floppy drive, hard disk controller that will support upto 140 Megabytes of Winchester storage and on board real time clock.

The Advanced AT/286 compatible will run **every** program writter for the IBM/AT as well as the PC/XT. High resolution (640 / 240) RGB color monitor $299 additional. 360K drive and 40 Meg. Winchester availble. Fully FCC commercial and consumer approved.

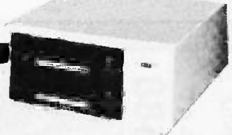
MASS STORAGE ALTERNATIVE

TAKE IT WITH YOU!

Bernoulli Box

was $3540 now only

$1595



The **Bernoulli Box** by Iomega, features 10 and 20 megabyte removable cartridges, and delivers reliability, expandability, transportability, security and speed in one versatile subsystem. It lets you transfer megabytes of information safely and swiftly for primary or backup storage. Or combine several software programs onto a single cartridge for easy switching from one to another.

Reliable... the Box has incredible resistance to shock and vibration completely eliminating the possility of head crash.

Expandable... grow at your own pace by adding inexpensive cartridges. When **security** is essential, don't lock up your system... just lock up the cartridges.

The Bernoulli Box delivers preformance that often exceeds the best of hard disk speed and the convenience of floppy disks. At these prices don't be caught wishing you had one after a loss of irreplacable data.

		List	Our Price
10+10 Meg.	**A2210H**	**$3450**	**1595**
20+20 Meg.	**A2220H**	**4540**	**2095**
Bootable Controller		**255**	**159**
10 Meg. Cartridge		**79**	**49**
20 Meg. Cartridge		**99**	**65**

PRINTERS

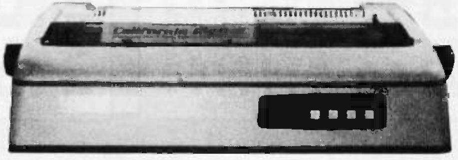
MATRIX PRINTERS

NEC/P7 132 col., par'l interface.	NEC-760	659.00
Star Gemini NL-15, 300 cps., 136 col. 24 wire head	STR-NB15	389.00
Star Gemini NX-10, 120 cps/30 cps NLQ, tractor	STR-NX10	359.00
Citizen MSP/10FT 160 char/sec.	CIT-MSP10	259.00
Panasonic KX1091 120 cps. draft, 29 NLQ tract & friction.	PAN-KX1091	259.00
Toshiba 351P/S, 240 char/sec. 24 wire head	TOS-351PS	1099.00
Toshiba 341PS/E part. 180 cps. 24 wire head	TOS-341PSE	759.00
Okidata 182P/IBM parallel 9½" paper	OKI-182P	239.00
Okidata 192A parallel interface, 160 char/sec.	OKI-192A	379.00
Okidata 84P parallel 15" paper	OKI-84P	695.00
Epson LX-80 10" 120 Char/sec.	EPS-LX80	259.00
Epson LQ800 near letter quality	EPS-LQ800	629.00
Epson FX85 160 cps. draft 32 cps. NLQ, 240 dot/inch.	EPS-FX85	399.00
Epson FX286 132 col., 200 cps. 29 cps NLQ, graphics.	EPS-FX286	599.00
Dataproducts B 600-3, band printer 600 LPM.	DPS-B600	6985.00
Printronix P300 high speed printer 300 lines per minute.	PTX-P300	3995.00
Printronix P600 ultra high speed 600 lines per minute.	PTX-P600	5795.00

WORD PROCESSING PRINTERS

Starwriter F10 (6400) parallel, 40 char/sec.	PRO-F10P	429.00
Same as above but 55 char/sec., 50 pin Diablo Interface	PRO-F55P	559.00
NEC8810 55 char/second, serial interface	NEC-8810	1179.00
NEC8830 55 char/sec. par'l interface.	NEC-8830	1179.00
NEC3550 popular printer designed for the IBM/PC	NEC-3550	819.00
Silver Reed EXP600, 25 cps. 10/12/15 pitch, serial/par'l.	SRD-EXP600	319.00
Silver Reed EXP800 same as 600 but 40 char/sec.	SRD-EXP800	729.00
Diablo 620, proportional spacing, horz.& vert. tab. 20 cps.	DBL-620	299.00
Juki 6100, 18 char./sec.	JUK-6100	359.00
Juki 6300, 40 char./sec.	JUK-6300	689.00

F/10 Daisy Wheel Printer $429



The TEC F-10 Daisy Wheel printer is the perfect answer to a reasonablly priced 40 character word processing printer. While this printer is identical to C.Itoh's F-10/40 Starwriter printer, it bears the name of a well known computer manufacturer.

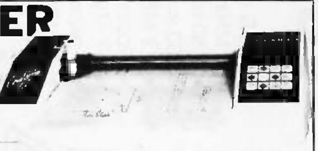
This 40 character per second printer auto Installs with Wordstar and Perfect Writer. Features extensive built-in word processing functions that allow easy adaptability and reduced software complexity. Industry standard Centronics interface provides instant compatibility with all computers equiped with a parallel printer port. The TEC F-10 accepts paper up to 15 Inches in width.

These printers were originally priced to sell at over $1400. Through a special arrangment California Digital has purchase these units from the computer manufacturer and is offering these printers at a fraction of their original cost.

Options available Include sheetfeeder, tractor feed, buffered memory and an assortment of printer cables for a variety of computers.

PLOTTER

$179



The Comrex Comscriber I is the ideal solution to make short work of translating financial and numeric data into a graphic presentation Many ready to run programs such as Lotus 1-2-3, Visi-on and Apple business graphics already support this plotter

The Comscriber I 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 Comscriber I immediate use with the printer port of most personal computers

The Comscriber I is manufactured for Comrex by the Enter Computer Corporation. The plotter is marketed by Heath Kit and also sold under Enters own "Sweet P" Label. This is your opportunity to purchase a plotter which was originally priced at $795 for only $219.

Also available is a support package which includes demonstration software, interface cable, a multicolor pen assortment and a variety of paper and transparency material

Quick-Link 300

$59

The Quick-Link 300 gives you an instant link to any dial up data base. Such as Dow Jones, Western Union or the Source. The Quick-Link has four user programmable log-on keys, allowing the operator, with only one key stroke, to dial the data base, log-in and give the password. All this information is permanently stored in non-volatile RAM.

Features include video output to television or monitor, auto dial, auto-log, full sized keyboard, 300 baud modem and 1200 baud auxillary printer port. All this is available for only $59.

SONY 53W Floppy Disk Drive

3 1/2" New IBM portable compatible

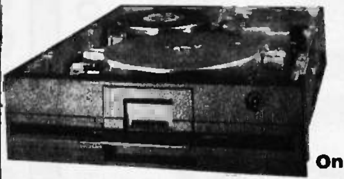
$139

5¼" DISK DRIVE

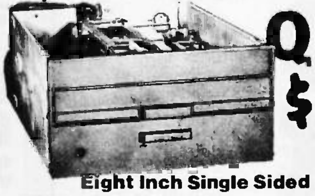
SALE $89

Quantity Two

Your Choice 48 or 96 TPI drive.
QUME MODEL 142 ● 48 TPI
MITSUBISHI 4853 ● 96 TPI



	One	Two	Ten
TEAC FD55BV half height	**109**	**99**	**89**
TEAC FD55FV 96 TPI, half ht.	**119**	**109**	**105**
TEAC FD55GF for IBM AT	**169**	**159**	**155**
PANASONIC 455 Half Height	**109**	**99**	**89**
PANASONIC 465 ½ Ht. 96TPI	**119**	**109**	**105**
TANDON 100-2 full height	**129**	**125**	**119**
MITSUBISHI new 501 half ht.	**129**	**119**	**109**
MITSUBISHI 4853 96/TPI½ Ht.	**99**	**89**	**89**
MITSUBISHI 4854 8" elec.	**295**	**285**	**275**
QUME 142 half height	**99**	**89**	**89**
Switching power supply			**49**
Installation Kit with manual			**10**
Dual enclosure for 5¼" drives			**59**
34 pin edge connectors			**5**
Scotch head cleaning kit			**19**
Flip & File Storage tubs			**15**



QUME $119

Eight Inch Single Sided Drives

QUME 841 single side	**129**	**119**	**call**
SHUGART 801R	**359**	**359**	**354**
SIEMENS FDD 100-8	**119**	**115**	**109**

Eight Inch Double Sided Drives

QUME 842 "QUME TRACK 8"	**189**	**179**	**call**
SHUGART SA851R	**495**	**485**	**475**
OLIVETTI double sided	**189**	**179**	**159**
REMEX RFD-4000	**179**	**169**	**159**
MITSUBISHI M2896-63 ½ Ht.	**459**	**449**	**409**
Dual 8" enclosure with power and fan			**259**
Switching power supply			**89**
Installation kit with manual			**10**

MEMORY

4164 DYNAMIC MEMORY **150ns**

Quantity 100 **$.99**

DYNAMIC MEMORY		1–100	100+	1000+
4164 150ns. 128 refresh	ICM–4164150	1.39	1.19	.99
41256 150ns. 256K	ICM–41256150	4.59	3.95	3.29

Shipping: First five pounds $3.00, each additional pound $.50.
Foreign orders: 10% shipping, excess will be refunded.
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Open accounts extended to state supported educational institutions and companies with a strong "Dun & Bradstreet" rating.

VISA

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1200 BAUD MODEM

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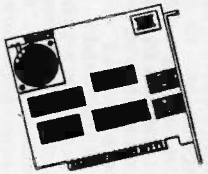

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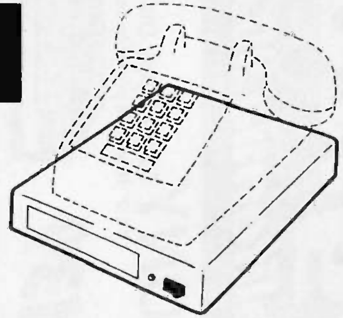

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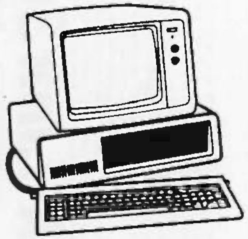

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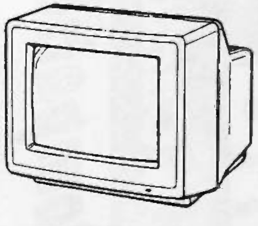

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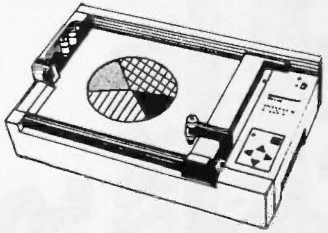

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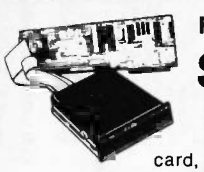

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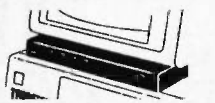

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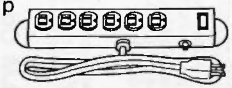

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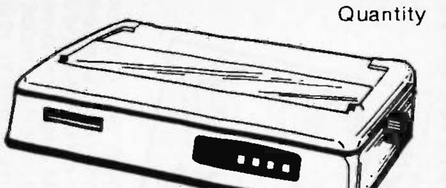

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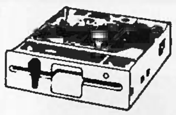

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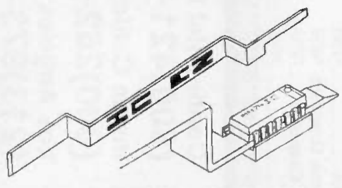

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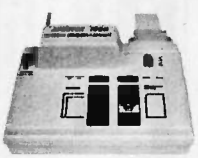

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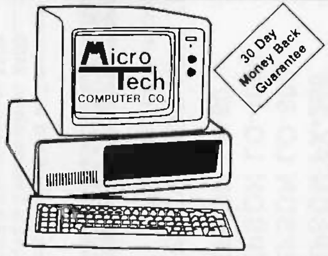

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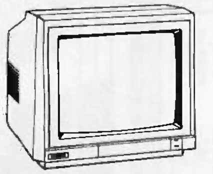

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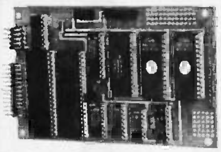

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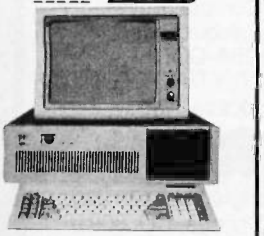
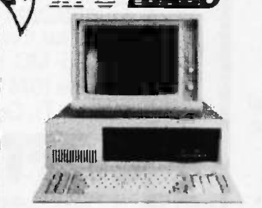


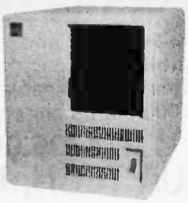
The **XAT** is out most versatile and powerful system Using Intel's 80286 processor, the system runs at 6 and 8 MHz with a true 16-bit data bus Comes standard with a 3 meg Add-On board. 2 parallel & one serial port, monitor, keyboard, DOS 3.1, two ½height DS DD 1.2 meg floppies.

XPC TURBO



This standard system is as compatible with IBM as it can be. Featuring a 4-layer motherboard, 8-slot expansion, up to 640K memory on the motherboard, and the 6.67 MHz ***TURBO*** mode Also included: DOS 3.1, keyboard, 135 watt power supply, TTL 720 x 348 resolution video card, green or amber monitor, serial & parallel ports, Real Time Clock and software.

XTC TURBO



The perfect choice for the system integrator who needs the IBM compatibility, but not in the standard PC cabinet. This model features hinged and removable sides, up to 3 ½height peripherals out front, front mount AC switch and rear mount 135 watt power supply. Also makes an ideal "Host" or "File Server" unit in multi-user configurations!

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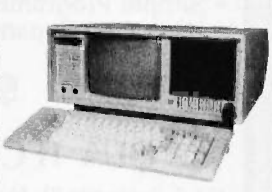
XPC Compact



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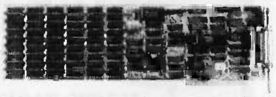

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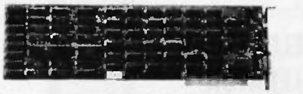
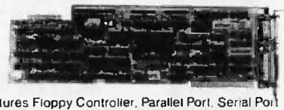


Supports two levels of graphics and text in composite monochrome or RGB color Low resolution 320 x 200 pixel, high resolution 640 x 200 pixel.

7 PAK Multi-Function



Features Floppy Controller, Parallel Port, Serial Port (optional 2nd Serial), Game Port, Real Time Clock/Calendar with Battery Back-up, RAMdisk, Print-Spooler, all cables & manuals.

PROM Laser

Hi-speed algorithmes will burn 2716, 2732, 2732A, 2764 (in 52 sec), 27128, 27256 EPROMS under software control right In your PC Zero Force Insertion Sockets, Software, and Manual.

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35 Components

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Motherboards

XAT *TURBO*

- RTC Calendar
- 6 & 8 MHz clock
- 8-slot expansion
- Intel 80286

XT-SBC

- 4.77 & 8 MHz clock
- Serial & Parallel
- 4-layer PCB design
- RTC Calendar

XPC *TURBO*

- 4.77 & 6.67 MHZ
- 4-layer PCB design
- 8-slot expansion
- up to 640K Memory
- 8088-2 processor

XPC-XT

- Standard 4.77 MHz
- up to 640K memory
- 8-slot expansion
- standard 8088 CPU
- 8087 socket avail

Power Supplys

XT 135 watt

- 135w switching
- Whisper Fan
- Side AC switch
- +5V·15A −5V·.5A
- +12V·4.2A −12V·.5A

XT 150 watt

- Whisper fan
- Hi-output 150 watt
- 4 DC connectors
- +5V·15A −5V·.5A
- +12V·5.5A −12V·.5A

AT 200 watt

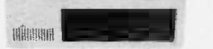
- 200 Watt power
- Exterior AC switch
- 4 DC power conn
- +5V·20A −5V·.5A
- +12V·7.7A −12V·.5A

XTC 135

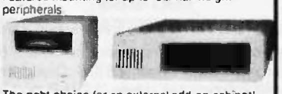
- Rear Mount
- Rear On Off switch
- extra AC outlets
- +5V·15A −5V·.5A
- +12V·4A −12V·.5A

Cabinets

The **XTjr.** cabinet is only 3" x 16.5" x 15" yet it will hold a standard XT compatible motherboard. Includes a switching power supply. Front panel cut-out for a half-height floppy or hard disk.



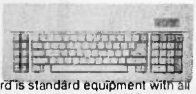
Our **XPC·XT** cabinet has an 8-slot back panel with additional cut-outs for two RS-232 I O ports. Features mounting for up to four half height peripherals



The right choice for an external add-on cabinet! Add-on a floppy, tape back-up, or up to 33 meg of hard disk (half-height) Switching power supply is included.

Keyboards

AT

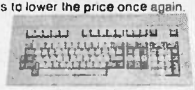


This Keyboard is standard equipment with all of our **XAT** systems, but the layout is so well liked, we're offering it here.

XT

Our volume purchases of these IBM style units allows us to lower the price once again.

5051



Now a fully selectric unit at an affordable price. Features a 10-key numeric pad & a separate cursor pad.

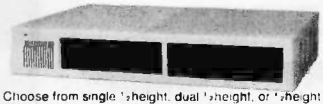
Drives

Archive
Irwin
Maxtor
Memtek
Miniscribe
Panasonic
Seagate
TEAC
Tulin

3 Sub-Systems

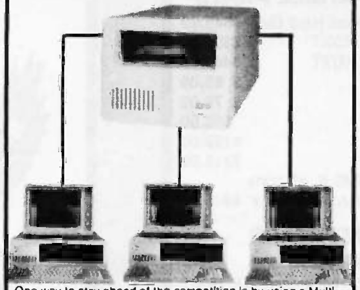
This full height cabinet will hold a Tape Back-up with full or ½height Hard Disk inside (or two Hard Disks)

A perfect cabinet for Tape or Hard Disk, a nice addition to your PC



Choose from single ½height, dual ½height, or ½height with full height base All Sub-systems include controllers, cables software, and manuals

3 Networks



One way to stay ahead of the competition is by using a Multi-User or Network system configuration from **Micro Products International**. Choose Hi-speed RS-232 · **XOR·NET SDLC** or Token Ring. Data transfer rates up to 4 megabytes second can be obtained

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- Runs the popular Hayes communications software

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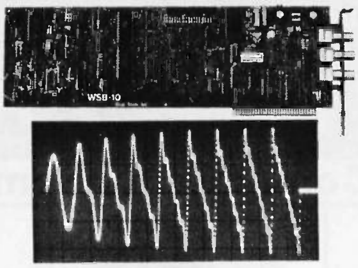

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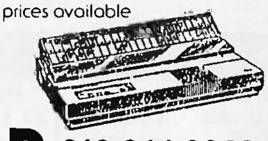

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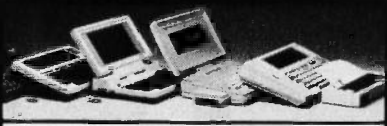
Inquiry 102



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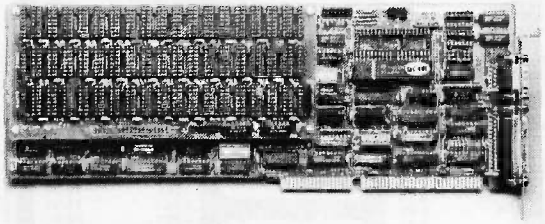

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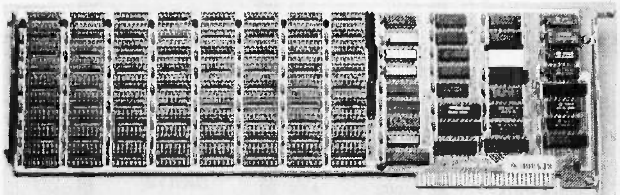

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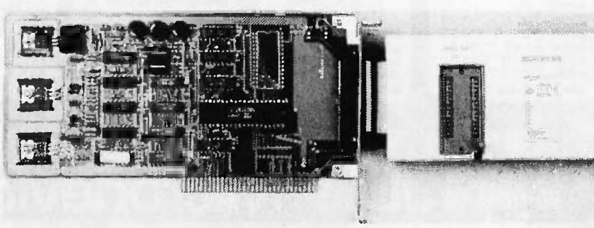

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LP=Low power

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4116-200	16384x1	(200ns)	.89
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5V=Single 5 Volt Supply 21V PGM=Program at 21 Volts

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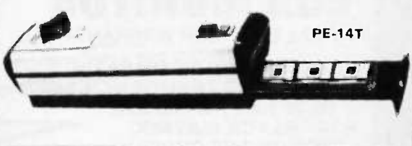

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24.0	4.95

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 (9ns 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	.59	74HC148	1.19
74HC02	.59	74HC151	.89
74HC04	.59	74HC154	2.49
74HC08	.59	74HC157	.89
74HC10	.59	74HC158	.95
74HC14	.79	74HC163	1.15
74HC20	.59	74HC175	.99
74HC27	.59	74HC240	1.89
74HC30	.59	74HC244	1.89
74HC32	.69	74HC245	1.89
74HC51	.59	74HC257	.85
74HC74	.75	74HC259	1.39
74HC85	1.35	74HC273	1.89
74HC86	.69	74HC299	4.99
74HC93	1.19	74HC368	.99
74HC107	.79	74HC373	2.29
74HC109	.79	74HC374	2.29
74HC112	.79	74HC390	1.39
74HC125	1.19	74HC393	1.39
74HC132	1.19	74HC4017	1.99
74HC133	.69	74HC4020	1.39
74HC138	.99	74HC4049	.89
74HC139	.99	74HC4050	.89

74HCT00

74HCT: Direct, drop-in replacements for LS TTL and can be intermixed with **74LS** in the same circuit.

74HCT00	.69	74HCT166	3.05
74HCT02	.69	74HCT174	1.09
74HCT04	.69	74HCT193	1.39
74HCT08	.69	74HCT194	1.19
74HCT10	.69	74HCT240	2.19
74HCT11	.69	74HCT241	2.19
74HCT27	.69	74HCT244	2.19
74HCT30	.69	74HCT245	2.19
74HCT32	.79	74HCT257	.99
74HCT74	.85	74HCT259	1.59
74HCT75	.95	74HCT273	2.09
74HCT138	1.15	74HCT367	1.09
74HCT139	1.15	74HCT373	2.49
74HCT154	2.99	74HCT374	2.49
74HCT157	.99	74HCT393	1.59
74HCT158	.99	74HCT4017	2.19
74HCT161	1.29	74HCT4040	1.59
74HCT164	1.39	74HCT4060	1.49

74F00

74F00	.69	74F74	.79	74F251	1.69
74F02	.69	74F86	.99	74F253	1.69
74F04	.79	74F138	1.69	74F257	1.69
74F08	.69	74F139	1.69	74F280	1.79
74F10	.69	74F157	1.69	74F283	3.95
74F32	.69	74F240	3.29	74F373	4.29
74F64	.89	74F244	3.29	74F374	4.29

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Inquiry 183

HOURS: M-W-F, 9-6 TU-TH, 9-9 SAT, 9-5

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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.

20MB HARD DISK SYSTEM ONLY $389.95!

CMOS

4001	.19	14419	4.95
4011	.19	14433	14.95
4012	.25	4503	.49
4013	.35	4511	.69
4015	.29	4516	.79
4016	.29	4518	.85
4017	.49	4522	.79
4018	.69	4526	.79
4020	.59	4527	1.95
4021	.69	4528	.79
4024	.49	4529	2.95
4025	.25	4532	1.95
4027	.39	4538	.95
4028	.65	4541	1.29
4035	.69	4553	5.79
4040	.69	4585	.75
4041	.75	4702	12.95
4042	.59	74C00	.29
4043	.85	74C14	.59
4044	.69	74C74	.59
4045	1.98	74C83	1.95
4046	.69	74C85	1.49
4047	.69	74C95	.99
4049	.29	74C150	5.75
4050	.29	74C151	2.25
4051	.69	74C161	.99
4052	.69	74C163	.99
4053	.69	74C164	1.39
4056	2.19	74C192	1.49
4060	.69	74C193	1.49
4066	.29	74C221	2.49
4069	.19	74C240	1.89
4076	.59	74C244	1.89
4077	.29	74C374	1.99
4081	.22	74C905	10.95
4085	.79	74C911	8.95
4086	.89	74C917	12.95
4093	.49	74C922	4.49
4094	2.49	74C923	4.95
14411	9.95	74C926	7.95
14412	6.95	80C97	.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	3.95
74143	5.95	9602	1.50
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

ADC0800	15.55	8T26	1.29
ADC0804	3.49	8T28	1.29
ADC0809	4.49	8T95	.89
ADC0816	14.95	8T96	.89
ADC0817	9.95	8T97	.59
ADC0831	8.95	8T98	.89
DAC0800	4.49	DM8131	2.95
DAC0806	1.95	DP8304	2.29
DAC0808	2.95	DS8833	2.25
DAC1020	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

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
LM328K	Adj. 5A	TO-3	3.95
78H05K	5V 5A	TO-3	7.95
78H12K	12V 5A	TO-3	8.95
78P05K	5V 10A	TO-3	14.95

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	.49
LM311	.59	LM1488	.49
LM311H	.89	LM1489	.49
LM317K	3.49	LM1496	.85
LM317T	.95	LM1812	8.25
LM318	1.49	LM1889	1.95
LM319	1.25	ULN2003	.79
LM320	see7900	XR2206	3.95
LM322	1.95	XR2211	2.95
LM323K	4.79	XR2240	1.95
LM324	.49	MPQ2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.79	CA3081	.99
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	6.95	CA3089	1.95
LM339	.59	CA3130E	.99
LM340	see7800	CA3146	1.29
LM350T	4.60	CA3160	1.19
LF353	.59	MC3470	1.95
LF356	.99	MC3480	8.95
LF357	.99	MC3487	2.95
LM358	.59	LM3900	.49
LM380	.89	LM3909	.98
LM383	1.95	LM3911	2.25
LM386	.89	LM3914	2.39
LM393	.45	MC4024	3.49
LM394H	5.95	MC4044	3.99
TL494	4.20	RC4136	1.25
TL497	3.25	RC4558	.69
NE555	.29	LM13600	1.49
NE556	.49	75107	1.49
NE558	1.29	75110	1.95
NE564	1.95	75150	1.95
LM565	.95	75154	1.95
LM566	1.49	75188	1.25
LM567	.79	75189	1.25
NE570	2.95	75451	.39
NE590	2.50	75452	.39
NE592	.98	75453	.39
LM710	.75	75477	1.29
LM723	.49	75492	.79

H=TO-5 CAN, K=TO-3, T=TO-220

EDGECARD CONNECTORS

100	PIN ST	S-100	.125	3.95
100	PIN WW	S-100	.125	4.95
62	PIN ST	IBM PC	.100	1.95
50	PIN ST	APPLE	.100	2.95
44	PIN ST	STD	.156	1.95
44	PIN WW	STD	.156	4.95

36 PIN CENTRONICS

	MALE	
IDCEN36	RIBBON CABLE	6.95
CEN36	SOLDER CUP	4.95
	FEMALE	
IDCEN36/F	RIBBON CABLE	7.95
CEN36PC	RT ANGLE PC MOUNT	4.95

INTERSIL

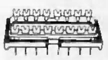
ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	4.95
ICM7207A	5.95
ICM7208	15.95

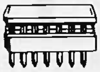
DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS								
		8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	---	.95	.95	---	---	---	1.75	---	2.95

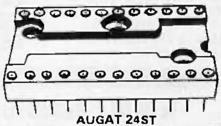
FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE BELOW

ICC16





IDP14



AUGAT 24ST

DIODES/OPTO/TRANSISTORS

1N751	.25	4N26	.69
1N759	.25	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP04	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	.99
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

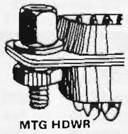
D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS					
			9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.25	1.80	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.50	2.35	4.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	---	1.95	2.65	---
	FEMALE	DBxxSR	1.25	1.55	---	2.00	2.79	---
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	---	3.89	5.60	---
	FEMALE	DBxxSWW	2.76	4.27	---	6.84	9.95	---
IDC RIBBON CABLE	MALE	IDBxxP	2.70	2.95	---	3.98	5.70	---
	FEMALE	IDBxxS	2.92	3.20	---	4.33	6.76	---
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30	---	---
	GREY	HOODxx	.65	.65	---	.65	.75	.95

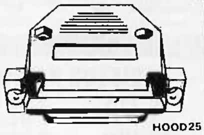
ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED.

EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR

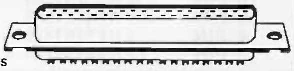
MOUNTING HARDWARE $1.00



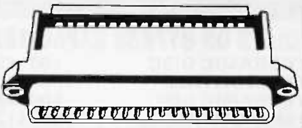
MTG HDWR



HOOD25



DB37S



IDB37S

LED DISPLAYS

FND-357(359)		COM CATHODE	.362"	1.25
FND-500(503)		COM CATHODE	.5"	1.49
FND-507(510)		COM ANODE	.5"	1.49
MAN-72		COM ANODE	.3"	.99
MAN-74		COM CATHODE	.3"	.99
MAN-8940		COM CATHODE	.8"	1.99
TIL-313		COM CATHODE	.3"	.45
HP5082-7760		COM CATHODE	.43"	1.29
TIL-311	4x7	HEX W/LOGIC	.270"	9.95
HP5082-7340	4x7	HEX W/LOGIC	.290"	7.95

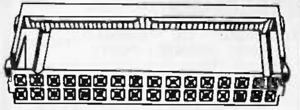
DIFFUSED LEDS

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

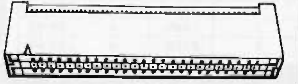
IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS					
		10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.79	.99	1.39	1.59	1.99	2.25
RIBBON HEADER	IDMxx	---	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.65	2.75	3.80	3.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE ABOVE



IDS34



IDE50

SWITCHES

SPDT	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.39
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CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER, ALL WITH .1" CENTERS

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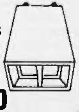

5/$1.00

Dear Mr. Rose:

I feel compelled to commend you and your people for the pleasant, polite, willingness to help and professional attitude you have displayed. In these times it is indeed refreshing to deal with a company whose staff consists of people of this caliber. My friends and associates will most certainly be doing business with you again.

Sincerely, Nicholas Chabra

RIBBON CABLE

CONTACTS	SINGLE COLOR		COLOR CODED	
	1'	10'	1'	10'
10	.18	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.50
25	.45	4.00	.75	6.85
26	.46	4.10	.78	7.15
34	.61	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

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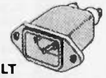

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18	IDWRAP 18	5	1.95
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28	IDWRAP 28	5	1.95
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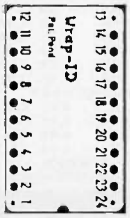

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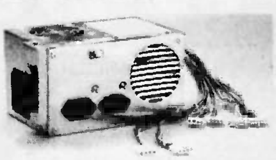

PS-IBM

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22	15V	1.35	4.7	35V	.85
.22	35V	.40	10	35V	1.00

DISC

10pf	50V	.05	680	50V	.05
22	50V	.05	.001μf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

MONOLITHIC

.01μf	50V	.14	.1μf	50V	.18
.047μf	50V	.15	.47μf	50V	.25

ELECTROLYTIC

RADIAL			AXIAL		
1μf	25V	.14	1μf	50V	.14
2.2	35V	.15	10	50V	.16
4.7	50V	.15	22	16V	.14
10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
100	16V	.18	220	25V	.30
220	35V	.20	470	50V	.50
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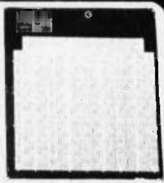

WBU-208

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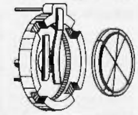

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20MB HARD DISK SYSTEM ONLY $389⁹⁵!

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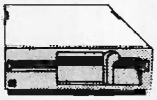
FOR APPLE COMPUTERS



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- ½ HT, DIRECT DRIVE
- 100% APPLE COMPATIBLE
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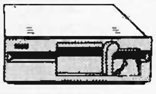

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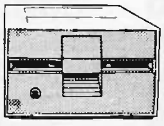

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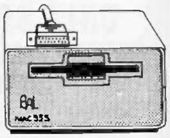

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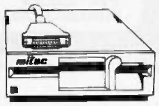

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- 100% APPLE IIc COMPATIBLE, READY TO PLUG IN, W/SHIELDED CABLE & MOLDED 19 PIN CONNECTOR
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ADAPTS STANDARD APPLE DRIVES FOR USE WITH APPLE IIc

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- USER DEFINED FUNCTION KEYS
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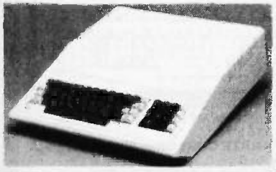
- AUTO-REPEAT



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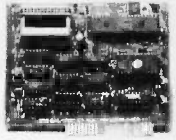

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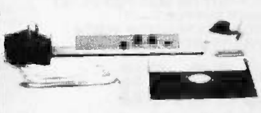

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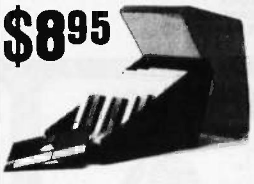

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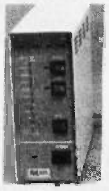

SP110

NASHUA DISKETTES DEALS

5¼" SOFT SECTOR
DS/DD WITH HUB RINGS

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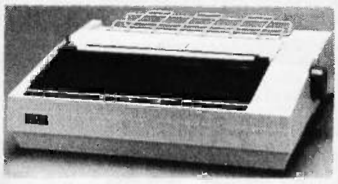

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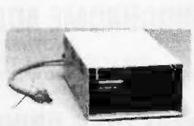

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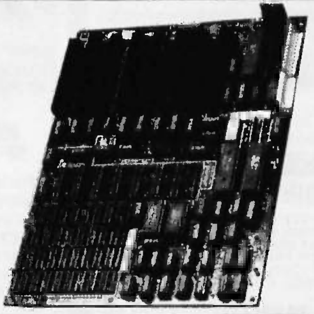

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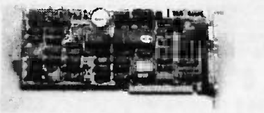

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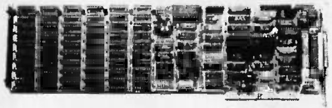

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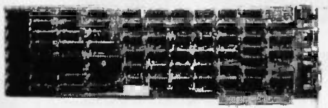

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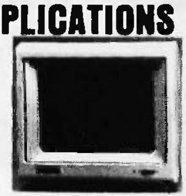

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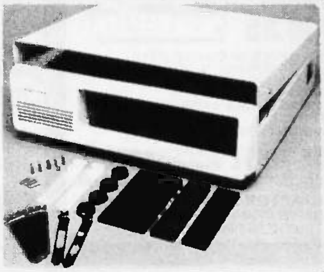

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Winner of $100 for placing first in June's BOMB is Robert A. Moog for his "Digital Music Synthesis," an overview of the general attributes of musical sound and how to produce it. In second place, and the winner of $50 is Eric Jensen for his review of the Atari 520ST. The $50 award for quality also goes to Robert A. Moog for "Digital Music Synthesis." Congratulations.

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HARDWARE REVIEWS:

An objective appraisal of the Amiga; the powerful, downsize Compaq II transportable; the UNIX-based, multiuser Tandy 6000; three 24-pin printers; and four magnetic-tape backup units.

SOFTWARE REVIEWS:

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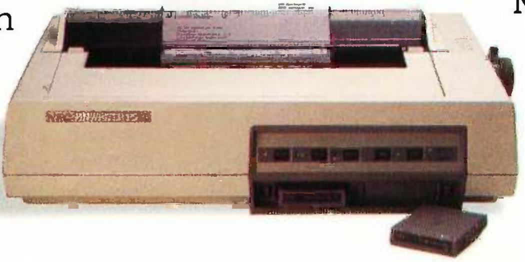

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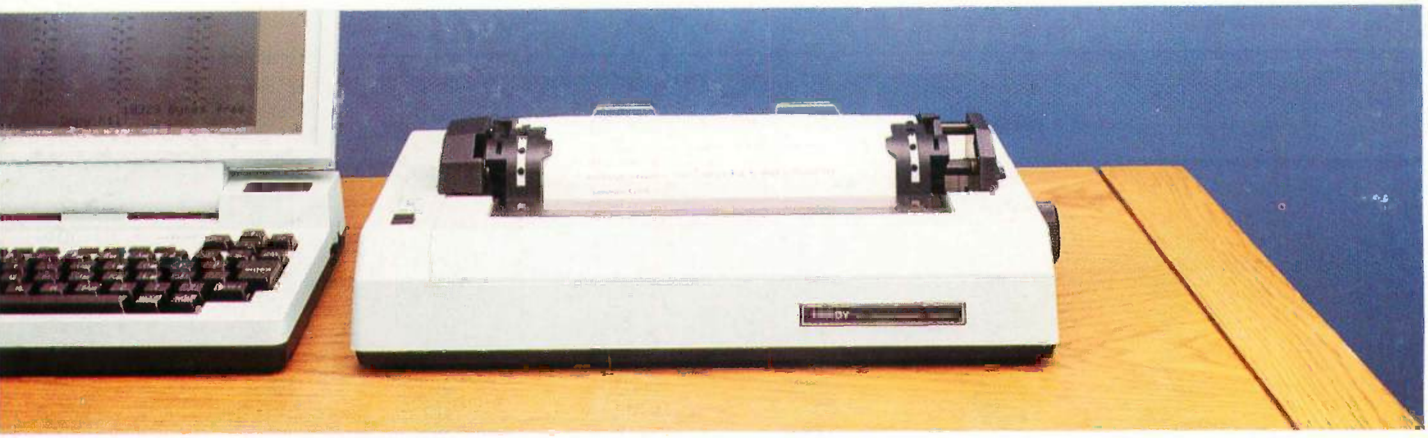

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