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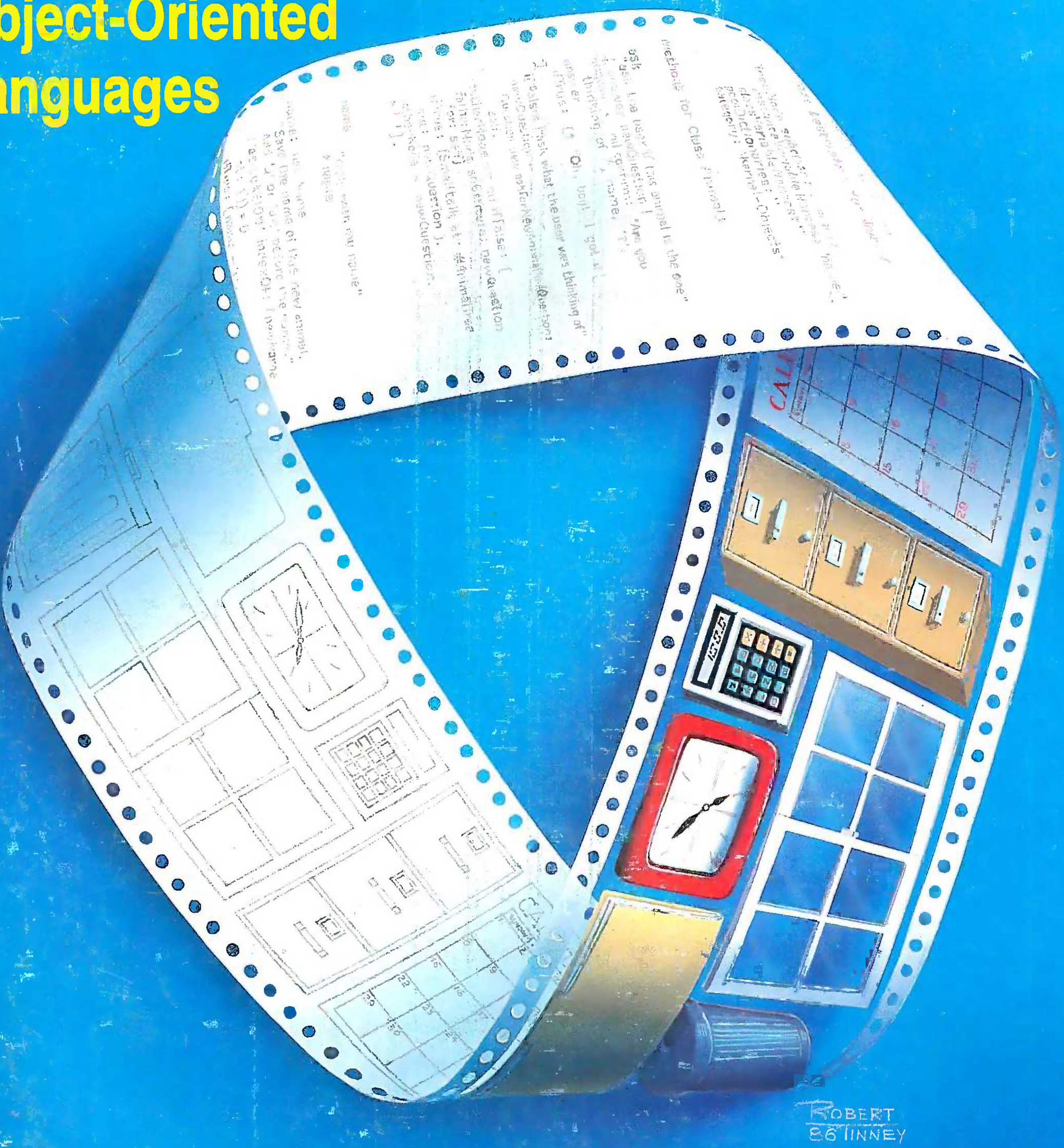
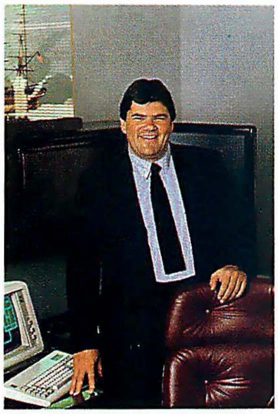
Object-Oriented Languages





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

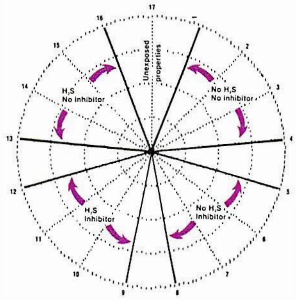
Circular charts (or CPPCs) are used by Michael J. Watkins of the Petroleum Technology Center in Houston, Texas, to plot a single performance property for a large number of elastomers, which have elastic, rubber-like properties.

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.*"

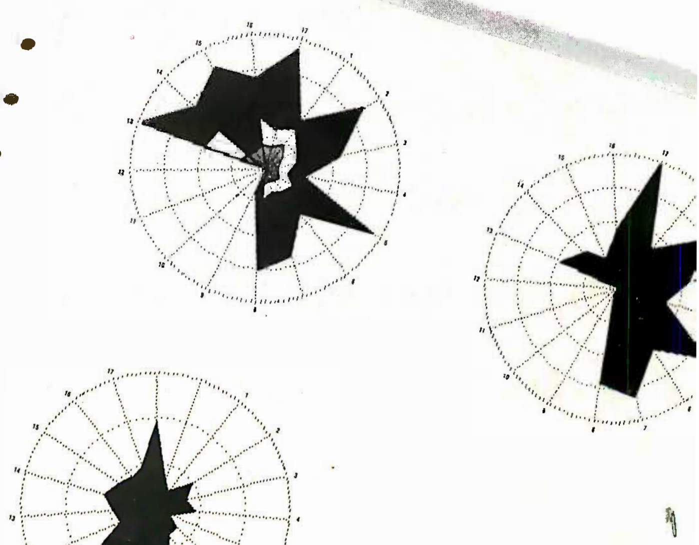
What he did to solve those problems was to write a Turbo Pascal program for IBM® personal computers to "*generate these charts quickly and easily.*"

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"



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.

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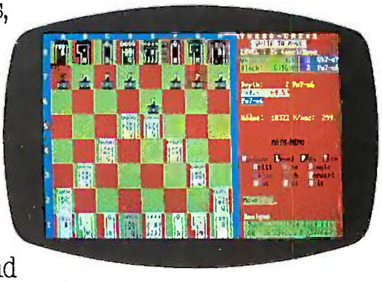
Borland's Electronic Reference Programs:

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.

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 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.

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.

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.

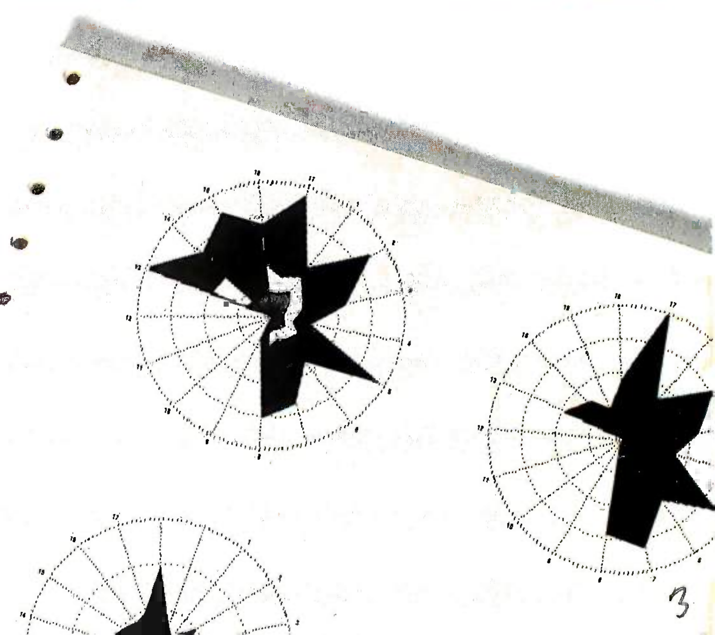
SIDEKICK* Minimum memory: 128K.

TRAVELING SIDEKICK* Minimum memory: 256K.

SUPERKEY* Minimum memory: 128K.

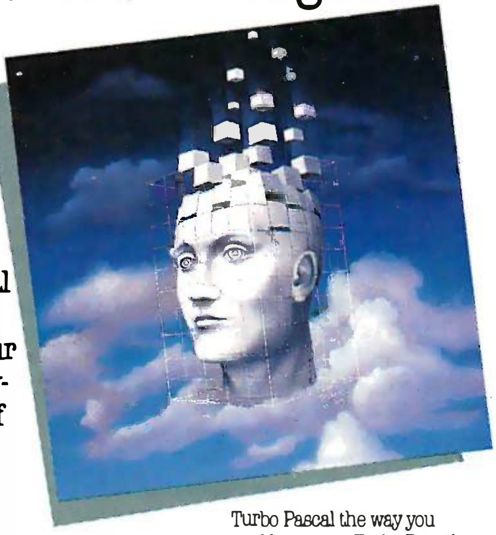
*For IBM PC, AT, XT, PCjr and true compatibles only, running PC/MS-DOS 2.0 or later.

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.



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

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

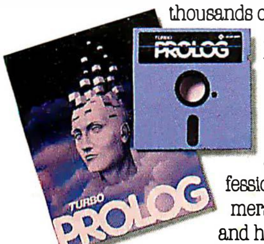


Prolog is probably one of the most powerful computer programming languages ever conceived, which is why we've made it our *second* language—and "turbocharged" it to create Turbo Prolog.™

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 th ugh 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.
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**Limited Time Offer until September 1, 1986.*

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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.

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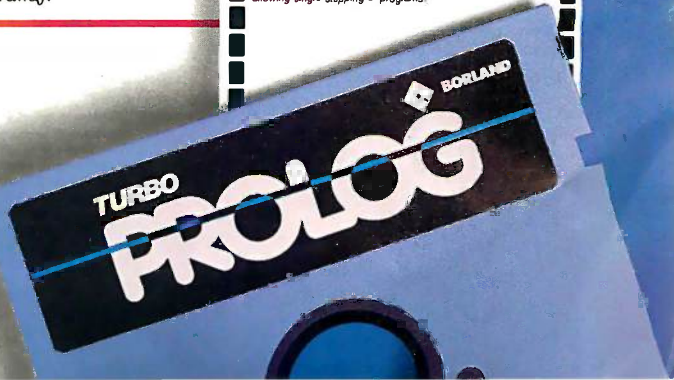

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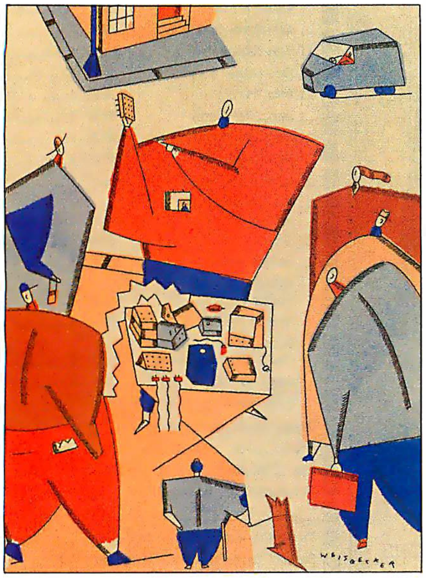

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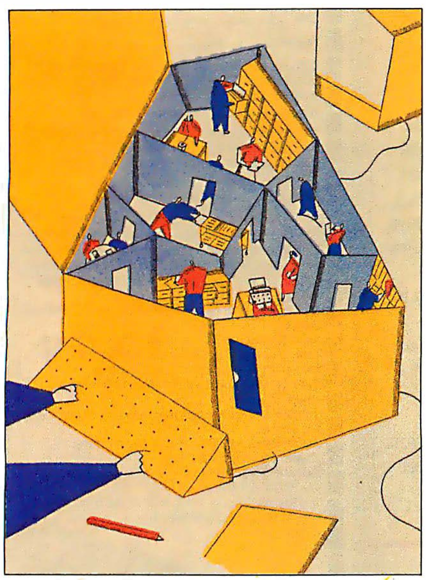

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THEME: OBJECT-ORIENTED LANGUAGES

REVIEWS

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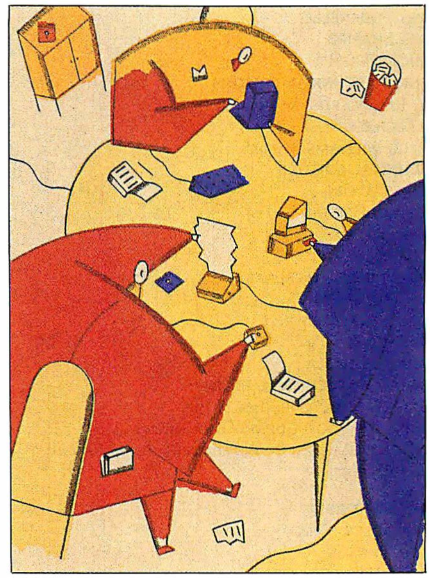

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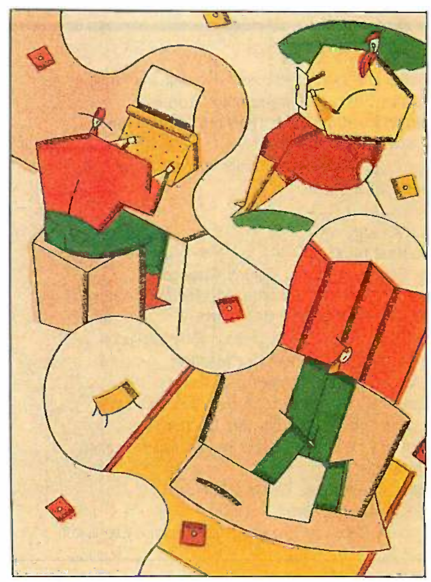

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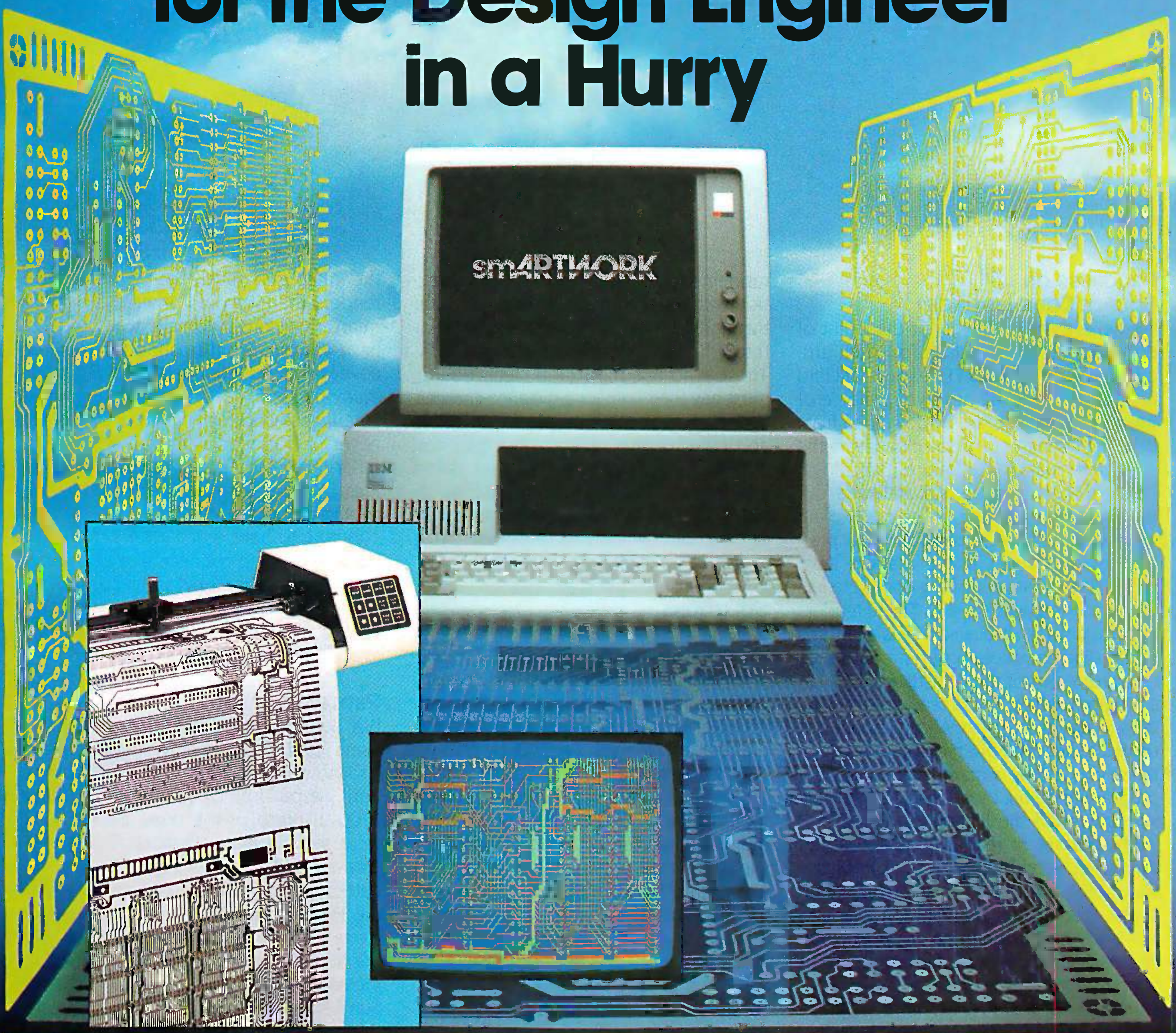

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PROGRESS ON SOURCE CODE LISTINGS

We believe we are finally at the point of providing program listings for BYTE articles in ways that all BYTE readers will find satisfactory. You will have your choice of listings on disk, in print, by download from BYTEnet Listings, or by download from the BYTE Information Exchange (BIX).

Before explaining more about these four ways of receiving listings, let me explain what we have found out about your preferences. For years, some readers have complained that publishing complete listings in the magazine is silly. These readers generally want discussion of algorithms rather than complete programs, and they consider it out of the question to type in a program listing. These readers say nothing is duller than 10 consecutive pages of source code when the program doesn't interest you. If they want to run or study the program in detail, these readers say, they will download the listing.

Another set of readers has expressed the opposite preference: listings in print—and nothing less than listings in print. These readers say they seldom want to run programs; rather, they want to study source code alongside the article about the program. They want all articles laid out so that descriptive text is always beside the relevant passage of source code—something that is seldom possible under the best of circumstances. These readers' primary interest is to learn programming techniques and apply them in their own programs. Readers of this type have been understandably upset by our recent emphasis on the electronic publication of listings. Whenever these readers have written, we have sent them photocopies of specific listings on request. This has been a strain on our editorial assistants and has been inconvenient for the readers affected.

Our impression is that most readers want the program listings in machine-readable form. Readers who don't have modems want the source code listings on disk. In trying to satisfy this need, we have tied up several staff members in converting data from one disk format to another and in making copies in each format.

North American readers who do own modems have expressed no dissatisfaction with the availability of listings, either through our three free bulletin boards or through our commercial service, BIX. Those who use the free bulletin boards must pay their own long-distance charges. Those who use BIX must pay a sign-up fee and connect-time charges, but they can call a local Tymnet node and avoid telephone tolls. Readers outside North America have faced high telephone tolls or data-communications charges in trying to get BYTE listings by modem.

SOLUTIONS

Starting in September, we will provide in BYTE postage-paid order cards for program listings in a choice of 12 disk formats. To make it possible to fulfill orders with acceptable efficiency, we had to limit the number of formats supported. But we have chosen the formats based on requests received over the past several months. We have also made an arrangement with a commercial disk-fulfillment service that will provide rapid turnaround on orders. The order card will permit you to subscribe to a year's listings on disk, if you wish. Readers will be able to subscribe to the listings on disk just as they subscribe to BYTE itself.

Also starting in September, we will offer quarterly printed volumes of source code to accompany BYTE articles. To help all readers catch up, we will first offer a single volume of printed listings to accompany the January–June 1986 issues. Thereafter, we will offer a volume of source code in the middle of the second month of each quarter. Readers will be able to subscribe to the listings in print if they prefer this medium to disk. The advantage of having the source code in volumes separate from the articles is that the reader will always be able to open both the listing and the article to the desired page. This solves the layout problem in the best possible way.

We are pricing the quarterly listings now. We want to hold the price as low as possible but must pay for paper, printing, shipping, postage, and handling. Our management thinks it unlikely that advertisers will want to buy space in a volume that consists entirely of program listings. Advertisements in BYTE's regular issues make the magazine much less expensive to readers than it would otherwise be. The quarterly listings volume will probably have to derive all its support from the cover price. But the quarterly will contain many pages of source code in high-level languages—code for which there could never be room enough in BYTE itself.

For those who prefer to download listings, BYTEnet Listings will remain free (except for your own telephone tolls); BIX will continue to have a one-time $25 sign-up fee and evening connect-time charges of $9 per hour plus $2 per hour Tymnet surcharge.

We hope every reader will find listings available in a satisfactory form.

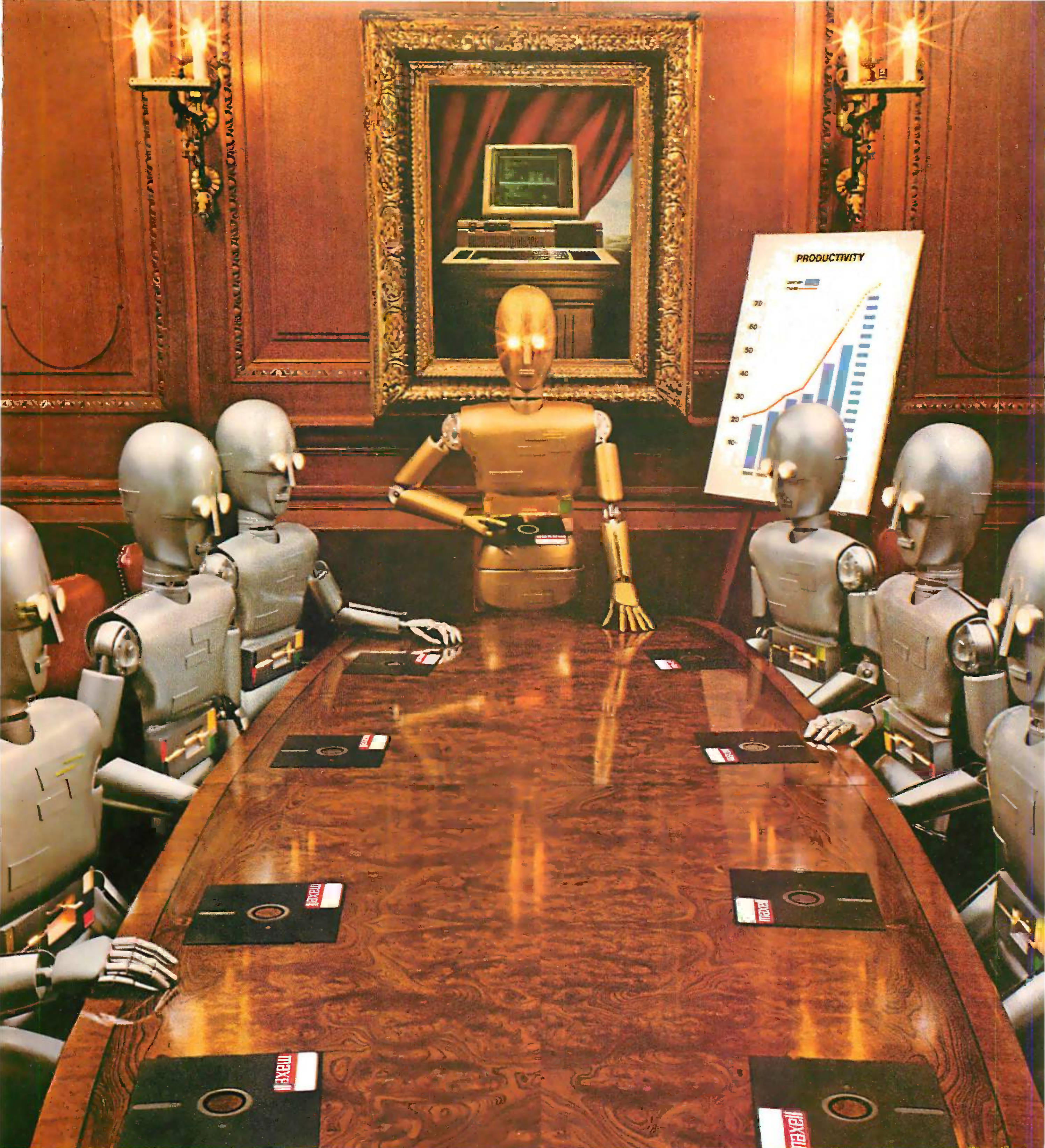
PROGRESS ON BIX

BIX now (mid-June) has more than 6000 users and continues to grow rapidly. Growth was slowing system performance until we put four 68020s into the Arete 1200 in place of the three 68000s that were serving as processors. We also increased RAM from 4 megabytes to 8. Together with the twelve 68000s that handle I/O, the four 68020s have made the Arete run with blazing speed again. We are considering the use of multiplexers, to increase the capacity of each port, and Sun's Network File System, to go beyond the capacity of one Arete 1200.

David Betz, BIX senior editor and author of XLISP, has made a number of enhancements to the BIX code since joining us. His new cyclic redundancy check routines have made downloads through packet nets (Tymnet) quite reliable and accurate. Other enhancements will make BIX easier to use. Programmers in New York are at work on direct-debit billing and corporate billing options to make BIX accessible to those who prefer not to use MasterCard or Visa.

McGraw-Hill has decided to send out requests for quote to provide the hardware for the next generation of BIX. The Arete machines are very much in the running, as are a number of other supermicros and some superminis. One large timesharing service wants to host BIX on Cyber mainframes.

—*Phil Lemmons*
Editor in Chief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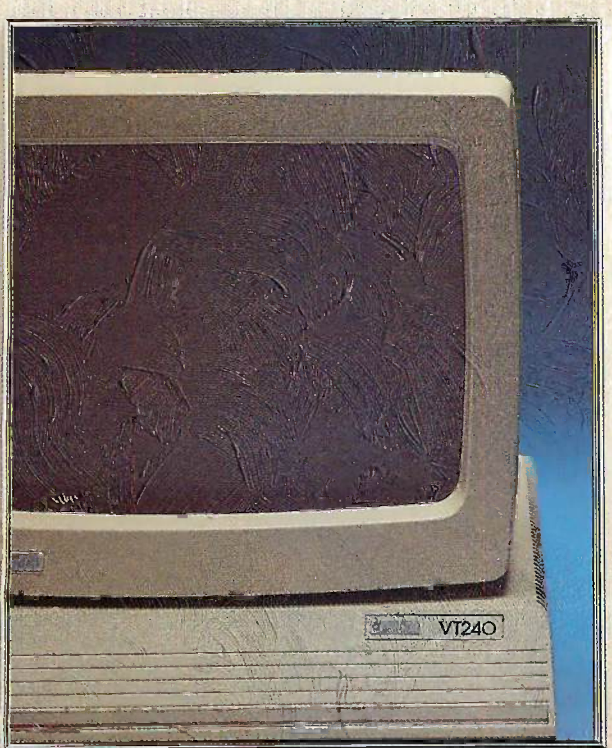

persoft

Inquiry 228

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

CMU Researchers at Work on Storage Device, NAND Gate Based on Biological Materials

Researchers at Carnegie-Mellon University in Pittsburgh are at work on two digital electronics devices based on biological materials: a storage device that can pack data at a density of 1 gigabyte per square centimeter and a NAND gate that is 1000 times smaller than current NAND gate circuits.

According to Robert Birge, head of the chemistry department at CMU, the storage device is based on a protein called bacteriorhodopsin, which can exist in two states, each of which absorbs light at a different frequency. The state of each molecule can be read and flipped with a laser tuned to one of these frequencies.

In a prototype built by the CMU group, three molecules can hold 1 bit of data. This triad of molecules is relatively small, encompassing an area of approximately 100 square angstroms. Although the storage density in the prototype is 1 gigabyte per square centimeter, the small size of the triad implies that the theoretical molecular limit for data storage is 100,000 gigabytes per square centimeter.

The speed of these molecules is estimated at 10 picoseconds per transaction, much faster than the time required by any optical modulator to access the molecules with the laser light. The data-access rate for this device is thus a function of the speed of the optical modulator.

Bacteriorhodopsin, produced by a genetically modified strain of bacteria found originally in the salt marshes of San Francisco Bay, is said to be very stable and can stand up to high temperatures and high amounts of optical radiation. Birge and his colleagues are working on genetically modifying the bacterium to yield a protein that will perform satisfactorily at room temperatures.

The CMU group is talking with Seagate Technology regarding possible implementations of research results.

The NAND gate that's based on biological molecules will be composed of two cyanine/quinone complexes joined to a porphyrin molecule. If both cyanine groups are excited, for example, by two lasers, the porphyrin molecule will become excited. The excited porphyrin can in turn excite a chromaphore molecule, which can be read by a third laser or can serve as input for another NAND gate.

Although an individual NAND gate has not yet been completed, Birge expects the gate to change states in a mere 3 picoseconds. As for size, at 10 nanometers per gate, the gates would be 100 times smaller than sizes predicted for future conventional NAND gates.

Funding for the NAND gate research is being supplied by IBM.

Cover Designed to Thwart Electronic Eavesdropping

In response to a report detailing the ease with which unauthorized persons can eavesdrop on computer terminals (see Microbytes in the March BYTE), a start-up company in Canada is planning to bring to market a flexible covering for terminals that will help eliminate this possibility. The new product, tentatively called the Erintec Security Canopy, is designed to absorb electromagnetic radiation emanating from a terminal's cathode-ray tube. Last year, a Dutch engineer named Wim van Eck demonstrated how easy it is to receive and decode that radiation. Using only an ordinary television, an antenna, and electronics parts worth about $15, van Eck was able to eavesdrop on confidential information on a terminal screen located hundreds of yards away.

The canopy is made of metalized fabric and glass and completely encloses a terminal. The product was designed by an Irish research firm called Securi-Tek Ltd.; it will be marketed by the newly formed Erintec, of Toronto, in the fall. According to a company spokesperson, the price of the canopy has not been set, but it will probably be in the neighborhood of $500.

(continued)

Ex-Apple Engineers Plan Card That Brings XT Compatibility to IIe

A start-up engineering firm headed by ex-employees of Apple Computer expects to give the venerable Apple II yet another life by adding IBM PC XT compatibility to the machine. The Engineering Department Inc. (Campbell, CA) hopes to have its Little Blue card for the Apple IIe in production and available by January 1987, according to marketing manager Dave Larson. The Engineering Department is headed by Wendell Sander, a former Apple engineer who designed the Apple III and the Integrated Woz Machine, a custom integrated disk controller used in the Apple IIc and Macintosh.

Based on a 7.2-MHz 8086 processor, the Little Blue design includes 640K bytes of user RAM, IBM CGA-compatible video, hard disk support (including the ability to store MS-DOS files on Apple hard disks such as the ProFile), and a socket for an 8087 math coprocessor.

Little Blue won't be the first attempt to bring IBM PC compatibility to the Apple II. One now-defunct product, the Rana Box, housed an 8088 in an external system with its own PC-style 5¼-inch disk drive. Little Blue is designed as an internal product that will be able to use newer Apple 3½-inch drives to read and write both Apple II and IBM PC XT software.

"Rana was external and it wasn't the right solution," Peter Quinn, executive vice-president of The Engineering Department, told BYTE/BIX. Quinn worked as hardware and product design manager of the Apple IIe and IIc and was an integrated circuit designer at Zilog. "The software alone will represent four man-years of development [when Little Blue is finished]," said Quinn. "There's a lot of skepticism [that it can be done], but we're not afraid."

Stanford Designs New RISC Chip

Engineers at Stanford University's Center for Integrated Systems have designed a microprocessor they say is capable of speeds of 20 million instructions per second and of running in parallel with others like it. The MIPS-X is a CMOS chip that uses the RISC (reduced instruction set computer) design. Although the actual chip has not been fabricated, one will be made this summer, according to Mark Horowitz, an assistant professor of electrical engineering and team leader of the project.

The 8- by 8.5-millimeter MIPS-X will contain 150,000 transistors. The MIPS-X project is the lineal descendant of one of the first RISC machines, the MIPS processor designed at Stanford by John Hennesey.

"In fairness, the 20 million instructions is really the peak, the best it could ever do," Horowitz said. "We hope to have an effective throughput of 10 million [to] 12 million instructions per second."

A computer built with 10 MIPS-X chips operating in parallel could perform as many as 100 million instructions per second, making it one of the fastest computers in the world. However, Horowitz said he has no intention of trying to build a computer system based on the MIPS-X chip. "If people who are doing work in operating systems and other kinds of software development are interested in using it, that's fine," he said.

NANOBYTES

VLSI Technology Inc. (Phoenix, AZ) and **Intel Corp.** (Santa Clara, CA) have teamed up to design and market the CMOS VL82C389 Message Passing Coprocessor (MPC) chip. According to the two companies, the MPC increases the reliability and decreases the power consumption of Multibus II boards by replacing as many as 50 chips. It handles interboard communications tasks and relieves the CPU of monitoring or directing those tasks. Use of the MPC could allow architects to fashion Multibus II systems with multiple 80386 boards, each dedicated to a particular part of a computing task. Intel used VLSI's software to design the 70,000-transistor chip, which is being manufactured by VLSI in CMOS technology. . . . **Corvus Systems Inc.** (San Jose, CA) says it is beta-testing a central processor for networks that is based on Intel's 32-bit 80386 microprocessor. Corvus calls the system a "departmental" processor and says that it would serve as the focal point of a LAN connecting several microcomputers. . . . **California State University, Northridge**, will host a three-hour presentation on the use of computers with learning-disabled students as part of the Computer Technology/Special Education/Rehabilitation conference, slated for October 16–18. For more information, contact Harry J. Murphy at CSU, Northridge, 18111 Nordhoff St., Northridge, CA 91330, (818) 885-2578. . . . Although the secrecy-shrouded **National Security Agency** will not comment on it directly, several sources in the security field say the NSA is withdrawing its support of the Data Encryption Standard (DES) and championing a new encryption scheme based on a classified algorithm that's being implemented only in hardware. The agency is apparently so adamant about keeping the algorithm secret that it is said to be investigating the use of special chips that will self-destruct if tampered with.

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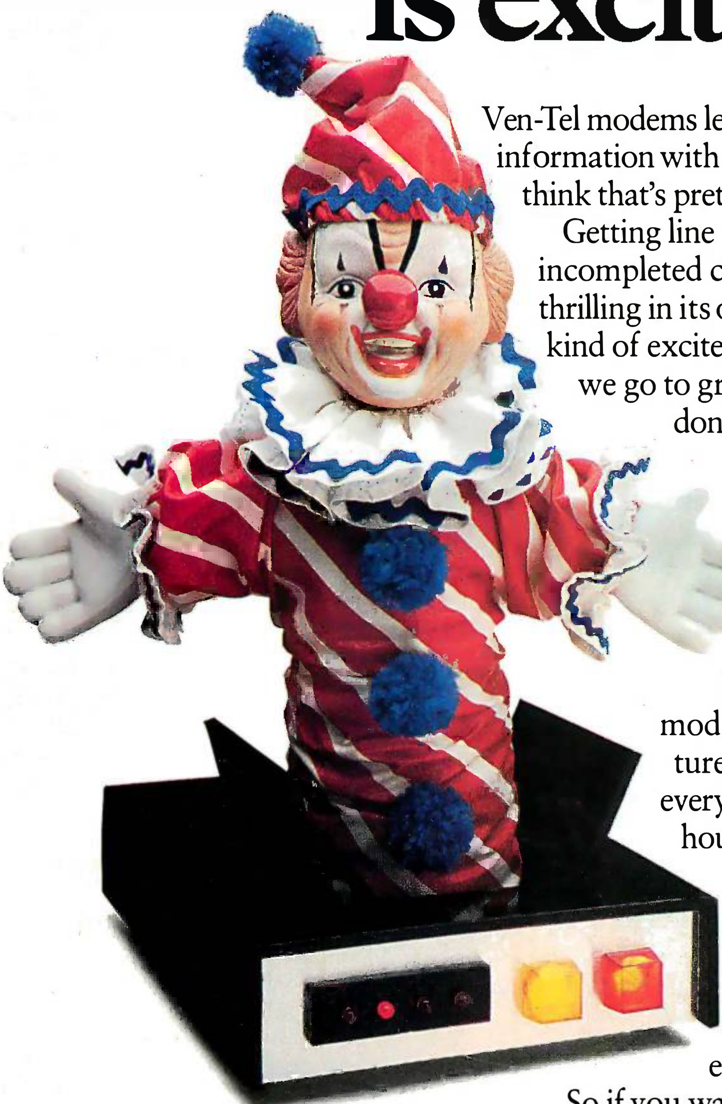

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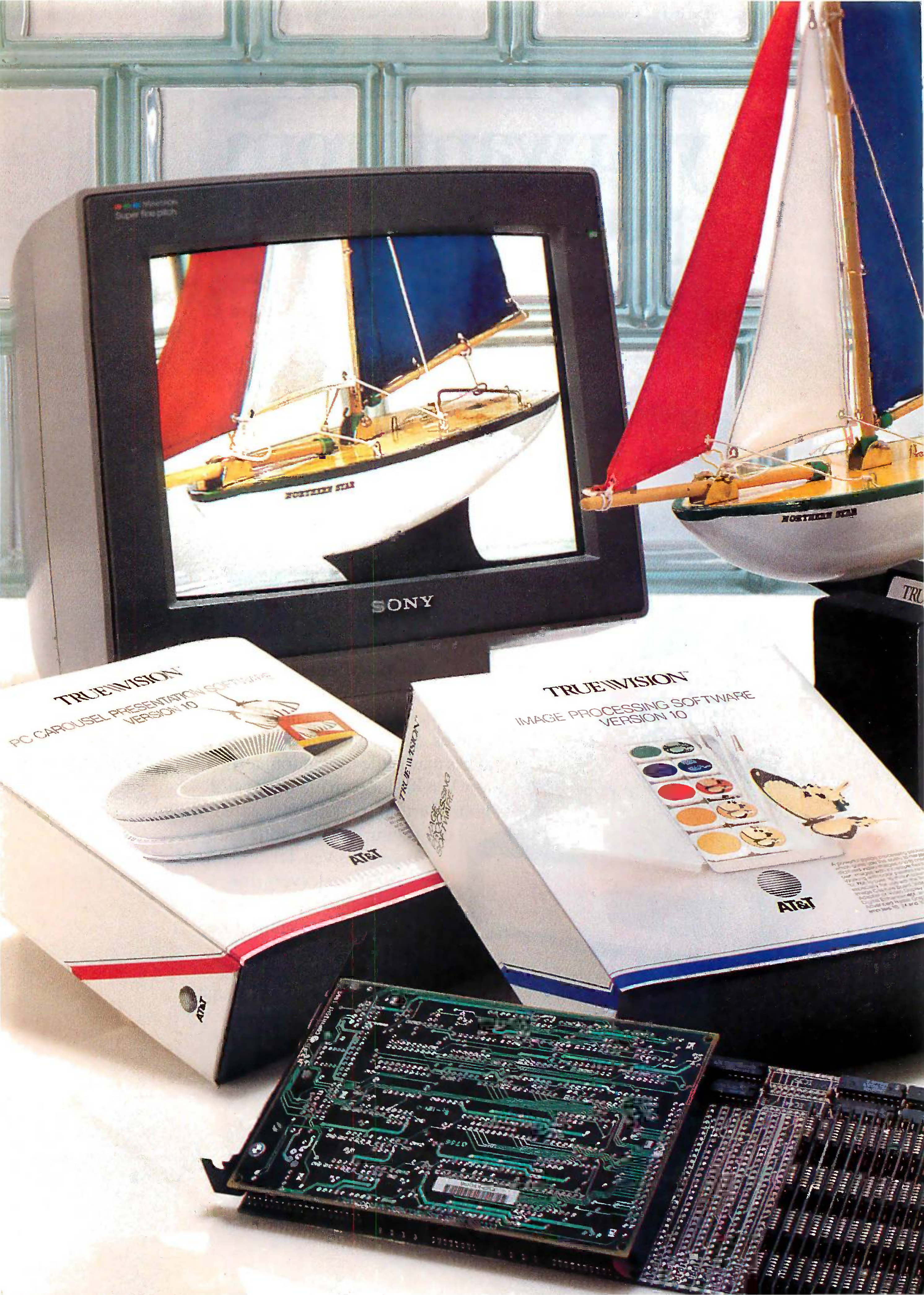

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Display shows unretouched TARGA 16 image on Sony CPD-1201 Monitor.

VOLLEYING ATARI AND AMIGA

Editor's note: The following two letters are representative of several we received on the subject, all of which were similar in opinion, if not in style.

In the May issue of BYTE, a letter appeared by Mike Farnsworth (page 16) giving a comparison of the Atari 520ST and the Amiga. Unfortunately, the letter contains some misinformation about the Amiga.

Concerning the Amiga, Mr. Farnsworth states, "In the low-resolution mode, those great graphics chips steal almost 75 percent. . .of the possible CPU time that could be used for other real-computer things." A more accurate description of the Amiga's bus timings can be found in the August 1985 BYTE. In brief, the Amiga's memory operates at exactly twice the speed of the CPU. Running at full speed, the CPU uses only half the memory cycle time available, leaving the other half to the custom chips. To fully utilize the 50 percent allotted to the custom chips, the Amiga could simultaneously read the disk, play four channels of audio, and show 16-color low-resolution bit-plane graphics and eight sprites with virtually no slowdown of the 68000. [*Editor's note: See page 87 of the August 1985 issue for more details.*] While higher screen resolution and high activity of the blitter (a custom graphics chip) will cause cycle stealing from the CPU, one must remember that these chips are doing work that would otherwise be done by the CPU, and they perform that work two to thirty times faster. As far as non-graphics timings, page 354 of the May BYTE contains a few benchmarks of the two machines. It should be noted that while the ST is somewhat faster in some benchmarks involving numeric computation, the expansion bus of the Amiga facilitates the addition of a math coprocessor (unlike the ST), which can speed calculations by an approximate factor of ten.

Looking at the same table on page 354, note that the difference in disk I/O ranges from a 315 percent advantage for the Amiga on disk writes, to a 25 percent advantage for the ST on random access. This brings up a point about the slowness of AmigaDOS in some activities. It is untrue, as stated, that the Amiga has anything in common with the C-64 disk formats. Remember that the original operating system and hardware design was not done by Commodore but by Amiga. An excellent description of the AmigaDOS formats and operation can be found on page 321 of the February BYTE. In short, files and directory blocks are scattered on an Amiga disk. While this improves on error recovery compared to other disk formats, it is inherently slow in operations such as directory listings. Its slowness is in finding the file, but it's quick once the file is found.

Mr. Farnsworth also states that AmigaDOS is clumsy, though he gives no examples to substantiate this claim. Considering that one must reboot an ST to change from monochrome to color or from a windowing to a command-line interface, I can't see how AmigaDOS could be considered clumsy in comparison.

Finally, support for the ST has been praised. Note that about 300 to 500 pages of technical documentation on the ST can be obtained from Atari, while a full set of manuals for the Amiga contains slightly over 2000 pages. I personally doubt that Atari intends to support its customers via a support line. So from whom would you rather get support, an Amiga dealer or your local department store?

BERNIE J. LOFASO JR.
Austin, TX

The 68000 CPU used in the Amiga has about a 50 percent duty cycle. By that I mean it spends about half its time on the memory bus and the other half doing internal processing. The quoted clock figures for the Amiga are stated with respect to the CPU. In fact, the Amiga uses an internal clock with twice that speed (yielding about 14.4 MHz). The custom chips do 16-bit transfers in one of those cycles.

That means the custom chips can do one heck of a lot of transfers in the "off" cycles where the 68000 is twiddling its thumbs internally. The bus arbitration is handled, again, with the custom chips. Each of the 25 DMA channels has its own slots in the timing, which let it get its work done without interfering with the 68000.

What this means is that you can have a 320 by 400 by 4 display with four audio channels, the disk, the sprites, and the 68000 all going at the same time. The 68000 will see no contention! It doesn't even think those DMA channels are on the bus!

The blitter is a cycle-stealing device. It will use whatever cycles are not taken up by the other DMA channels and it will use the cycles normally reserved for the CPU. In normal blitter operation, it is set up to yield whenever the CPU tries to access memory on that bus. This means the CPU can get in to process interrupts, for instance, even if the blitter is in the midst of a large transfer.

The upshot is that blitter operations happen as fast as the memory can go, with 16-bit transfers continuously going at twice the memory bandwidth of the 68000, not even including any 68000 processing time that would be involved if you used it instead of the blitter. This is why the machine really screams for blitter-supported operations such as area move, area fill, and line draw.

The display coprocessor is also a cycle-stealing device. It allows raster-beam synchronized control of all the machine's custom chip functions without requiring the 68000 to take the time to perform an interrupt context switch. This is why we've got enough horsepower to slide screens around in real time while animation and graphics rendering is going on in the screens.

You can set up the display so the 68000 sees contention. The worst case is a four-plane high-res image, where the video bandwidth blocks the 68000 except during horizontal and vertical blanking intervals.

Note, however, that the 68000 can only

(continued)

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

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Inquiry 309

see contention on the internal RAM, never on the Writable Control Store RAM *or on any* external RAM (this is why the external RAM is referred to as "fast" RAM).

You can avoid contention by going to fewer bit planes (for instance, Workbench and the CLI use two planes of high res, yielding no contention) or by reducing the vertical size of your image (such as by using the Intuition screens to make most of your display be at some other resolution).

Note that interlace is not an issue here. Yes, there is twice as much data to display, but remember that the machine takes two frames to display it.

The next revision of the hardware manual will include detailed information on the DMA priority and the time-slot allocations, for all you guys who want to run right at the edge.

The only (charitable) explanation I can come up with for someone to say that the Amiga custom chips slow down the 68000 by 70 percent in normal operation is that someone misread the chart showing the allocation of DMA channels to the off cycles and assumed that the 68000 was in fact capable of using those cycles. An 8-MHz 68000 can't. Does anybody have a 16-MHz 68000 they'd like to loan me?

ROBERT S. PARISEAU
Santa Clara, CA

EUROPEANS LEFT OUT OF THE TELECOMMUNICATIONS REVOLUTION

Although I agree with the tenor of your May editorial ("Let Our Modems Go"), there are some misunderstandings:

First, you are mixing international telephone fees with Datex-P fees. Only one of those applies to a given connection.

Second, although modem leasing is expensive, a Datex-P20 (PAD connection via your own line) is not much more expensive than a modem alone. The U.S. Air Force in Geilenkirchen uses this. A Datex-P line costs 130 deutsche marks (about $57) per month and DM 200 for first-time installation. This is cheaper than comparable U.S. prices.

By the way, modems are part of the monopoly situation of the Bundespost. This will probably change quickly because of a lawsuit against the government.

So modems of some kind will become available on the free market *after* being approved (and having received a license number) by the ZZF (part of the Bundespost).

Technical problems: When I say "modems" I do not mean those units available in the U.S. The modems to which I

(continued)

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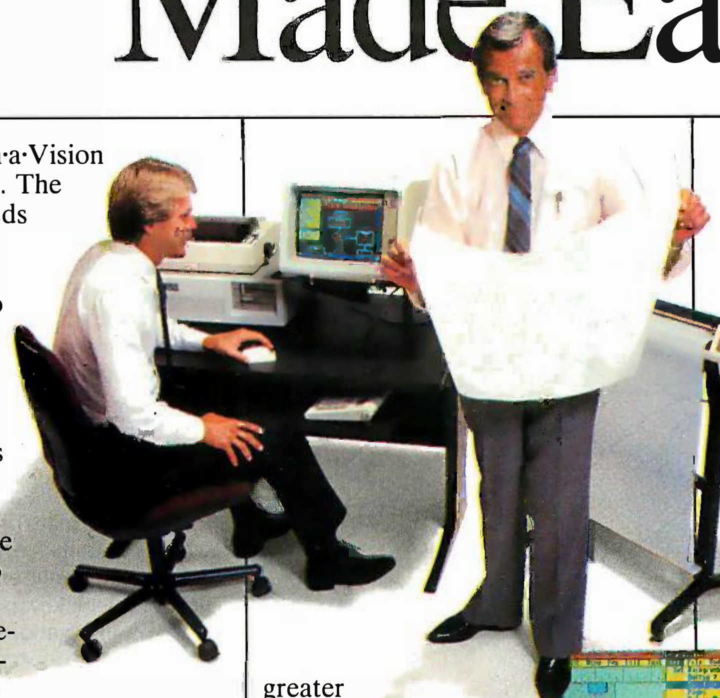

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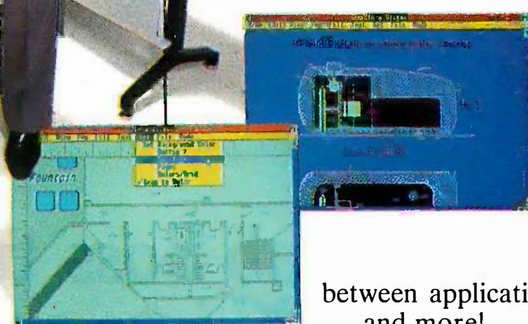

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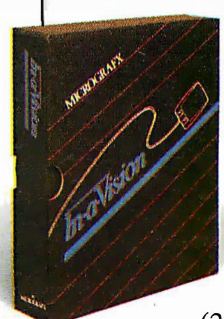

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refer use the CCITT conventions. So there will not be a direct market for Hayes-compatible modems here, I think.

A further complication is the different tone systems used in European nations.

Third, you can get into the network in several ways:

By telephone: A call to the PAD (one of 17 locations) is DM 0.23 for 0.5 to 12 minutes, depending on distance, plus DM 0.06 per minute telephone access costs.

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By Datex-P10 line: If you have an X.25 equipment/line, it costs DM 0.20 per minute to the U.S. and DM 0.016 per segment, plus:

Any connection costs are DM 0.05 extra. Also, a segment is not a kilocharacter but 64 bytes or a packet, whichever comes first. This means an empty carriage return costs 1.6 pfennigs!

That last one is a difficulty Europeans (not just Germans) have with U.S. hosts, which sometimes echo single characters. This is extremely expensive for us. The next problem: Reversing charges does not work on international lines, but most of the U.S. hosts depend on this and charge users with connection fees, which they have already paid to their local authorities. So we have to pay twice for CIS, BIX, The Source, etc. And no one understands our problems, because all those companies think the whole world is just like the U.S. It is not!

If there is any way I can help you in learning the German (Austrian, Swiss) telecommunications networks, please don't hesitate to ask.

MATTHIAS R. MOHR
RMI Aachen
Aachen, West Germany

I thoroughly approve of, and appreciate, your editorial titled "Let Our Modems Go." I talked with some people in Belgium and France and quickly realized that the local PTT monopolies prevented them from joining the telecommunications revolution. Now I am moving from the University of Maryland into a permanent academic job in Geneva, Switzerland, and I am almost certain that I won't be able to connect from home to the mainframe any longer or pick up public domain software from a local bulletin board.

Furthermore, as teleconferences will surely become the new way of American academic communication in the near future (see the June 1984 BYTE), how long will I be left out of this development

(continued)

because of my move to Europe? If you know of any people or institutions in Geneva who are pushing to reform the system, please kindly send me their address so I can add my voice to theirs.

FRANKLIN MENDELS
Columbia, MD

I have been a longtime reader (and off-and-on subscriber) for many years now. Never has an issue arisen that has affected me to the point where I thought I had to write. Until now. I've lived in France for two years and am scheduled to remain for another seven. I would like to share with you the horror story of access to BIX from France. This could explain why you might hear from me on BIX next summer, but not before.

You may use any 300- or 1200-baud modem that you can buy, as long as it has a French PTT agreement number.

You may use any telephone line as long as it corresponds to your name and address on the application form (i.e., no using your friend's computer).

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- 43 francs (about $6) per 64K bytes transmitted.

Help!

Anyhow, I took the liberty of sending photocopies of your editorial to the director of Network Services for the PTT, Jacques Chirac (new prime minister and minister of telecommunications). Not that any of this does any good. The only people who use large networks are rich companies. Right? Hah!

Keep up the good work at BYTE. (Some day I'll share with you the horror story of how long it takes the local bookstore to get BYTE, but as long as my subscription comes early. . .)

NAME WITHHELD
Paris, France

CRT RADIATION

In the May letters column ("CRTs Are Safe," page 24), William G. Nabor stated, "In my 12 years as a health physicist. . . I have yet to measure *any* ionizing radiation from *any* CRT, old or new, color or monochrome." Mr. Nabor further claimed that ". . .CRTs do not emit hazardous radiation. Period. Any claim to the contrary is misleading to the point of fraud." Perhaps Mr. Nabor should have stated that CRTs do not emit hazardous *levels* of radiation. He has not identified the radiation-monitoring instruments he has used to check CRTs. I have detected radiation from color CRTs by means of simple Geiger counters that I designed and built. I have also used a commercial Geiger counter for this purpose. Though the radiation level from CRTs is very low, it does exceed the background count. For example, the background count inside my office is typically 17 events per minute. The counts at the glass surfaces of two different color CRTs I checked are 28 and 35 events per minute. These counts are so very low that there is no cause for alarm. Indeed, a brick tile I checked generated 40 events per minute and a thorium mantle from a camping lantern registered a much more potent 0.3 milliroentgens per hour.

Incidentally, it is a simple matter to connect a Geiger counter to a computer to generate random numbers. One such pro-

(continued)

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cedure is described in detail in *Forrest Mims's Computer Projects* (Osborne/McGraw-Hill, 1985). I will explain at length how to use a computer-enhanced Geiger counter to make long-term measurements of very low-level radiation, including that emitted from CRTs, in a future installment of my column in *Modern Electronics*.

FORREST M. MIMS, III
Seguin, TX

SHORTCOMINGS OF MODULA-2

"Modula-2 As a Systems Programming Language" by Ryn C. Corbeil and Anne H. Anderson (May) is an interesting overview of some of the features of the language. Modula does indeed provide some features that are useful in a "bit-banging" environment and allows access to the bare iron when necessary. Whether or not it will displace Pascal is problematic, given that the better Pascal implementations provide many of the Modula mechanisms as extensions to elementary Pascal.

Corbeil and Anderson did not address the suitability of Modula for other than system programming, nor did they discuss Modula's shortcomings as a programming language, regardless of the application area. Modula does have a fix for Pascal's conformant array problem, for instance. Unfortunately, the fix only extends to single-dimensional arrays. One is still hard pressed to produce general-purpose procedures that accept an array of strings as an argument, for example, unless one of the dimensions is passed as another argument, à la FORTRAN.

The lack of any intrinsic I/O capability may also be considered a Modula shortcoming. The weakness of Pascal's I/O has been roundly criticized, but at least a rudimentary mechanism exists that often suffices, and the mechanism can be (and regularly is) extended to something useful. Modula gives you nothing to criticize, nor does it give you anything with which to work. Library modules are supposed to provide the I/O interface, but again, what assurance is there of these being adequate, complete, and having any degree of commonality among implementations? If one must deal with the bare iron, then Modula isn't burdened with excess baggage, but you are at the mercy of the underlying operating system (if any) and you had better have a good set of reference materials for the hardware and operating system. Modula is not for the faint of heart.

I found the letter of Chuck Musciano (May, page 14) to be ironically coincidental. There are some of us who become livid when faced with legislated morality, in this case the enforced case-sensitivity of identifiers and keywords. Modula's forcing the use of uppercase characters should please Mark Pickerill (February Letters, page 356), but some of us wouldn't care if we never saw another uppercase character in a source program. Having worked in the industry since the days of punched cards and uppercase-only printers, I've seen enough all-uppercase printouts to last the rest of my life. On the other hand, C's insistence on lowercase alphabetic characters is just as bad. The point is that computer programs shouldn't be establishing arbitrary requirements.

In addition to displeasing half or more of the users, case-sensitivity lends itself to the bad practice of using the same identifier capitalized differently to represent different variables. The user's manual for one implementor's Modula-2 contains several examples of this abuse in the ex-

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ample programs, including the use of an otherwise reserved word as a procedure name. To be "thrashed with a stack of listings," as suggested by Mr. Musciano, is too kind for the supposed professional who perpetrates such a crime.

E. M. GREENE
Ridgecrest, CA

ARGUMENTS IN C

I write to correct two inaccuracies in John D. Unger's book review of *Variations in C* in the May issue. I will also present an argument against a third point of his.

In what is otherwise a favorable review of the book, Mr. Unger raises the criticism that examples follow the proposed ANSI C standard rather than the Kernighan and Ritchie standard. The evidence cited for this is the use of enumeration data types and the void type for functions that return nothing. The interesting fact is that there is a page of the UNIX reference manual dated November 15, 1978 (actually the same year as that of K&R) defining two extensions to the C language, implemented by the portable C compiler, and therefore existing on all current UNIX systems. The first of these is the ability of a function to return a structure, and the second is enumeration types. The C compilers on UNIX also admit the void declarator, but I do not know what year this came out.

I would also like to take issue with Mr. Unger's complaints about the dependence on #define and typedef. He claimed that heavy use of these reduced readability. I am on shaky ground here, not having read the subject book, but I would like to make some comments on the use of these and on good C style for large programs.

Nobody can argue with the simple application of #define to replace integer values with meaningful symbolic equivalents, for example:

```
#define TRUE 1
#define FALSE 0
#define MAXINT 32767
```

It is when #define is used to define a parameterized macro, as in

```
#define putchar(x) putc(x, stdout)
```

that debate might arise. It is usually done as an efficiency measure to save the overhead of a function call. Although the example above, taken from the source of 4.2BSD UNIX, is pretty clear, such macros are often relatively unreadable, and the calls thereof are not traceable by symbolic debuggers. Consider the following horror, taken from the same source:

```
#define getc(p) (--(p)->_cnt>=0?
*(p)->_ptr++&0377:_filbuf(p))
```

In the language C++, which is essentially C extended to have classes, a provision was made to specify that member functions of classes produce in-line code where desired, and it was pointed out that this provision should reduce the extent to which #define is used for the same purpose.

Now a word about typedef. The important, legitimate use of this construct is in conjunction with structure, or union, declarations. In the construction

```
struct silly {
        int a;
        char b[6];
        struct silly *next;
} s1, s2
```

I have declared a structure consisting of an integer, an array of six characters, and a pointer to an instance of the same structure, and declared s1 and s2 to be variables that are instances of the structure. The

(continued on page 339)

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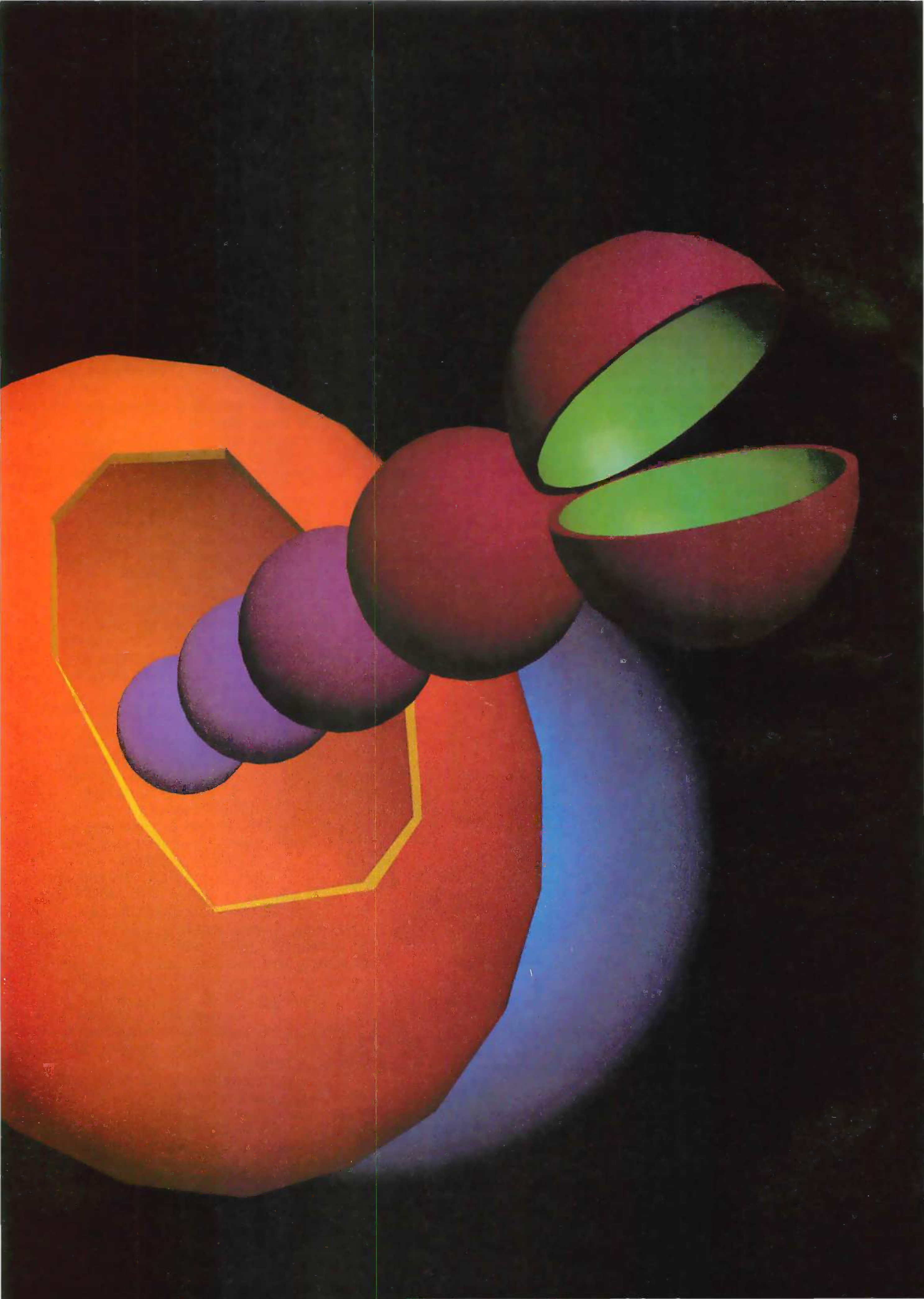

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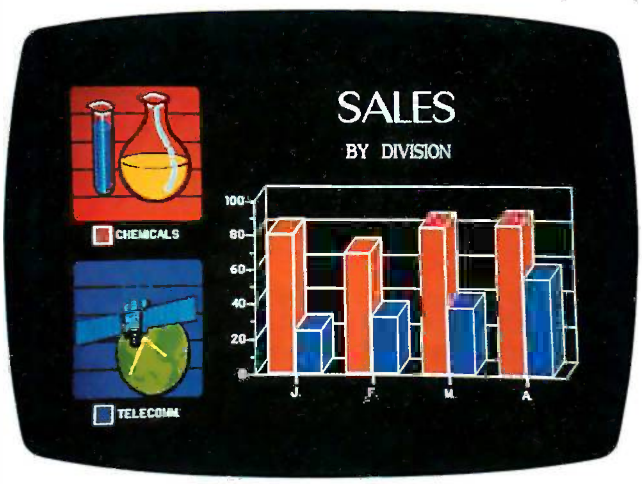

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The Data General/One Model 2

Data General announced a second version of its Data General/One portable computer. The new model, which weighs less than 12 pounds, is equipped with an electroluminescent display or a liquid-crystal display that, the company claims, provides twice the contrast of the previous model's LCD.

Like the first version of the portable, the Data General/One Model 2 is compatible with the IBM PC. It runs on an 80C88 processor and comes with 256K bytes of NMOS RAM (expandable to 640K) and a 3½-inch floppy disk drive. Prices start at $2795 for a base configuration with an electroluminescent display or $1795 for the same configuration with an LCD screen.

The electroluminescent screen displays 80 columns by 25 lines and 640 by 200 pixels. The LCD screen also displays 80 columns by 25 lines and features a resolution of 640 by 256 pixels. According to the company, the LCD displays characters with a 2:1 height/width ratio, which enables it to display IBM PC–compatible graphics without distortion. The Model 2 EL has an optional external battery pack that reportedly will power the system for up to 3 hours; with the LCD version, internal nickel-cadmium batteries provide up to 7 hours of power.

Other standard features of the Model 2 include a serial and a parallel interface, a 79-key keyboard, and two slots at the rear of the machine for expansion cards. Among the available options are a 10-megabyte internal hard disk drive, a second 3½-inch floppy drive, an 8087 math coprocessor, an internal 300/1200-bps modem, an interface card for an external monitor, an external 5¼-inch floppy disk drive, and an expansion chassis that will hold PC-compatible expansion cards.

An LCD unit with two floppy drives sells for $1995; with one floppy drive and a 10-megabyte hard disk drive, it costs $2995. An electroluminescent model with two floppy drives costs $2995; with a floppy and a hard disk drive, it sells for $3995. The company has also reduced the price of the Data General One/Model 1 from $2195 to $1495. Contact Data General Corp., 4400 Computer Dr., Westboro, MA 01580, (617) 366-8911. **Inquiry 551.**

Graphics Chips from Intel and TI

Intel has developed a graphics coprocessor chip, the 82786, that can manipulate windows and other graphics elements as much as 100 times faster, the company says, than is possible through software. Designed

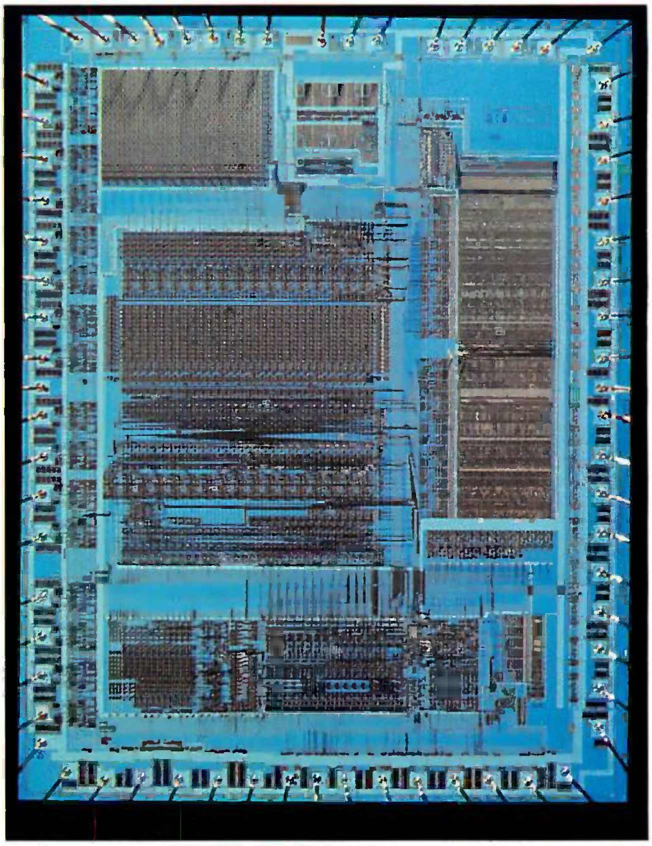
(continued)

to work alongside an 8-, 16-, or 32-bit general-purpose processor such as the 8088, 80286, or 80386, the 16-bit 82786 is made by the same CMOS process as the 80386 processor. It handles up to 32 DRAMs in a dedicated graphics memory and has its own complete DRAM controller.

The chip includes two processors: a graphics processor (GP) and a display processor (DP). The system processor sends a command to the 82786's GP, which executes the command and updates graphics and text in graphics or system memory. This execution can run concurrently with further processing by the main processor. The DP operates independently from the GP: It collects bits from memory and sends them to display devices such as CRTs, LCDs, and laser printers.

The GP works with several bit maps to perform line drawing, color filling, or polygon creation. To change the size, shape, or information content of a window, the processor changes only the pointers to the proper bit maps. Bit maps in the chip's linear, 4-megabyte memory can be as much as 32,000 pixels on a side and 8 bits deep (for color or gray scale).

According to Intel, the 82786 working on a 6-MHz IBM PC AT with a 640 by 480 by 8 screen resolution shows a speed increase over software-driven graphics of 100 times in line drawing, 25 times in bit-blitting, and 15 times in displaying bit-map characters. Windowing, panning, and scrolling are virtually instantaneous. The technical specs are: 2.5 million pixels/second on lines and polygons, 2 million pixels/second on circles and arcs, 24 million bits/second for bit-blt, and 30 million bits/second for fills.



TI's TMS34010 *is a 32-bit processor for graphics operations.*

The 82786 supports the ANSI CGI (Computer Graphics Interface) standard and IBM's CGA (Color Graphics Adapter) standard. Ashton-Tate, Digital Research, Graphic Software Systems (GSS), Lotus Development, and Microsoft are supporting the chip.

82786 samples are in the hands of hardware designers, and Intel expects production runs in the fourth quarter of 1986. At that time, the chip should cost approximately $100 in quantities of 1000 and $80 in quantities of 10,000. The company foresees the large-quantity price eventually dropping to approximately $50 per chip. Contact Intel Corp., 1900 Prairie City Rd., Folsom, CA 95630, (916) 351-5000.

Inquiry 552.

Texas Instruments has released the Software Development Board, which incorporates the company's recently developed TMS34010 Graphics System Processor (GSP). In addition to the GSP processor, the Software Development Board contains 256K bytes of multiport display memory, 512K bytes of program memory, and the TMS34070 Color Palette chip with three high-speed D/A converters for driving analog RGB outputs. The board is priced at $3995.

TI describes the GSP as a high-performance (6 MIPS or a draw rate of 48 million pixels per second) CMOS 32-bit microprocessor optimized for graphics display systems.

The processor has a 1-gigabit address space, addressable on bit boundaries using variable-width data fields. The GSP also features 31 general-purpose 32-bit registers, a 256-byte on-chip instruction cache, an instruction set containing 79 general-purpose instructions, 27 specialized variable field MOVE instructions, and 23 graphics instructions, including the specialized PIXBLT instructions.

The PIXBLT instructions manipulate pixel data, accessed via memory addresses or *x,y* coordinates. These instructions provide the capability for array and raster operations as well as individual pixel processing, windowing, plane masking, and transparency.

The company is sampling the GSP now and plans to have large-volume shipments of the final version early next year. In quantities of 50,000, the company anticipates a price of about $40; in single-unit quantities, the chip will cost about $155.

TI provides hardware and software support tools for GSP developers. The hardware consists of a Color Graphics Controller Board with Debugger interface software (an IBM PGA emulator) for the TI Professional Computer and IBM PC and compatibles, as well as the Software Development Board, which works with the same computers.

Software tools include a C compiler, an assembly support package, graphics function libraries, and a CGI standards package. The C compiler is a full-featured Kernighan and Ritchie C with in-line assembly extensions, 64-bit IEEE floating point, and memory-management run-time support. The assembly support package includes an assembler, linker, ROM utility, software simulator, and librarian/archiver.

Contact Texas Instruments Inc., P.O. Box 809066, Dallas, TX 75380-9990, (800) 232-3200.

Inquiry 553.

(continued)

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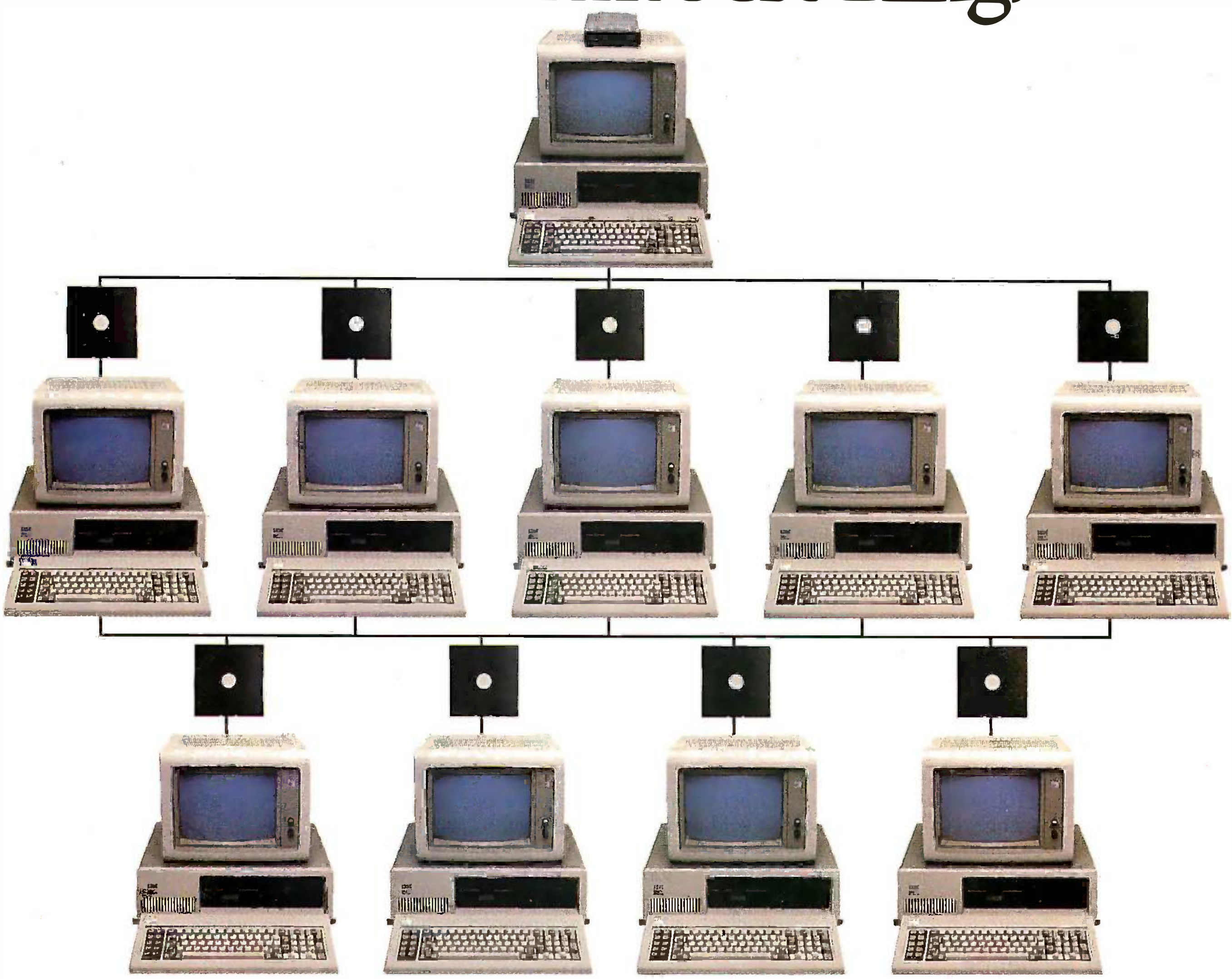

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Inquiry 128

Smalltalk for $99

Smalltalk/V, an implementation of the Smalltalk environment for IBM PCs and compatibles, comes with a Prolog compiler that allows integration of object-based and rule-based programming techniques. The package's graphics capabilities provide bit and form editors for making icons and fonts. Each graphical object has its own behavior and can be linked to other objects through the language's message-passing paradigm; as a result, you can build simulations using algorithms or rules.

This version of Smalltalk lets you object-swap to a hard or RAM disk, which means you can write large programs (up to 32,000 objects and 4 megabytes of memory). The package comes with a source-level debugger; you can check and change local variables and then resume the program or execution of a particular method.

Smalltalk/V costs $99. Contact Digitalk Inc., 5200 West Century Blvd., Los Angeles, CA 90045, (213) 645-1082.
Inquiry 554.

Object-oriented Graphical Modeling Program

Sherrill-Lubinski's Object-Oriented Graphical Modeling System consists of software for drawing, animating, coloring, or rotating pictures and objects. The company describes it as a tool for programmers who are modeling data or viewing it graphically. Typical applications include developing real-time process control displays, building workstations for graphics design, and creating graphically oriented interfaces.

OOGMS comes with a drawing/editing program called SL-Draw; a collection of C function calls termed the Graphical Modeling Function Library; and a graphics interpreter, called the Graphical Modeling Language Interpreter, for handling and animating models.

SL-Draw is $2400 in binary form, $6000 in source; the function library and the interpreter are sold as a package for $3500 in binary form, $35,000 in source. Contact Sherrill-Lubinski, Suite 110 Hunt Plaza, 240 Tamal Vista Blvd., Corte Madera, CA 94925, (415) 927-1724.
Inquiry 555.

Amiga Math Coprocessor

Designed for the Commodore Amiga and other 68000-based systems, the math coprocessor board from Netch Computer Products features a Motorola 68881 chip and 68010 microprocessor. The company says the board can boost the processing speed of math-intensive software by 300 to 500 percent.

The board is sold as an internal piggyback replacement for the Amiga's 68000. The 68010 runs on the 68000's system clock, while the 68881 operates asynchronously with a maximum clock rate currently at 16.5 MHz. Because the 68010 is not directly compatible with the 68881, the company provides a software emulation of the 68020's coprocessor interface, which is installed in AmigaDOS. Software libraries for Aztec C and Lattice C compilers and assembler tools are also included with the board.

A bare-board kit is priced at $149. Assembled and tested without the 68881, the board costs $269; assembled and with the 68881, the board costs $529. The company says the board should work in any 68000-based system with adequate board clearance and software-accessible trap vectors. Contact Netch Computer Products, P.O. Box 645, Monrovia, CA 91016, (818) 334-1002.
Inquiry 556.

DEC's Engineering Workstation

Digital Equipment Corp. introduced the VAXstation II/RC, an entry-level member of the firm's VAXstation series of computers. According to the company, the workstation is designed for applications in electronics, mechanical computer-aided design, software development, computer-aided software engineering, technical publishing, and others that require computation-intensive performance and networking.

The workstation is based on DEC's MicroVAX II 32-bit processor and is available in configurations with 3 megabytes and 5 megabytes of RAM, priced at $14,995 and $16,995, respectively. Both versions of the workstation are equipped with a 19-inch monochrome monitor with 1024 by 864 resolution, a 71-megabyte hard disk and disk controller, an Ethernet interface, a 95-megabyte streaming tape drive, a video controller, a keyboard, and a three-button mouse. The workstation supports the MicroVMS and ULTRIX-32m (DEC's implementation of UNIX) operating systems; a license for one of these operating systems is included in the system price.

Fully compatible with the company's line of VAX computers, the workstation can be linked with the systems via Digital's network. Contact Digital Equipment Corp., Maynard, MA 01754-2571.
Inquiry 557.

Smalltalk-80 for IBM PC AT

Softsmarts has combined its ST80 "virtual machine" with Xerox's "virtual image" to put Smalltalk on the IBM PC AT. The combination converts the AT into a fully functional Smalltalk-80 version 2 workstation with as much as 2 megabytes of memory space and a 640 by 350 bit-mapped graphics interface.

The company says that because it designed the underlying virtual machine specifically for the AT, users get complete PC-DOS compatibility and the full power of the 80286.

Softsmarts ST80 runs on an AT with 640K bytes of base memory, at least 512K expansion memory (1 megabyte preferred), an IBM Enhanced Graphics Adapter, a Mouse Systems three-button mouse, and a monochrome or IBM enhanced color monitor. An 80287 math coprocessor enhances performance. The system can run on an AT with a single 1.2-megabyte floppy drive, but a hard disk is needed for full source browsing. ST80 for the AT costs $995. Contact Softsmarts Inc., 4 Skyline Dr., Woodside, CA 94062, (415) 327-8100.
Inquiry 558.

Drives Work with Apples and Macs

The ProAPP 10 and ProAPP 20, 10-megabyte and 20-megabyte hard disk drives, can be used with Apple II and Macintosh computers without the need for changing or adding disk controllers. Moving a drive from one Apple machine to another requires disconnecting the subsystem from the first, reconnecting it to the second with the appropriate

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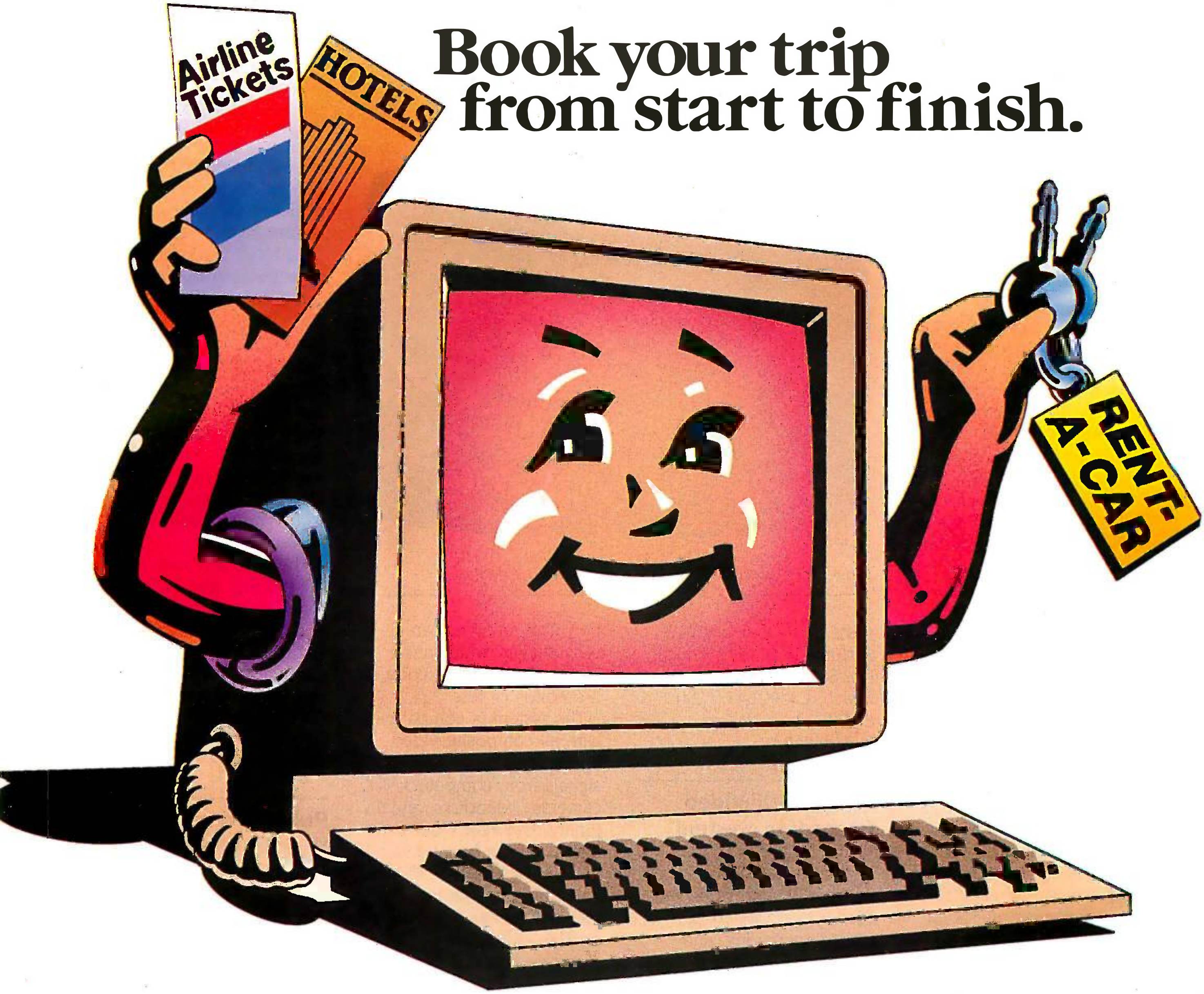

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cabling, and then reconfiguring an 8-pin DIP switch on the bottom of the drive.

The drives attach to the floppy disk ports on the Apple IIe/IIc and 128K and 512K Macintoshes or the SCSI port on the Macintosh Plus. You can use the drives to transfer text files between IIs and Macs, the company says. The drives also include a printer/spooler interface that's compatible with the Apple Imagewriter.

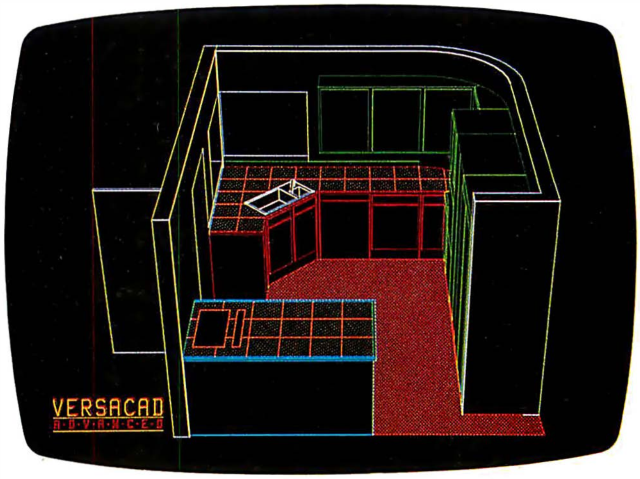
The ProAPP I sells for $795; the ProAPP-20 costs $995. For more information, contact ProAPP Inc., 1475 South Bascom Ave., Suite 101, Campbell, CA 95008, (408) 559-3552.
Inquiry 559.

CAD in Three Dimensions

T&W Systems has developed a module that works with the company's VersaCAD Advanced for three-dimensional computer-aided design. VersaCAD 3D is a true three-dimensional surface modeling system that accomplishes geometric design in *x*, *y*, and *z* coordinate space, absolute or relative; isometric and perspective views include real 3D lengths rather than lengths created by 2D conversion, T&W says.

Cones, cylinders, spheres, and boxes are among the primitives in the package. They can be rotated about the *x*, *y*, and *z* axes, and most can be shown as partial objects. The program has four display modes: sketch, for a quick preview showing only front vectors; wireframe, which shows all vectors; hidden line removal, which cleans up the design; and hidden line conversion, which displays hidden lines as dotted ones.

VersaCAD 3D runs on IBM PCs and compatibles. It costs $495. Contact T&W Systems Inc., 7372 Prince Dr., Suite 106, Huntington Beach, CA 92647, (714) 847-9960.
Inquiry 560.



VersaCAD 3D adds 3D modeling to VersaCAD Advanced.

Sony's Still-Video Recording System

Sony's ProMavica system, a still-frame video recorder, is designed for recording, storing, and manipulating video images on 2-inch still-video floppy disks. According to the company, the system can connect with IBM PC–compatible computers, allowing you to store computer-generated text and color graphics and mix them with video images on the floppy disks. The system enables you to display the images on a monitor, project them on a wall, or transfer them to hard copy. The system also lets you generate computer-controlled video presentations that can be reordered, edited, duplicated, and combined with other audio/visual media.

On each video 2-inch disk, the ProMavica unit can record 50 frames of still-video pictures or 25 frames with double the vertical resolution and with up to 360 lines of horizontal resolution. The recorder can access images, which are keyed with a 6-digit code, in 2 seconds or less.

The system is compatible with all composite video and analog/digital RGB signals from computers, cameras, videodisks, and TV tuners. The RGB input connector on the back of the unit works with IBM PC–compatible computers. The recorder has an RS-232C port as well as two 6-pin remote control ports for the company's Program Editing Controller, which enables you to make dubs between two recorders.

The ProMavica Still Video Recorder is priced at $3400; 10 video floppy disks sell for $100. Contact Sony Corp. of America, 9 West 57th St., New York, NY 10019, (212) 418-9470 or (201) 930-6432.
Inquiry 561.

Networking Atari STs and IBM PCs

BMB Compuscience Canada released a version of its Imaginet network that connects IBM PCs and Atari STs. The network runs at speeds of up to 2 megabits per second and can transmit data over distances of up to 1500 feet on either side of the server. Longer distances can be achieved by adding repeaters to the cable.

Up to 63 workstations can be supported by a dedicated disk and print server, which must be a PC-compatible computer with a hard disk. The server itself can be a workstation on a higher-level Imaginet network. Workstations in the network have access to several simulated disk drives and a simulated printer, which are resident on the server.

The network costs $900 for the first IBM PC, $800 for each additional IBM PC, and $500 for each Atari ST. Contact BMB Compuscience Canada Ltd., 500 Steeles Ave., Milton, Ontario, Canada L9T 3P7, (416) 876-4741.
Inquiry 562.

Public Domain, User-Supported Programs on CD-ROM

PC-SIG, a clearinghouse for public domain and user-supported software, is selling a CD-ROM optical disk holding 490 "volumes" (equivalent to 490 floppy disks) of applications and utilities for PC- and MS-DOS machines. The collection covers word-processing, communications, accounting, and programming software. Educational programs, games, printer utilities, languages, and BASIC development tools round out the disk.

The CD-ROM collection costs $195; you're asked to send a donation to authors of programs that perform "satisfactorily." PC-SIG also sells a Hitachi CD-ROM player, PC controller, cabling, and software drivers for $995. Contact PC-SIG Inc., 1030D East Duane Ave., Sunnyvale, CA 94086, (408) 730-9291.
Inquiry 563.

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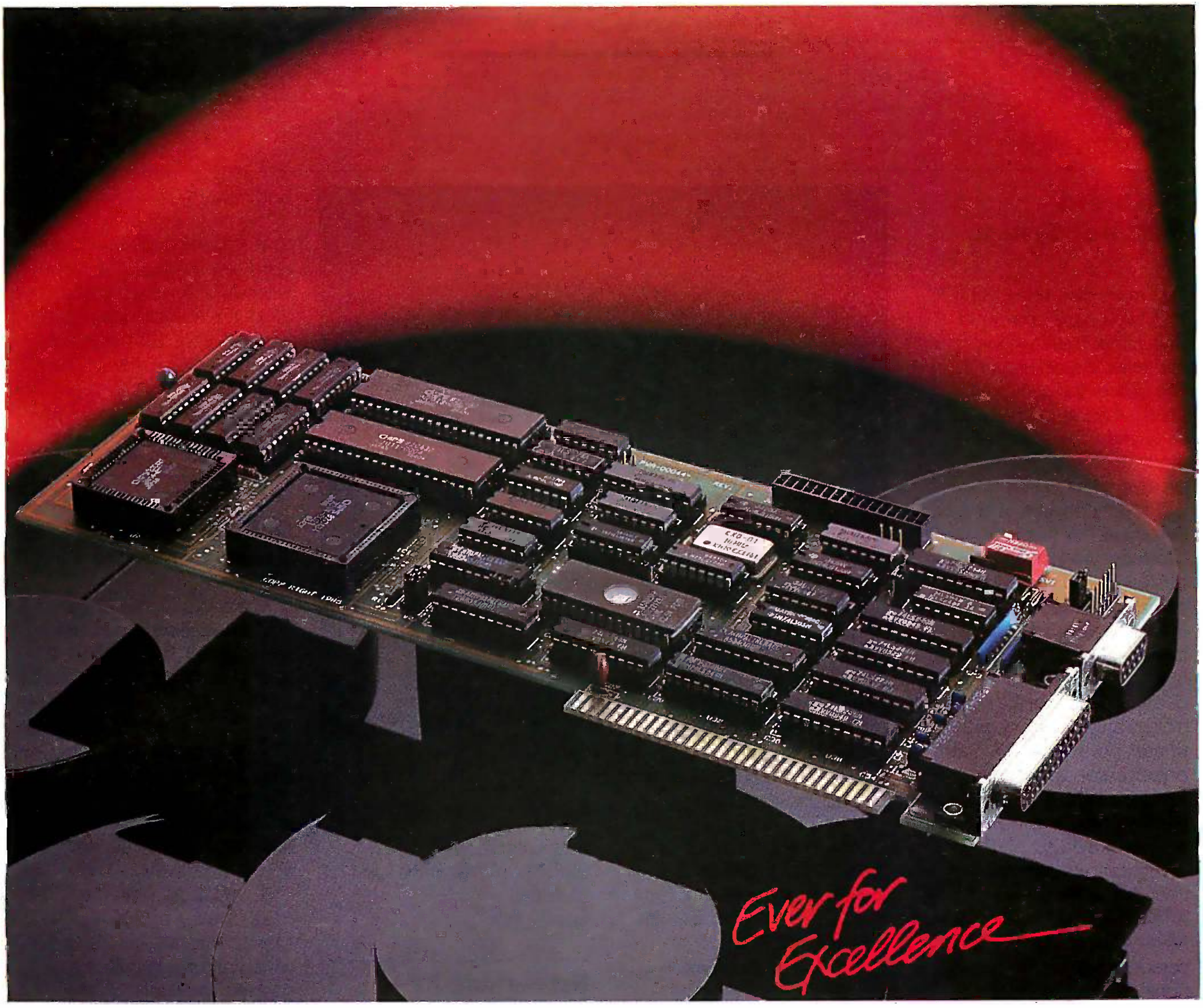

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SYSTEMS

Two-Board Multiuser System

Ampro has released a two-board computer that offers multitasking, multiuser capabilities. The two-board set occupies nearly the same space as a half-height 5¼-inch disk drive, according to the company.

The set consists of the Little Board/186 single-board computer and an Expansion/186 daughterboard. The boards include an 8-MHz 80186 microprocessor, 1 megabyte of RAM, 128K bytes of EPROM, four serial ports, a floppy disk controller, an SCSI port and a printer port, an 8087 math coprocessor, a battery-backed clock, and an I/O expansion bus. The boards support RS-232C or RS-422 asynchronous or synchronous serial protocols.

The two-board set sells for $895 without a math coprocessor, which costs an additional $119. A two-user ($250) or four-user ($300) version of Concurrent DOS 4.1 for the Ampro hardware is also available. For more information, contact Ampro Computers Inc., 67 East Evelyn Ave., Mountain View, CA 94041, (415) 962-0230.
Inquiry 564.

System for Scientists and Engineers

The System 488 comes with an IEEE-488 interface and specialized software.

Compatible with the IBM PC AT, the System 488 computer is designed specifically for use by scientists and engineers. The system runs on an 8-MHz 80286 microprocessor and comes with 512K bytes of RAM, a serial and a parallel port, an IEEE-488 interface card, a hard disk and floppy disk controller, and a 1.2-megabyte floppy disk drive. An enhanced graphics display adapter for color or monochrome monitors and a monochrome monitor are also standard features with the base model.

In addition to MS-DOS 3.1 and BASIC, software bundled with the computer includes SuperKey, PC-Write, HP-85 graphics emulation, and application programs for use with digital oscilloscopes, IEEE-488 printers and plotters, and other common instruments such as digitizers and digital voltmeters. According to the company, about 90 files are provided on disk, including source code.

Expansion options include an additional 512K bytes of RAM, 128K bytes of ROM, a second floppy drive, an enhanced color monitor, and three serial ports. System configurations with 20-, 30-, or 40-megabyte hard disks and a professional color monitor are also available.

Priced at $3980, the system runs IBM PC–compatible software and the UNIX operating system. Contact Capital Equipment Corp., 99 South Bedford St. #107, Burlington, MA 01803, (617) 273-1818.
Inquiry 565.

Networking AT Compatible

The A∗Star, an IBM PC AT–compatible computer from Wells American, is "network-ready," according to the company. The computer incorporates multiuser circuitry that enables it to connect to up to 255 units when used with the firm's Network Adapter card.

The A∗Star is based on a 6- and 8-MHz 80286 microprocessor. The machine is equipped with 512K bytes of memory (expandable to 1 megabyte on the motherboard), a 1.2-megabyte floppy disk drive, and a hard and floppy disk controller. Other features include a keyboard, eight available expansion slots, and a 220-watt power supply. The computer has space for two additional half-height drives.

The base unit sells for $1495; additional configurations are available. A Network Adapter card costs $295 for A∗Star computers and $495 for IBM PCs, XTs, ATs, and compatibles. Contact Wells American, 3243 Sunset Blvd., West Columbia, SC 29169, (803) 796-7800.
Inquiry 566.

Datavue's Single-Board Computer

Datavue Technical Systems announced the Datavue 8612, a single-board computer that can be used to replace an existing IBM PC XT motherboard. The 8612 comes on a full-size expansion card and includes an NEC V30 or Intel 8086-1 microprocessor operating at 10 MHz, as well as a 16-bit data bus.

The 8612 is available with 512K bytes of RAM and a Master Interconnect Board, which can be installed in a passive backplane as the bus control device for IBM PC expansion cards. The computer's proprietary ROM BIOS, the company says, is fully compatible with IBM PC hardware and software. The 8612 sells for $695.

The company also announced the Datavue Series 30 computer, which is powered by the 8612 single-board computer. The base model is equipped with an IBM PC AT–type keyboard, a 360K-byte floppy disk drive, a Master Interconnect Board, a monochrome video controller, and a power supply. Prices for a monochrome system start at $1695; prices for a system with an RGB monitor start at $1895. Contact Datavue Technical Systems, 4355 International Blvd., P.O. Box 2687, Norcross, GA 30093, (404) 564-5783.
Inquiry 567.

(continued)


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PERIPHERALS

Removable Hard Disks

SyQuest announced the SQ1500, an external removable hard disk subsystem that provides up to 90 megabytes of fixed and removable storage for IBM PCs, XTs, ATs, and compatibles. The SQ1500 is available with single or dual 5¼-inch 15-megabyte removable drives; with a 45-megabyte fixed drive and a 15-megabyte removable drive; or with two 45-megabyte fixed drives.

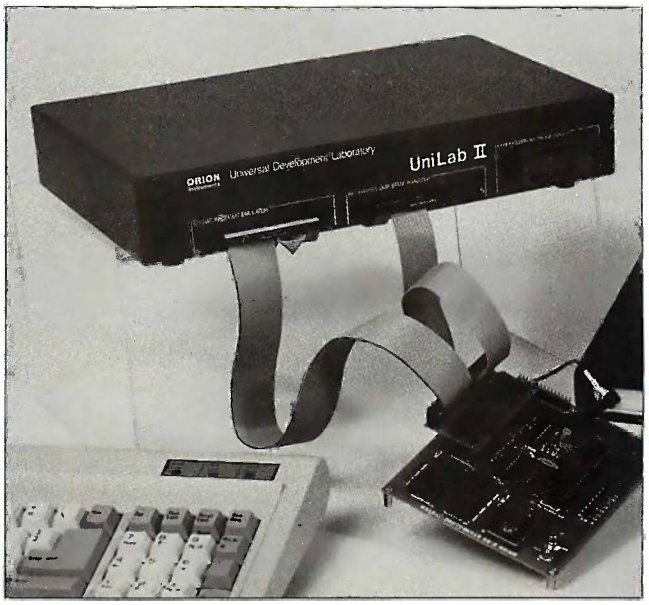
The company reports that the subsystem transfers data at 7.5 megabits per second. A controller, utility software, two removable hard disks, cables, and mounting brackets come with the unit.

The company also sells the SQ319, an internal version of the SQ1500. It features a 5¼-inch 15-megabyte removable hard disk drive and includes a controller, utility software, and installation hardware.

Prices for the SQ1500 start at $2499; the SQ319 kit is $1395. Contact SyQuest, 47923 Warm Springs Blvd., Fremont, CA 94539, (415) 490-7511.

Inquiry 568.

Universal Development Lab



The UniLab II, a development system for CAE.

Orion Instruments' UniLab II, a development system for computer-aided engineering, connects to IBM PCs and compatibles and provides support for more than 120 microprocessor types. The system combines an advanced 48 channel bus-state analyzer, a real-time in-circuit emulator that uses a target microprocessor for code execution, a stimulus generator for special test cases, and a built-in EPROM programmer.

Like the firm's original Universal Development Laboratory, the UniLab II can be used for programming 2708 through 27256 EPROMs.

According to the company, the device can be used on virtually any 8- or 16-bit microprocessor. Personality Paks are also available for specific microprocessor types and include cables and software.

The standard UniLab II-32 with 32K bytes of emulation memory is priced at $4980 and works with processors running at speeds of up to 10 MHz. A model with 128K of memory works with processors operating at up to 13 MHz and costs $6080. A Personality Pak for an 8-bit processor typically costs $575; for a 16-bit processor, $675. The UniLab II runs under PC-DOS 3.1 or later on IBM PCs or compatibles with a minimum of 256K bytes of RAM and two floppy disk drives. Contact Orion Instruments Inc., 702 Marshall St., Redwood City, CA 94063, (800) 245-8500; in California, (415) 361-8883.

Inquiry 569.

Professional Graphics Tablet

The Professional Series graphics tablet from Summagraphics works with the IBM PC and compatibles and the Macintosh. The 18- by 12-inch tablet has a resolution of 1000 lines per inch, and the tablet's active area can accommodate a B-size drawing or two A-size sheets of paper.

The Professional Series comes with an interface cable, stylus, four-button cursor, and power supply.

The tablet costs $995. Contact Summagraphics Corp., 777 State St. Extension, Fairfield, CT 06430, (203) 384-1344.

Inquiry 570.

Ink-jet Printer from H-P

Hewlett-Packard's QuietJet Plus ink-jet printer offers draft and near-letter-quality printing. It works with the IBM PC, XT, AT, and compatibles, as well as the Apple II series and Macintosh computers.

According to the company, the wide-carriage printer operates at 40 characters per second for near letter quality, and 160 cps (10-pitch) and 192 cps (12-pitch) for draft quality. It offers three graphics resolutions: 96 by 96 dots per inch, 192 by 96 dpi, and 192 by 192 dpi.

The QuietJet handles tractor-feed and cut-sheet paper in widths from 5 to 15 inches. It features RS-232C and Centronics interfaces and comes with Hewlett-Packard's Printer Command Language.

The QuietJet costs $799. For more information, contact Hewlett-Packard, 1820 Embarcadero Rd., Palo Alto, CA 94303, (800) 367-4772.

Inquiry 571.

Low-Cost Network

Designed to work with IBM PCs and compatibles, Macintoshes, and other computers, the Microlink network can connect up to 255 computers and peripherals capable of communicating asynchronously through a V.24/RS-232C or current loop interface. The network consists of twisted-pair cables and connector units, one of which is required for each peripheral or port. Each connector costs approximately $520.

According to the manufacturer, the network can operate over distances up to 1200 meters. It uses a transmission rate of 125K bits per second, which permits more than 10 simultaneous connections at 9600K bits per second.

For more information, contact Tech Trade ab, Box 197, 191 23 Sollentuna, Sweden, 08-92 01 35.

Inquiry 572.

(continued)

QNX vs UNIX

A QUESTION OF ARCHITECTURE

What do QNX and UNIX have to do with architectural design?

The design determines the environment in which you and your applications must survive. If the shear weight of the UNIX operating system brings the PC to its knees, all applications running under it will suffer. Unix was conceived more than a decade and a half ago and the product today is the result of modifications, additions and patches by hundreds of programmers. The result is a large and convoluted piece of software which needs the resources of an AT or more.

QNX's superb performance and compact size is the result of one dedicated design team with a common purpose, and complete understanding of both the software and the environment in which it must run. It runs quickly and efficiently on PC's and soars on an AT. Unlike Unix, QNX is capable of real time performance and is the undisputed choice for real time process control, and office systems. You can buy an OS that offers you a 1 to 3 user dead end on an AT, OR, you can consider QNX which allows you anywhere from 1 to 10 users on both PC's and AT's. And we don't stop there. Unlike other Unix-type systems for PC's, QNX is also a networked operating system. Not a patch-on network, but a fully integrated networking system for up to 255 micros. QNX allows you to start with a single machine and grow if and as required. There are no dedicated file servers and you can attach terminals (users) to any machine. To choose a solution which ignores networking, is closing the door on your future.

Everyone is talking about Unix like systems, but no one wants to abandon the tremendous amount of DOS software available. QNX does not force you to make that decision. You can run either PC DOS 2.1 or 3.1™ as one of QNX's many tasks. (DOS File compatibility and DOS development tools are also available). Don't misunderstand us. We at Quantum have a great deal of respect for Unix. It was a major force in moving operating systems out of the 1960's and into the 70's. QNX however, was designed in the 80's and will be a driving force of the 1990's. **Over 20,000 systems have been sold since 1982.**

Quantum strongly believes that there are good reasons for buying QNX, DOS and Unix. If you want more than DOS and a working alternative to PC Unix, give us a call and we will discuss your needs.

End-Users, VAR's, OEM's and software developers are invited to take the QNX challenge.

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  –Call for runtime prices.
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Inquiry 247

PERIPHERALS

AST's Hard Disk with Tape Backup

AST Research announced an external 3½-inch hard disk and tape backup subsystem for the Macintosh Plus and Apple IIe. The AST-2000, which uses an SCSI port, incorporates a 20-megabyte hard disk drive and a 20-megabyte cartridge tape drive. The Macintosh Plus version of the unit can be expanded to 60 megabytes.

The company reports that the disk's transfer rate is 5 megabytes per second; the tape's is 500K bytes, and it backs up 20 megabytes in 8 minutes. The tape drive allows file-by-file backup and restore operations.

The AST-2000 connects to the Mac Plus via cable and to the Apple IIe with a cable and a controller card that plugs into an I/O slot. The system costs $2795; if purchased separately, the tape drive is $1695. Contact AST Research Inc., 2121 Alton Ave., Irvine, CA 92714, (714) 863-1333.
Inquiry 573.

ADD-INS

AutoSwitch EGA

The Autoswitch EGA Card from Paradise Systems supports IBM's Enhanced Graphics Adapter and other display modes and automatically switches to the appropriate mode depending on the software being used. The half-slot card includes 256K bytes of memory and supports Color Graphics Adapter, Monochrome Display Adapter, Hercules graphics, and Plantronics ColorPlus display modes.

Suggested retail price is $599. For more information, contact Paradise Systems Inc., 217 East Grand Ave., South San Francisco, CA 94080, (415) 588-6000.
Inquiry 574.

Dual-Tasking Turbo Board

The Bi-Turbo board, an accelerator board from Alloy Computer Products, offers dual-tasking capabilities for IBM PCs, XTs, ATs, and compatibles. The board has an 8-MHz NEC V20 microprocessor, 640K bytes of RAM for applications programs, 256K bytes of RAM for disk caching, and a COM2 port for use by the second task. It comes with Alloy's proprietary BTNX software that can control two tasks from the computer's keyboard and monitor.

According to the company, the board is based on the multiuser technology incorporated in the firm's Slave/16 boards. The Bi-Turbo sells for $995. For more information, contact Alloy Computer Products Inc., 100 Pennsylvania Ave., Framingham, MA 01701, (617) 875-6100.
Inquiry 575.

Data Acquisition Processor

The Data Acquisition Processor installs in a single slot in an IBM PC or compatible and offers real-time processing of analog data, according to Microstar Laboratories, the product's manufacturer.

The board has an 8-MHz 80186 microprocessor, 128K RAM, and one serial port. It features a 16-channel analog section with a programmable gain amplifier, dual sample and hold circuits, a 16-bit A/D converter, and an 8-bit analog output port. The board's 64- by 16-bit FIFO and direct memory access allow it to run real-time computations while the host computer operates other applications simultaneously. The board also has a multiprocessing operating system that handles control and communication functions.

The Data Acquisition Processor sells for $2500. Contact Microstar Laboratories Inc., 2863 152nd Ave. NE, Redmond, WA 98052, (206) 881-4286.
Inquiry 576.

Graphics Card for IBM RT PC

Microfield Graphics' T4 Color Graphics Controller card plugs into a single slot on the IBM RT PC's peripheral bus and provides high-speed 1024 by 800, 4-plane color graphics. The T4's proprietary architecture uses the 2901 bit-slice processor chip.

The board supports the ANSI CGI interface and works with applications on the RT's RISC processor or the optional DOS coprocessor. Applications can access the line drawing, polygon and text manipulation, bit-blt (bit block transfer), and window-management microcode of the T4 directly from subroutines written in C. Microfield's terminal emulator for the T4 lets the board act as a console device for the RT's AIX (Advanced Interactive Executive) operating system.

The T4 costs $2850 and works with the IBM RT PC or the PC AT and compatibles. The price includes a first-level graphics package but not the CGI software ($300/board). The RT support package costs $150. Contact Microfield Graphics Inc., 8285 Southwest Nimbus Ave., Suite 161, Beaverton, OR 97005, (503) 626-9393.
Inquiry 577.

PC Compatibility for Sun Workstations

The Sun Integrated Personal Computer (SunIPC) from Sun Microsystems is a 10-MHz 80286 coprocessor board with 1 megabyte of memory that provides Sun workstations with IBM PC AT compatibility and the ability to run MS-DOS applications in a window under UNIX.

The SunIPC, a VMEbus board, executes MS-DOS color or monochrome applications requiring the IBM PC AT color graphics adapter or the Hercules monochrome adapter. The board includes one parallel port, which allows the use of two workstation ports as standard serial ports. Options include an 8-MHz 80287 coprocessor and external 360K-byte and 1.2-megabyte floppy drives. The accompanying software includes MS-DOS 3.1, GW-BASIC, file-sharing software for the Sun Network File System, and utilities.

The SunIPC board costs $1995 in single quantities plus $395 for a single-user version of the software. A multiple-access version is available for $995. Site licenses are also available. Contact Sun Microsystems Inc., 2550 Garcia Ave., Mountain View, CA 94043, (415) 960-1300.
Inquiry 578.

(continued)

SOFTWARE • PROGRAMMING LANGUAGES AND AIDS

MS-DOS Version of C++

Oasys is selling a version of AT&T's programming language, C++, for MS-DOS computers. Called Designer C++, it works with the Lattice 3.0 or Microsoft 3.0 C compilers. It functions as a translator/preprocessor that generates compilable C source code from C++ source files. The generated C code adds no run-time overhead, Oasys says.

Developed by Glockenspiel Ltd. (Dublin, Ireland), Designer C++ features strong type checking, function and operator overloading, data abstraction and hiding using classes, virtual functions, stream-oriented I/O, and other facilities for object-oriented programming.

Priced at $500, Designer C++ comes with a tutorial and release notes. It runs on a 512K-byte IBM PC or workalike. Contact Oasys, 60 Aberdeen Ave., Cambridge, MA 02138, (617) 491-4180.
Inquiry 579.

Two Prologs

Chalcedony Software announced two Prologs, one for the IBM PC and the other for the Macintosh.

Prolog/i, the IBM PC version, features floating-point arithmetic, transcendental and trigonometric math functions, a built-in integrated editor, and interactive debugging facilities. This version requires PC- or MS-DOS version 2.0 or later, true IBM compatibility, ANSI-standard support, one disk drive, and at least 256K RAM (320K is recommended).

Prolog/m, for the Macintosh, has the following features in addition to those of Prolog/i: 8087 support, calls to subroutine function library, calls to DOS, and screen and graphics management. System requirements are the same as those for the MS-DOS version except that 512K RAM is needed and an external disk drive is preferred.

Prolog/i costs $69.95; Prolog/m, $99.95. Contact Chalcedony Software Inc., 5580 La Jolla Blvd., Suite 126, La Jolla, CA 92037, (619) 483-8513.
Inquiry 580.

A Toolkit for Framework's FRED

The FRED Development Toolkit is a collection of user-defined functions, utilities, abbreviations, macros, and templates for use with FRED, the object-oriented language built into Ashton-Tate's Framework II. FDT turns many of FRED's functions into tools for system development and macro programming.

According to vendor PCE Inc., all of Framework II's pull-down menu options and function and navigational keys are accessible through the FDT. A "toolkit compiler" converts FDT functions into FRED code.

The package includes source code and costs $49.95. You also get a subscription to, and on-line support from, PCE's Expert WorkBench NETwork, a private network on The Source. Contact PCE Inc., 6033 West Century Blvd., Los Angeles, CA 90045, (213) 757-7537.
Inquiry 581.

OS for Software Development

PAX (Personal Applications Executive), an operating system for software development, runs with PC-DOS on IBM PCs or compatibles.

Included are high-speed device drivers and a demonstration system. The drivers include assembly language procedures for video display, interrupt-driven serial I/O over multiple channels, printer output, and interrupt management.

Baker & Rabinowitz reports that the PAX System 8632 can execute 32 tasks concurrently and that individual tasks can be written and debugged under DOS, then ported to PAX.

The system requires 128K RAM, DOS 2.x or 3.x, and a macro assembler.

PAX System 8632 sells for $149.95. Contact Baker & Rabinowitz Inc., 3869 Kilbourne Ave., Cincinnati, OH 45209-1814, (513) 871-0886.
Inquiry 582.

Three 68020 Operating Systems

Technical Systems Consultants announced the UniFLEX/DA, the UniFLEX/RT, and the UniFLEX/MX operating systems, all of which are written in assembly language.

UniFLEX/DA is a ROM-based operating system intended for process control and dedicated applications. You can configure it with or without a file system.

UniFLEX/RT is a real-time OS with communications facilities. Each real-time task has control of its own priority. RT also has a communications driver intended for transferring data, and a named enqueue/dequeue mechanism, which the company says allows you to run semaphore and resource-control operations.

UniFLEX/MX, an enhanced version of the original UniFLEX/VM, is a virtual-memory OS designed for use in a multiuser, multitasking environment. MX has all the features of DA and RT plus the ability for the user to create and control multiple RAM disks.

These three systems can be configured for most hardware built around the 68010 or 68020 microprocessors, according to the company.

Prices range from $400 to $1000. Contact Technical Systems Consultants Inc., 111 Providence Rd., Chapel Hill, NC 27514, (919) 493-1451.
Inquiry 583.

Display Management for IBM and TI Machines

Sydetech's C-Display Utilities include C-Display Compiler, a screen-management utility that has editing capabilities and supports color and character-generated graphics. Requirements include 128K RAM, one disk drive, a color monitor (with a CGA for the IBM PC model), MS-DOS 2.11 or higher, and a Microsoft C 3.0 or Lattice C 2.15/3.0 compiler.

C-Display Librarian is a collection of C functions that allow you to execute BIOS video services, perform virtual display management, create bit-mapped graphics, and conduct interactive screen I/O via high-level function calls. System requirements are the same as for the C-Display Compiler.

C-Display Utilities are available for the IBM PC, XT, AT, and PCjr and for the Texas Instruments Professional or Business Professional. C-Display Compiler sells for $125, Librarian for $145; the two combined in a package called the C-Display Manager costs $245. Contact Sydetech System Devel-

(continued)

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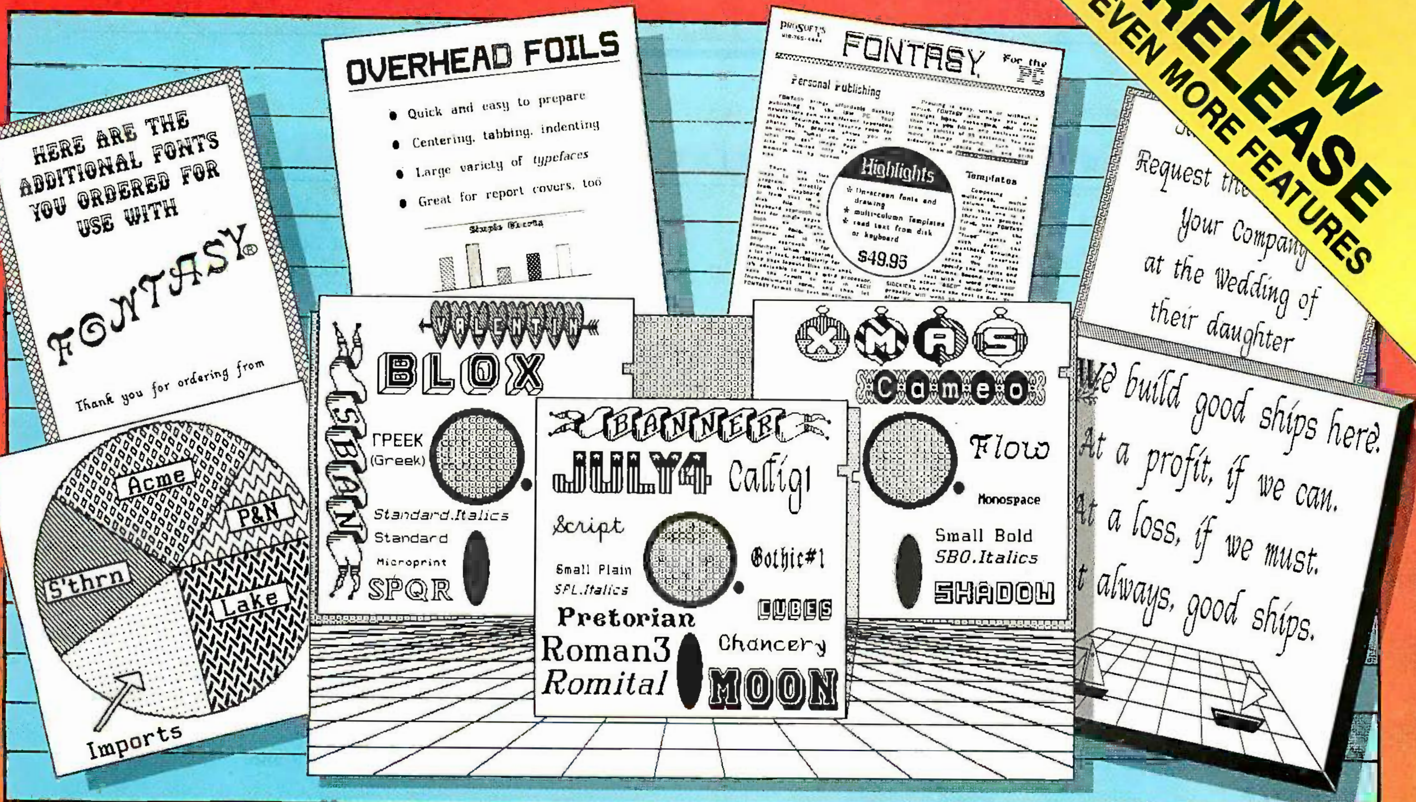

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SOFTWARE • PROGRAMMING LANGUAGES AND AIDS

opment Technologies, 43-23 Colden St., Suite 17C, Flushing, NY 11355, (718) 886-0221.
Inquiry 584.

Programming Tools for True BASIC

True BASIC Inc. has expanded its True BASIC Programming Libraries with tool and utility companion products: the Developer's Toolkit, Communications Support, Forms Management Library, Btrieve Interface, Sorting and Searching, and Advanced String Library.

The company reports that Communications Support allows simultaneous use of two COM ports at up to 19,200 bits per second. The Btrieve file management package is from SoftCraft Inc. and allows for database management of up to 4 million bytes per record and 24 key fields per file, according to True BASIC. Sorting and Searching provides 14 subroutines for string and numeric sorting. And a 38,000-word dictionary is included in the Advanced String Library, which also provides pattern matching, parsing, and text manipulation.

All libraries are available for the IBM PC or compatibles running DOS 2.0 or higher. Communications Support and Sorting and Searching also run on the Macintosh and Amiga. Each package costs $49.95. Contact True BASIC Inc., 39 South Main St., Hanover, NH 03755, (603) 643-3882.
Inquiry 585.

C Cross Compiler for AT&T 6300 Plus

UniPress announced a Lattice C Cross Compiler for AT&T's 6300 Plus operating under UNIX. You can use UNIX software tools with the Lattice C Compiler to develop MS-DOS code for 8086 and 80186 microprocessors. Relocatable machine code is produced by the compiler; then, using the linker, you can produce MS-DOS executable code.

The compiler supports the Kernighan and Ritchie C standard and library. It comes with a linker, librarian, disassembler, and floating-point support, and it requires a hard disk drive with 1 megabyte of RAM.

The cost of the compiler is $795. Contact UniPress Software, 2025 Lincoln Highway, Edison, NJ 08817, (201) 985-8000.
Inquiry 586.

SOFTWARE • SCIENTIFIC AND ENGINEERING

Mac Package for Structural Engineering

Erez Anzel's Frame-Mac helps in the analysis and design of any two-dimensional frame or truss, with any number of nodes, elements, and supports (limited by RAM only). The package utilizes scrollable windows, the mouse, and pull-down menus. You never need to type in commands. Any number and type of loads can be applied or changed at any time, as can the structure, units, and decimal formats. I/O is shown in numeric and graphic form.

Frame-Mac does linear analysis by using the modified Cholesky method to solve a structure's stiffness matrix; this matrix is made and calculated as a band matrix. At your request, the program provides values such as displacements, internal forces, and bending stresses.

The package runs on a 512K Mac with a 400K-byte internal drive (or bigger configuration). Price is $495. Contact Erez Anzel, 5800 Arlington Ave., #5T, Riverdale, NY 10471, (212) 884-5798.
Inquiry 587.

Statistical Analysis Package for Macintosh

CLR ANOVA, for the 512K Macintosh and Macintosh Plus, can compute up to a 10-factor analysis of variance with unequal sample sizes and repeated measures. It lets you plot interactions by clicking the mouse and making a menu selection. Marginal means, pairwise comparisons (Neuman-Keuls, Duncan, Tukey hsd, and t-tests), simple effects, and specific contrasts (planned or unplanned) among means can also be computed. A desk-accessory editor lets you enter or change data even after an analysis has been started. Data from MacWrite, MS-File, MS-Word, Multiplan, Excel, and MacTerminal can also be analyzed.

The package sells for $50 until September 1; thereafter, it's $75. Add $3 shipping. Contact Clear Lake Research, 5615 Morningside #127, Houston, TX 77005, (713) 523-7842.
Inquiry 588.

Protein Programs

DNASTAR is selling two packages for researchers dealing with protein data. The first product, an analysis program, plots secondary structural predictions and hydrophilicity. It includes programs for determining optimal DNA probes for specific proteins or peptides, titration curves, isoelectric points, molecular weights, and other analytic functions.

The other package, Geneman, helps search protein and genetic databases and retrieve information based on keywords, sequence matrices, and a combination of terms. It lets you create screen, printer, or subindex files from a search. GenBank and the Protein Identification Resource databases are supplied with the package. Other databases, such as PGtrans and EMBL, can also be used.

Both programs run on IBM PCs and compatibles. Each is packaged with other programs and sold for $3000. For more specific information, contact DNASTAR Inc., 1801 University Ave., Madison, WI 53705, (608) 233-5525.
Inquiry 589.

Stat Package for Apple IIs

Histogram Plot, a statistics program for the Apple II, IIe, and compatibles, lets you input, edit, print, and save data. It can display and print raw and computed data and can compute means, medians, standard deviations, expected cell frequencies, and actual cell limits and frequencies. Graph sizes are variable. The price is $29. Contact Andent Inc., 1000 North Ave., Waukegan, IL 60085, (312) 223-5077.
Inquiry 590.

(continued)

Explore AI on your PC

Smalltalk/V transforms your PC into a versatile AI workstation

Only Smalltalk/V lets you experience the thrill of a responsive AI workstation while learning artificial intelligence techniques and using them to create practical applications.

"Smalltalk/V gives me the feel of an AI workstation on my PC."

—Darryl Rubin,
Technical Editor,
AI Expert
Magazine

"Smalltalk/V is the highest performance object-oriented programming system available for PCs."

—Dr. Piero Scaruffi
Chief Scientist
Olivetti Artificial Intelligence Center

$99.00

Watching someone use an AI workstation is a vision of what the computer was meant to be. Fingers dance across the keys as windows dilate, shift, overlap, and disappear on the bit-mapped display. Ideas spring to life as program fragments execute, are modified, expanded, combined and tried again in a creative arabesque of text and graphics. The interface vanishes, man and machine are one. Smalltalk/V brings that experience to your IBM-PC.

"We use Smalltalk as our primary language for teaching artificial intelligence."

—Dr. John Pugh
Director, School of Computer Science
Carleton University

Of the three main AI languages, Smalltalk, LISP, and Prolog, only Smalltalk was intended for individual use on a personal computer. Only Smalltalk was designed to provide a match between human and computer models of reality. Only Smalltalk is easy to learn, easy to read, and easy to use.

"We found Smalltalk/V excellent for developing advanced decision-support tools based on decision analysis and AI techniques."

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Smalltalk/V is pure object-oriented programming — a powerful tool for designing frame/script-based knowlege representations, inference engines, expert systems, simulation environments, intelligent interfaces, network control software, communications interfaces, and much more.

Methods, our character-based Smalltalk, is now available for $79. It has all of the features of Smalltalk/V except graphics, rules, source-level debugger, and object-swapping. However, it supports color, includes the communication package, and does not require a mouse.

BYTE and BIX are trademarks of McGraw-Hill, Inc. IBM, IBM-PC, and IBM PC-AT are trademarks of International Business Machines Corporation. Unix is a trademark of Bell Laboratories.

Inquiry 91

Smalltalk/V Features

- High-performance object-oriented programming
- Integrates object-based and rule-based programming with object-oriented Prolog
- A user-extensible, open-ended environment
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- Supports exploratory programming and prototyping
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Smalltalk/V requires DOS and 512K RAM on IBM PCs (including AT) or "compatibles," a Microsoft or compatible mouse, and a CGA, EGA, Hercules, or AT&T Hi-Res graphic controller.

digitalk inc.

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Los Angeles, CA 90045 (213) 645-1082

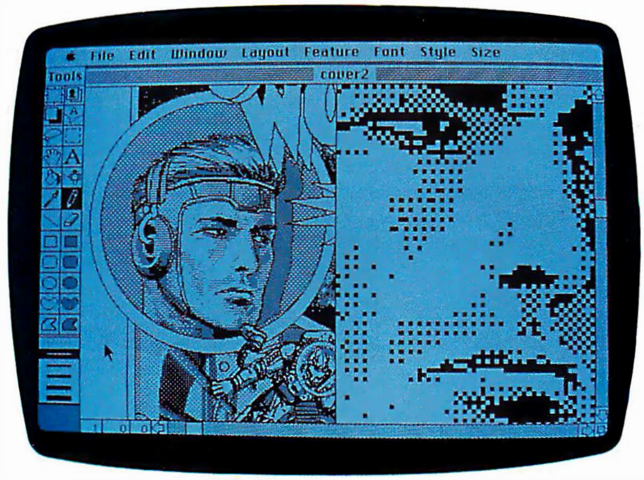
SOFTWARE • BUSINESS AND OTHER

Mac Comics

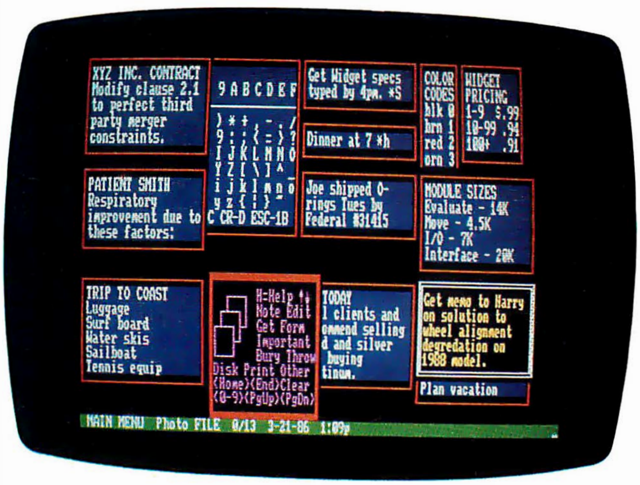
ComicWorks is a Macintosh program that lets you play Stan Lee and draw comic strips. The package incorporates drawing and painting tools, text editing, and the ability to mix text and graphics anywhere on a page. You can pull in images from other ComicWorks documents or from MacPaint (using Art Grabber). The program also includes graphics objects you can move independently, comic-book fonts, panels, and voice balloons.

ComicWorks, developed by MacroMind Inc. (Chicago), is being sold by Mindscape for $79.95. It runs on the 512K Mac. Contact Mindscape Inc., 3444 Dundee Rd., Northbrook, IL 60062, (312) 480-7667.

Inquiry 591.



Comic-book art created with ComicWorks and a Macintosh.



Random data arranged by Tornado Notes.

Access to Random Data

A RAM-resident program for IBM PC-type machines, Tornado Notes is designed to let you store and access random information. You enter text into logical modules. When you need to find a note, the program uses a search tool based on an "and-or-not" system. You can hunt for related notes based on any word, phrase, or combination.

The publisher says that, unlike spreadsheets and databases, which handle structured data, this package uses a form of parallel text processing that treats windows of data according to content. The software includes an editor with cut and paste, a "pile-of-paper simulator," and a note-joining function.

Tornado Notes runs under MS- or PC-DOS 2.0 or later, does not use bit graphics, and supports most 80-character monochrome and color displays. The publisher says the program works with most software and uses 50K bytes of RAM, plus space for notes. It's not copy-protected, and it costs $49.95. Contact Micro Logic Corp., P.O. Box 174, 100 Second St., Hackensack, NJ 07602, (201) 342-6518; by modem, (201) 342-8101.

Inquiry 592.

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.

Personal What'sBest

General Optimization has released the Personal Version of its "spreadsheet optimization" package, What'sBest. This edition (not copy-protected) functions like the original but runs in 256K RAM and can optimize spreadsheets with as many as 800 numeric cells. Up to 250 of these can be variable (manipulated by the program during the optimization process).

What'sBest is designed to generate solutions to business problems modeled in Lotus 1-2-3 or Symphony. It uses a linear programming approach and a spreadsheet interface to answer "what if" questions.

It runs on IBM PC-type computers and costs $149. Contact General Optimization Inc., 2251 North Geneva Terrace, Chicago, IL 60614, (312) 248-7300.

Inquiry 593.

Idea Processing on the Amiga

New Horizons Software has developed a package for helping you process your ideas on an Amiga. The company says the program's primary use is in organizing and rearranging information in preparation for writing, or for planning and decision making. You enter your ideas in an outline fashion and use the mouse or keyboard to manipulate them. The program provides pull-down menus for command entry. Because Flow opens its own window on the Workbench, you can use the computer's multitasking capabilities, New Horizons says.

Suggested retail is $99.95. Contact New Horizons Software, P.O. Box 43167, Austin, TX 78745, (512) 280-0319.

Inquiry 594.

100 MHz scope, counter, timer, multimeter: All one integrated system.

100 MHz dual time base scope. 3.5 ns risetime; sweeps from 0.5 s to 5 ns/div; alternate sweep; ±2% vertical/horizontal accuracy; vertical sensitivity to 2 mV/div @ 90 MHz.

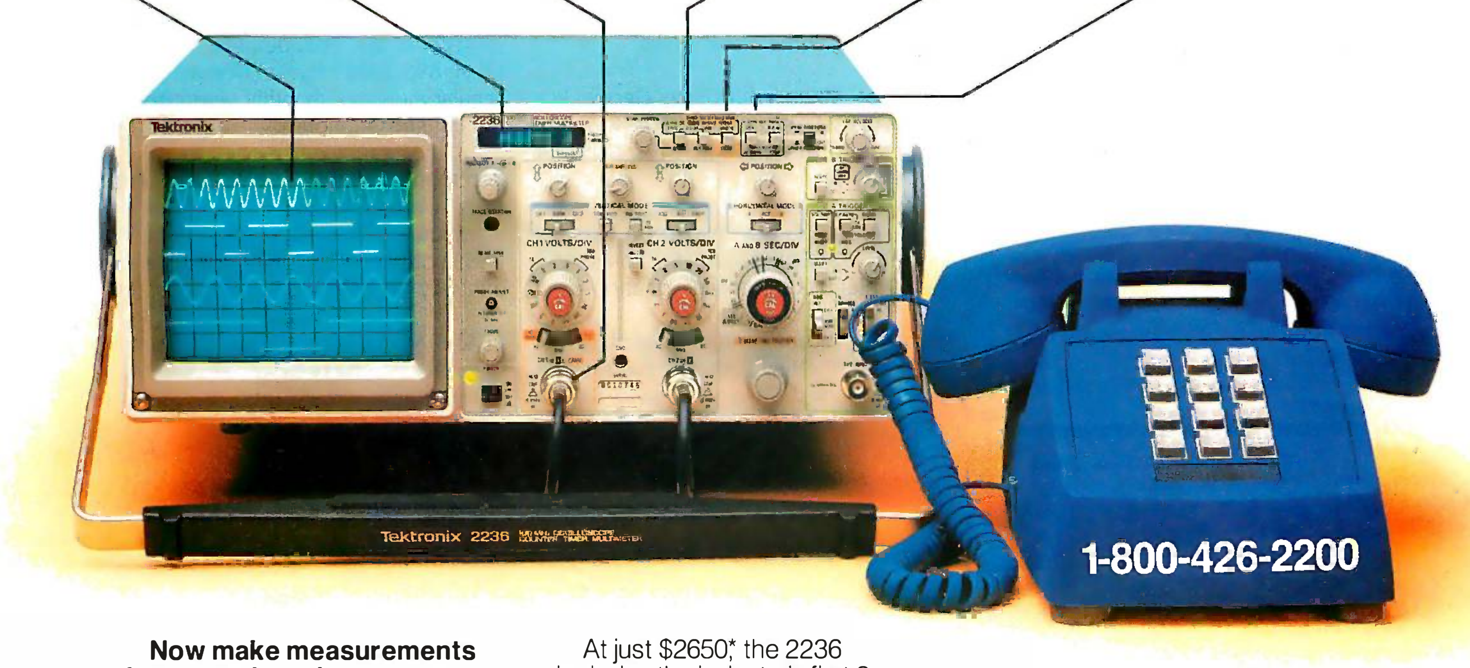
9-digit fluorescent display. Digitally accurate readouts accompany the CRT waveform. Error messages and prompts also appear on the display.

Dc volts and ac coupled true RMS volts. Measured through the Ch 1 scope input.

Gated measurements. Use the scope's intensified marker to measure frequency, period, width and to count events within specified portions of the signal.

Auto-ranged, auto-averaged counter/timer. Frequency, period, width, delay time, Δ-time, plus totalize to more than 8 million events —with 7 digits plus exponent displayed.

Auto-ranged DMM. Use floating DMM side inputs with up to 5000-count resolution. Get precise readouts of average dc and true RMS voltage. Measure resistance from milliohms to gigohms.



Now make measurements faster, easier, with greater accuracy and user confidence. The Tek 2236 makes gated counter measurements, temperature, time, frequency, resistance and voltage measurements pushbutton easy. You see results concurrently on the 9-digit numeric readout and CRT display.

Its complete trigger system includes pushbutton trigger view, plus peak-to-peak auto, TV line, TV field, single sweep and normal modes.

At just $2650* the 2236 includes the industry's first 3-year warranty on all parts and labor, including the CRT.

Integrated measurement system. 3-year warranty. 15-day return policy. And expert advice. One free call gets it all! You can order, or obtain literature, through the Tek National Marketing Center. Technical personnel, expert in scope applications, can answer your questions and expedite delivery. Direct orders include probes, operating manual, 15-day return policy, full warranty and worldwide service back-up.

Order toll-free: 1-800-426-2200 Extension 57

In Oregon call collect:
(503) 627-9000 Ext. 57
Or write Tektronix, Inc.
P.O. Box 1700
Beaverton, OR 97075

Tektronix
COMMITTED TO EXCELLENCE

Inquiry 295

C·L·U·B·S A·N·D N·E·W·S·L·E·T·T·E·R·S

DISABILITY NEWS ONLINE, Robert Mauro, 257 Center Lane, Levittown, NY 11756. Electronic newsletter by and for the disabled.

PC TECH REPORT, William J. Claff, 7 Roberts Rd., Wellesley, MA 02181, (617) 235-9505. Technical code and techniques for professional software developers; $18 subscription rate includes back issues.

MADISON MACINTOSH USERS GROUP, P.O. Box 1522, Madison, WI 53701. $15 subscription to the *Mad Mac News*; frequent meetings.

FOREFRONT, C-128 NATIONAL USERS GROUP, P.O. Box 21836, St. Louis, MO 63109. Send SASE for information.

PC USERS GROUP OF NEW YORK, P.O. Box 560, Wall St., New York, NY 10005. Free publication with 98-cent-stamped, 8½- by 11-inch self-addressed envelope. $25 membership includes newsletter and discounts; send SASE for details.

COMPAQ CORNER, 714 Ocean Ave., Sea Bright, NJ 07760. 300- or 1200-baud BBS, on-line 24 hours a day at (201) 530-5639.

SMALL COMPUTERS IN THE ARTS NEWS (SCAN), P.O. Box 1954, Philadelphia, PA 19105. Triannual newsletter, annual symposium; $15 subscription.

PC-HUG (HUNTINGTON PC USERS GROUP), P.O. Box 1958, Huntington, WV 25720, (304) 526-5189. Monthly meetings, no admission fee; dues only for use of public domain library.

THE INSTITUTE OF INTELLIGENCE TECHNOLOGY, 571 Ontario St., Toronto, Ontario, Canada M4X 1M9, (416) 924-3819. Correspondence courses, bimonthly newsletter, IQ evaluator. One-time fee of $25 U.S., $35 Canadian.

MINDSET BBS—EAST COAST CHAPTER OF THE FIRST MINDSET USERS GROUP (FMUG), James Pallack, 23 Hayward St. #8, Burlington, VT 05401-4759, (802) 658-1255. Operating 7 days a week at 300 and 1200 baud at (802) 658-2494.

THE MCSPIRITT NEWSLETTER, 185A Smith Ave., Garden City, GA 31408, (912) 966-2323. ISPF techniques and programs. Subscription: $51 annually.

PHILADELPHIA AREA COMPUTER SOCIETY'S MACINTOSH SPECIAL INTEREST GROUP (MAC SIG), Melanie Hoag and Simon Edkins, Drexel University, Biosciences and Biotechnology, Philadelphia, PA 19104, (215) 895-2628. Public domain library, regular meetings, monthly newsletter; $10 annual subscription.

INTERNATIONAL COMPUTING ASSOCIATION (ICA), c/o Markus Mäge, Röbbek 6, 2000 Hamburg 52, West Germany. BBS, global BBS information, quarterly newsletter. $20 annually.

CLACK! AMIGA USER GROUP, Stefan Ram, Claszeile 27, 1000 Berlin 37, West Germany. English and all European languages welcome for information exchange about the Commodore Amiga.

TELECOMMUNICATIONS USERS GROUP (TUG), P.O. Box 45254, Seattle, WA 98145-0254. Monthly journal, regular meetings. $12 annual dues.

MICRO BULLETIN BOARD SYSTEMS, MBBS Headquarters PDSE, 8033 Sunset Blvd. #975, Los Angeles, CA 90046, (213) 653-6398. Clearinghouse for sysops and users. Membership: $10 per year.

ANKARA APPLE USERS CLUB (AAUC), Çağlan M. Aras, 4. cadde 165/31, 06490 Bahçelievler, Ankara, Turkey, (90) 41 23 43 69. Regular meetings, monthly newsletter. Annual fee: 2000 Turkish liras, or about $4.

SANTA BARBARA ATARI COMPUTER ENTHUSIASTS (SBACE), P.O. Box 3678, Santa Barbara, CA 93130. Regular meetings, newsletter, BBS at (805) 965-5709. ■

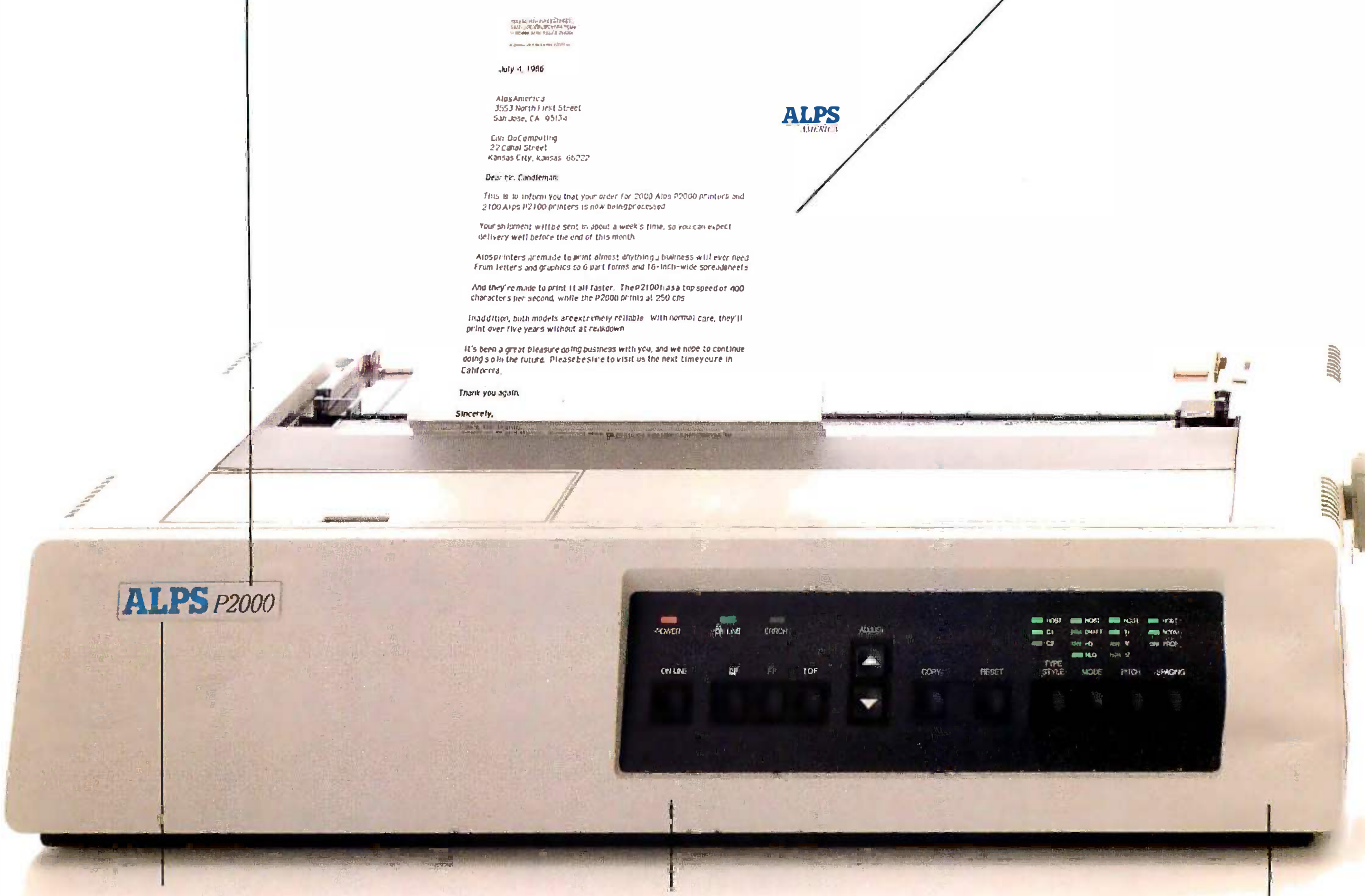
CLUBS AND NEWSLETTERS *is an acknowledgment of new clubs and newsletters received at* BYTE. *Allow at least four months for your club's mention to appear. Send information to* BYTE, *Clubs and Newsletters, One Phoenix Mill Lane, Peterborough, NH 03458.*

IT'S TIME YOU SAW THE ALPS.

SO HERE

Only $995.

Fast. Top speed 250 cps in draft mode.



Manufactured by Alps Electric, a $1.5 billion Japanese maker of computer and electronic products, and member of the International Fortune 500.

Fully compatible with all the most popular business PCs and software.

Built like a tank.

Welcome to the Alps.

The Alps P2000™ and new P2100™ Dot Matrix Printers. They just may be the perfect printers for a department full of PCs.

They're fast. The P2100 prints drafts at an amazing 400 characters per second (cps), the P2000 at an almost amazing 250 cps.

They're reliable. With normal care, they'll last for over five years without a breakdown.

THEY ARE.

Sold, serviced and supported in the U.S.A. by Alps America.

Very fast. Top speed 400 cps in draft mode.

Likewise.

Only $1,595.

And they're versatile. They'll print most anything, and run with all the most popular PCs and software.

Now, if you'd like to explore these Alps further, our free tour begins on the next page.

It's your chance to see something you probably don't see every day.

Printers that work as hard as you do.

MEET
DISTINGUIS

Diagnostic self-test signals errors with flashes and beeps.

A choice of paper feeding controls.

Go off-line to change type styles and modes without lengthy software commands.

12 pushbuttons control printing functions.

Lets you feed paper line-by-line, by 1/216-inch increments, or continuously.

The first thing that sets Alps printers apart from similarly-priced models is their sheer wealth of printing functions. And the ease with which you can perform them.

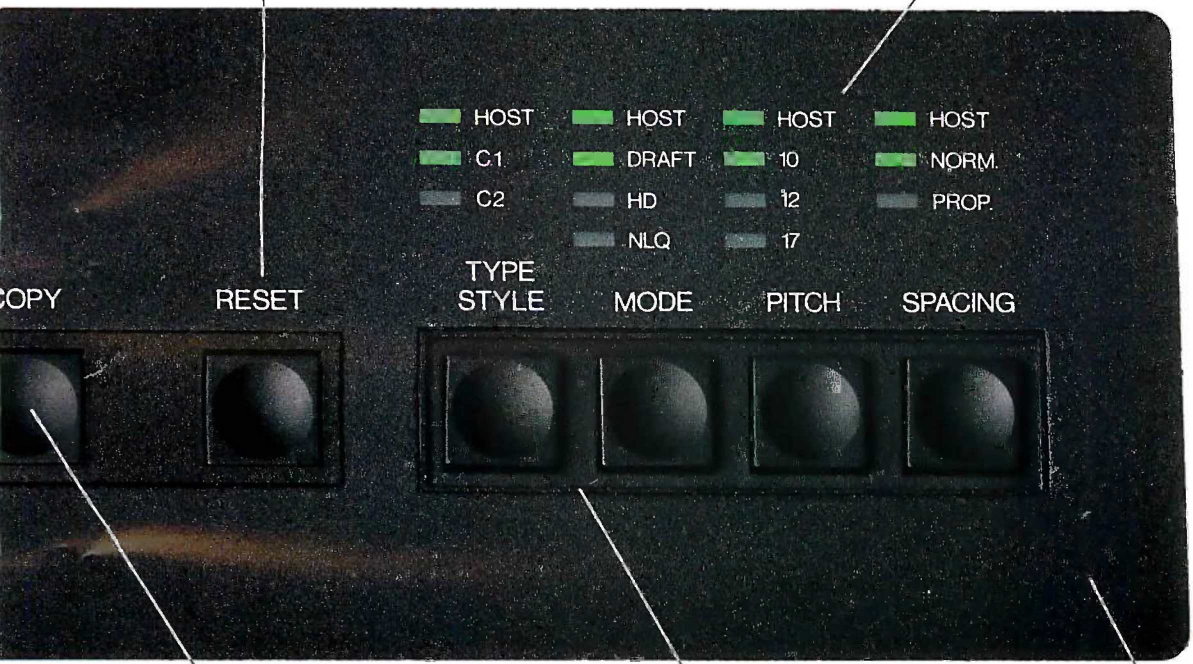
For example, you can change type styles or print modes without getting involved in lengthy software commands. Just push a button on the front panel instead.

Which is about all you'll ever have to do to handle any Alps printing job. Whether you're feeding paper in 1/216-inch increments or reprinting

OUR
HED PANEL.

Clears print buffer of data without printing it.

17 LEDs indicate functions in operation.



Automatically reprints data stored in print buffer.

Select type styles, printing modes, print pitches and spacing quickly and easily.

Boy, is it fast. 400 cps in draft mode.

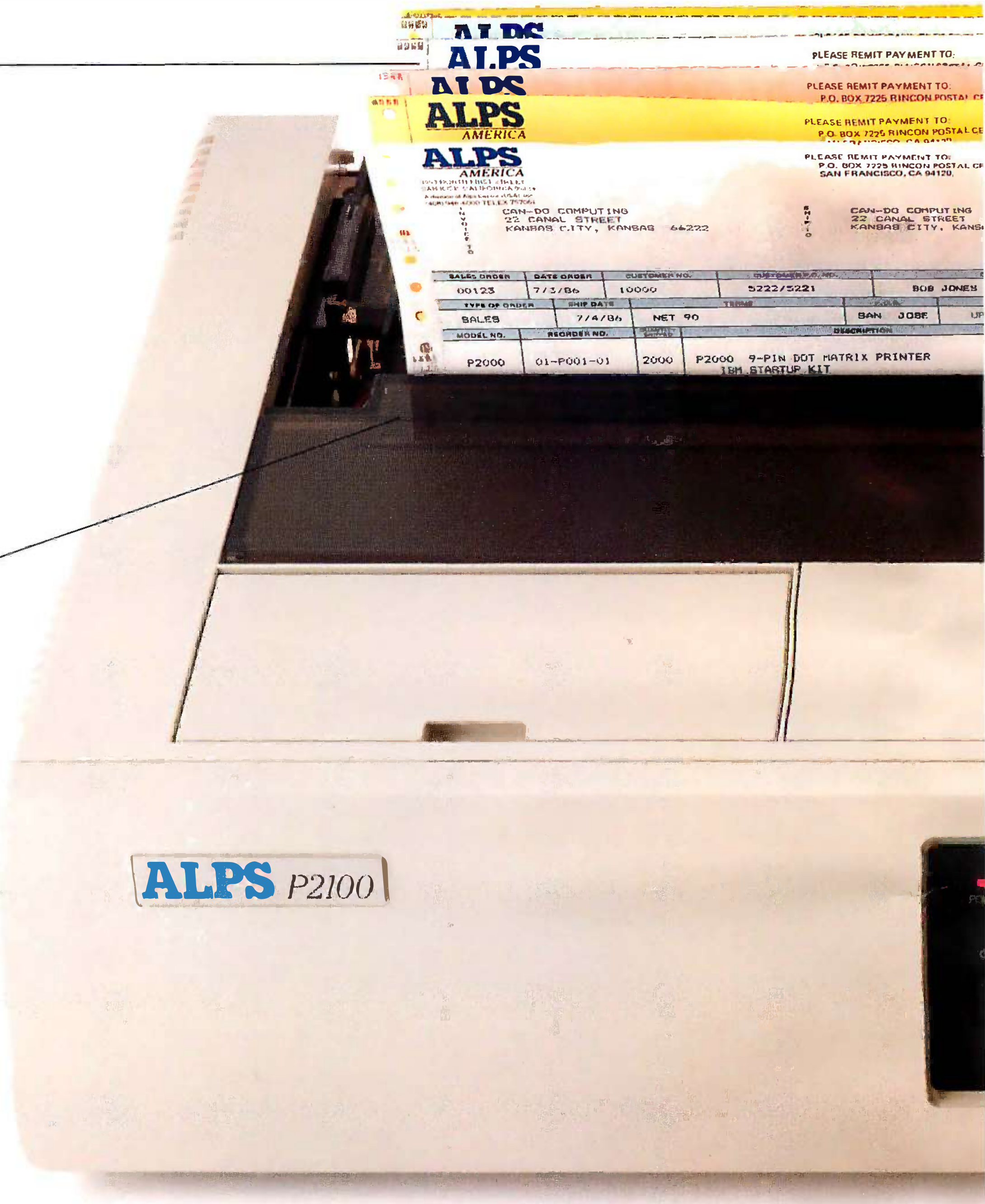
data stored in the print buffer.

The built-in print buffer (4K expandable to 256K) also frees up your PC for other jobs while the Alps is still printing.

And in the unlikely event of an operating error, our panel will immediately diagnose the problem and inform you.

With distinguished beeps and flashes.

FEED IT A



Most business printers are very picky.

They simply refuse to deal with some of the jobs you have to deal with. Like printing on heavy stock. Or on oversized sheets.

But Alps printers are different.

They're made to print almost anything your business will ever need. From letters and graphs to six-part forms and 16-inch-wide spreadsheets.

And they not only handle most

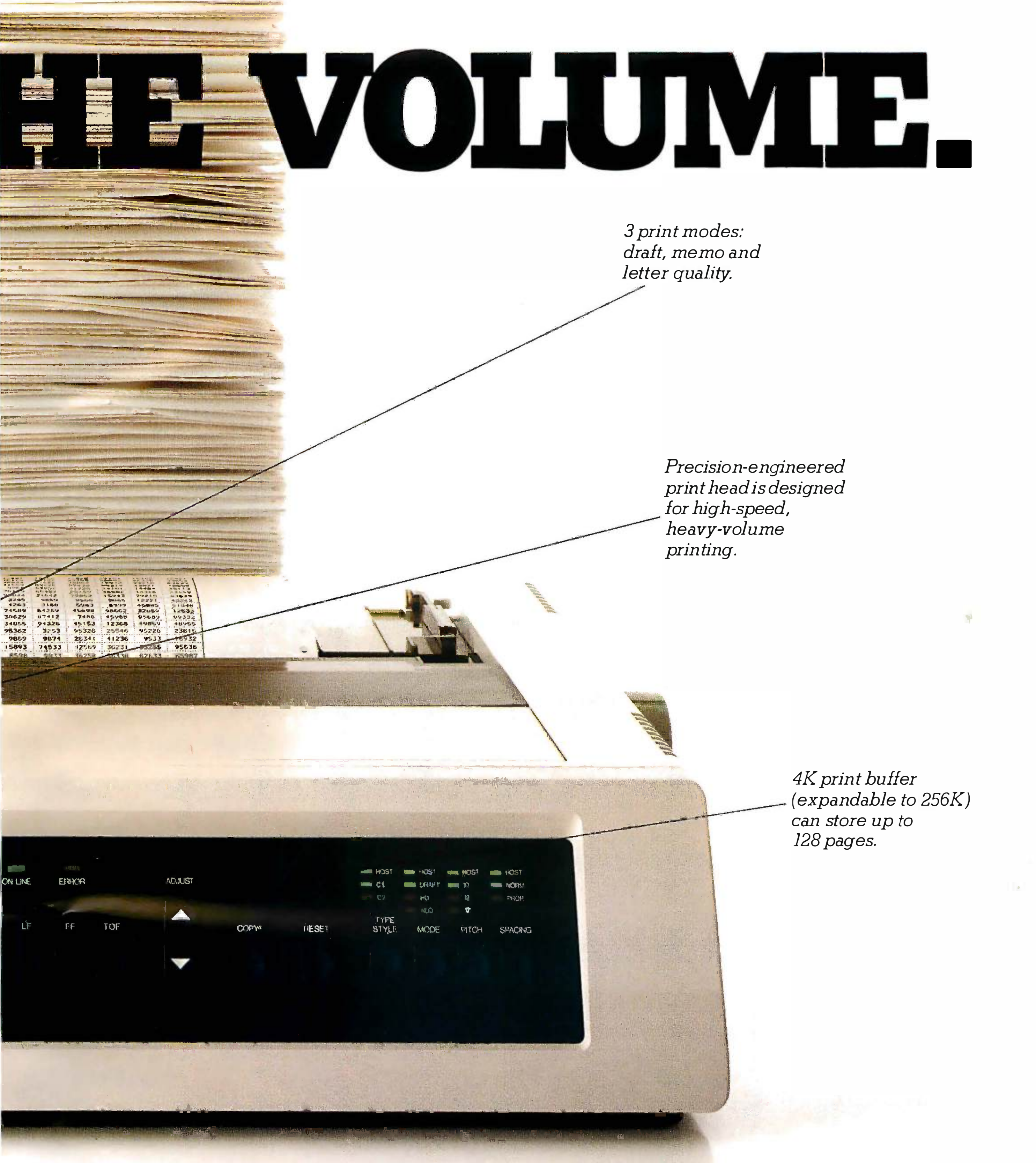
NYTHING.

everything, they handle it more efficiently.

Both come with a built-in two-way tractor feed (push and pull) that saves paper other printers would normally waste. Plus a choice of three different paper feeding methods, all standard.

All in all, you'd be hard pressed to find printers with a greater appetite for work.

HE VOLUME.



So either printer can easily take on all the work an office full of PCs can dish out.

And they'll take care of it faster, thanks to time-saving features like a built-in tractor feed, expandable print buffer and multiple type font cartridges.

In fact, for heavy volume work, Alps printers stack up favorably against much more expensive machines.

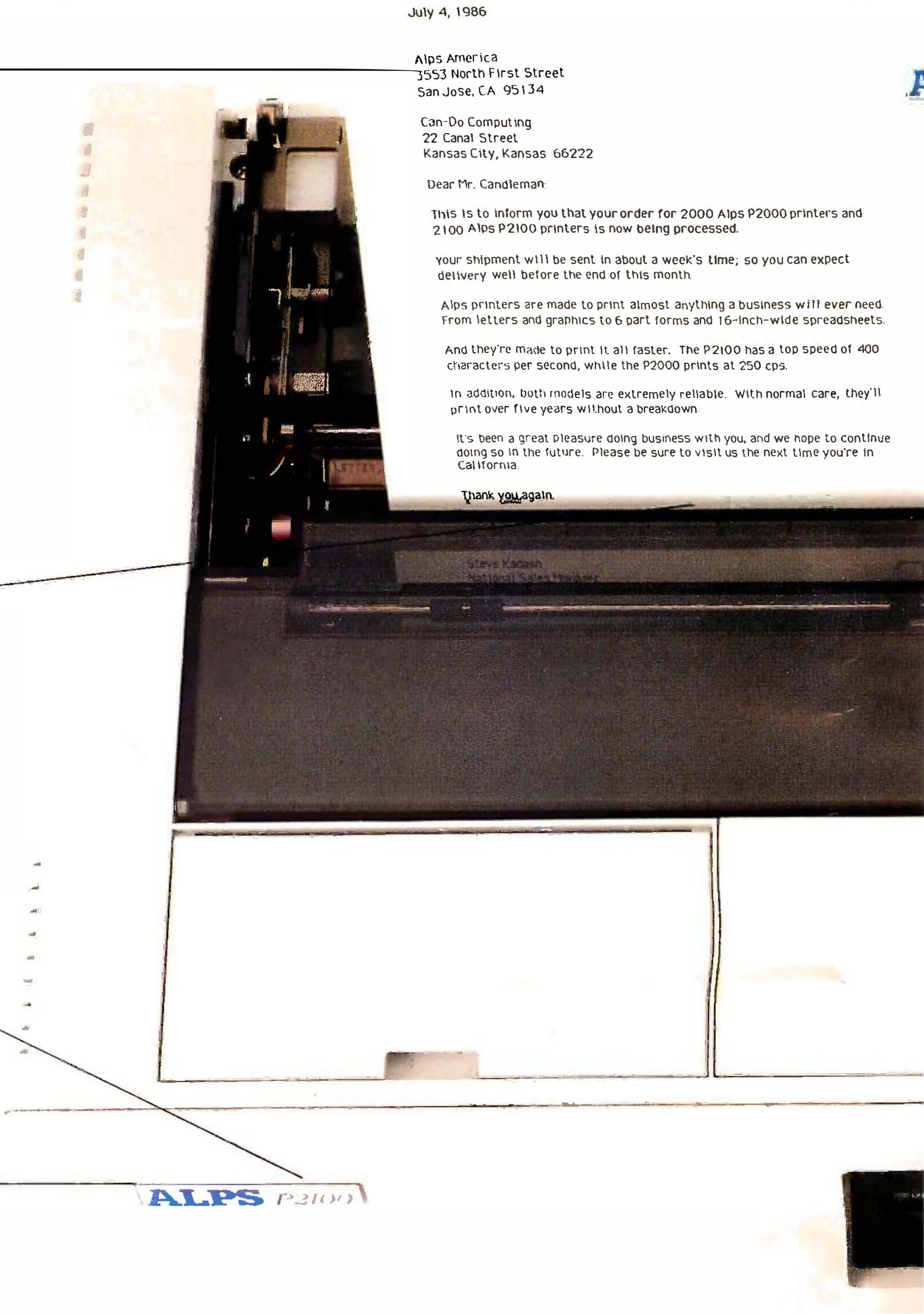
LISTEN TO

Superb print quality in all three printing modes.

Rugged print head has life span of over 200,000,000 characters.

With normal care, will last over five years without a breakdown.

One-year warranty.



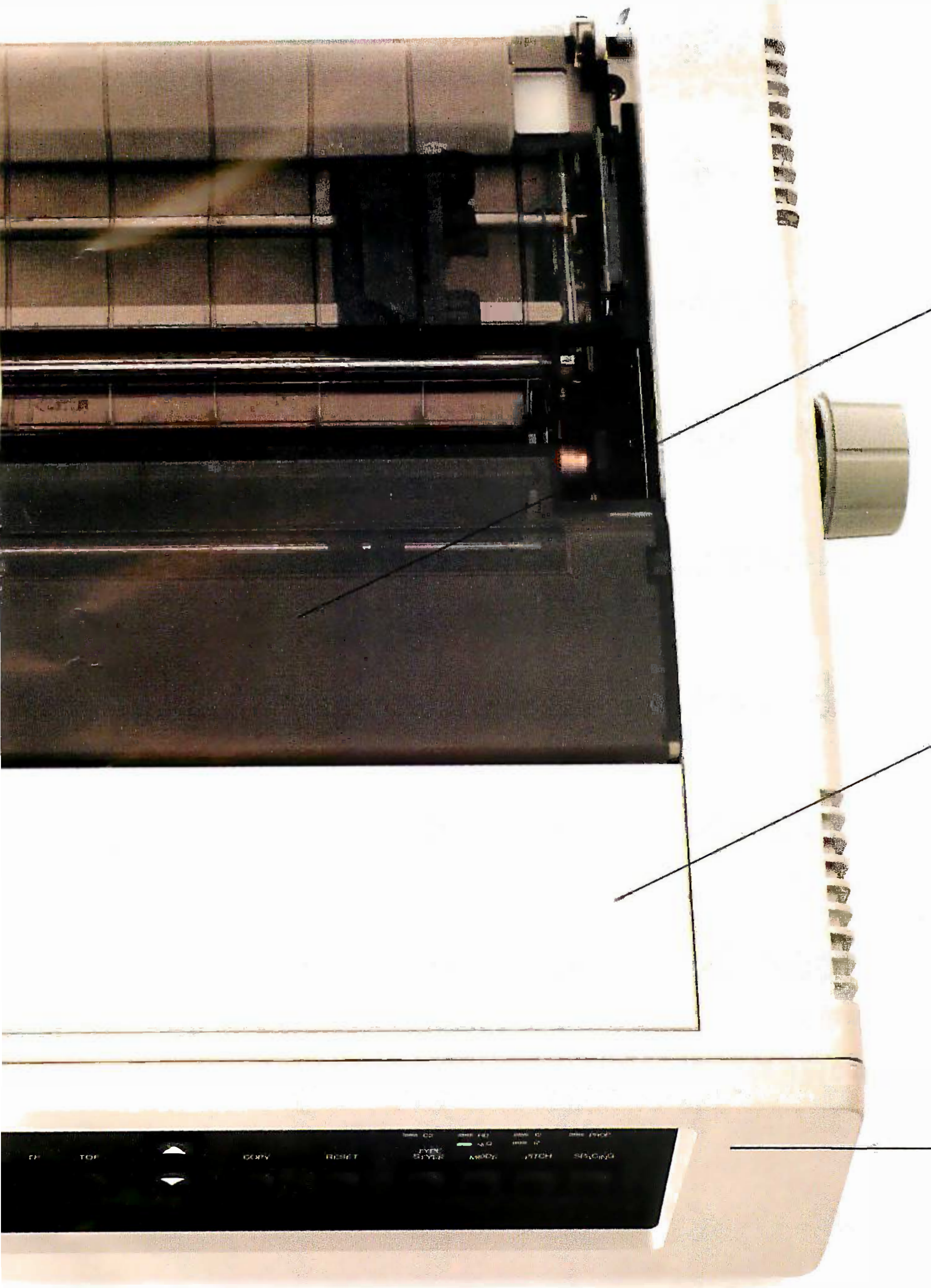
Even when the volume's up all the way, you won't hear much. Because Alps printers are built to print up a storm without sounding like one.

Every open space is covered with sound-absorbent layers, keeping noise in and dust out.

But Alps printers aren't just built to run quietly. They're built to run a long, long time.

Our precision-engineered print head will deliver over 200 million characters of superb output. No matter how hard you work it.

THIS PAGE.



Built like a tank, but doesn't sound like one.

Sound-absorbent layers ensure quiet operation at noise level under 55 dBA.

Have we mentioned how fast it is?

What's more, if you give our printers normal care, they'll give you over five years of trouble-free printing.

Which is not surprising when you consider that they're built by Alps Electric, a $1.5 billion Japanese company that's been successfully manufacturing computer printers for over a decade.

And though our printers are quiet, we're sure you'll be hearing a lot about them from now on.

SEE THE ALPS FREE.

☐ Yes, I'd like to see the Alps P2000 and P2100 Dot Matrix Printers in action. Please contact me to arrange a free demonstration. And enter my name in your drawing for a free 10-day vacation to the Japanese or Swiss Alps.

☐ No, I'm not interested in a free demonstration right now. But please enter my name in your drawing anyway.

NAME: ____________________

COMPANY: ____________________ TITLE: ____________________

ADDRESS: ____________________

CITY: ____________ STATE: _____ ZIP: ________ PHONE: ____________

NO PURCHASE NECESSARY TO ENTER OR CLAIM A PRIZE.

1. To enter sweepstakes, fill out the information on this card and return it to Alps America, 3553 North First St., San Jose, CA 95134. Only one entry per person. Mechanically reproduced entries not eligible. All entries must be received no later than Sept. 30, 1986. Not responsible for late, lost, or misdirected mail.

2. Winner will be selected in a random drawing on or about October 15, 1986, from all entries received under the supervision of Marden-Kane, an independent judging organization. By participating in the sweepstakes, entrants agree to be bound by the rules and the decision of the judges, which shall be final. Winner will be notified by mail and must be required to sign an Affadavit of Eligibility and Release which must be returned within 14 days, or an alternative winner will be selected. The awarding of the prize to an individual shall be made at the discretion of your employer and/or in accordance with your employer's written policies governing promotion awards, where applicable. Winner grants permission to the use of their name, photograph/likeness for advertising and promotion for this and similar promotions without additional compensation. Odds of winning depend upon the number of entries received. All taxes are the responsibility of the winner.

3. Prize structure: (1) Grand Prize: a 10-day trip for two to the Japanese or Swiss Alps. Trip consists of round trip air transportation (coach) from a major airport nearest to the winner's residence, 9 nights and 10 days hotel accommodations, 2 meals daily and $500 spending money. No prize substitution permitted, nor is prize transferable. Trip must be completed by June 30, 1987, and is subject to availability.

4. Sweepstakes open to individuals who purchase, specify, evaluate, recommend or use printers for personal computers, and are residents of the United States, except for employees and their immediate families of Alps Electric (USA), Inc., their subsidiaries, affiliates, advertising or public relations agencies, and Marden-Kane. Void where prohibited by law.

5. For the name of the winner, send a stamped, self-addressed envelope to "See the Alps" Winner, Alps America, 3553 North First St., San Jose, CA 95134.

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FIX

Man Baffled by Maryland Move

Boy, was Mike Barlow surprised when he found out he had moved from Pierrefonds, Quebec, to Wheaton, Maryland. We told him about his relocation in the Clubs and Newsletters section of our February issue. Mike edits the newsletter of the American Cryptogram Association, and he still does that job at his place in the Great White North. It's the ACA's *treasurer* who lives in Maryland.

You can get information about the newsletter for cryptologists by writing to Mr. Barlow at 5052 Chestnut Ave., Pierrefonds, Quebec, Canada H8Z 2A8.

If you want to join the association, write to the ACA treasurer, who is still staking out the 12317 Dalewood Dr., Wheaton, MD 20902 address.

BYTE'S BITS

Software Exchange for Turbo Pascal Users

Steve Wood, author of *Using Turbo Pascal* (Osborne/McGraw-Hill, 1986), tells us he's organized Turbo SIX, the Turbo Pascal Software Information Exchange. Mr. Wood says the objective is "to collect, analyze, and disseminate information and software" to users of Borland International's Turbo Pascal. The software is from the public domain and from members. For more information, contact Turbo SIX at 2012 Lake Air, Waco, TX 76710, (817) 753-2182.

Publications We'd Like to Tell You About and Can't Find an Appropriate Place for Anywhere Else

Ken Knecht is offering his booklet *Macintosh Hints and Kinks* on a shareware basis. It describes undocumented command- and option-key combinations, the MacPaint/Write/Draw trio, and other programs. "I will encourage the recipient to, in turn, send me $3 or whatever seems fair," Mr. Knecht writes.

Send a 6- by 9-inch SASE (with 39 cents postage) to Ken Knecht, 1340 West 3rd St. #130, Yuma, AZ 85364, (602) 783-9259.

Howard Boyet writes to tell us about a book he cowrote with Ron Katz called *The 16-Bit 8096—Programming, Interfacing, Applications: 122 Hands-On Experiments with Intel's iSBE-96 Emulator*. Mr. Boyet says, "The aim of this book is the complete understanding and mastery of this formidable chip and all its functionality."

With Intel's emulator, the programs for the 122 experiments can be entered in ASM-96 and downloaded with an IBM PC AT, PC XT, or compatible.

The book sells for $39.95 (plus $2 shipping). Contact MTI Publications, 14 East 8th St., New York, NY 10003, (212) 473-4947.

The Society of Manufacturing Engineers has bound 22 technical papers representing highlights of the CIMTECH Conference sponsored recently by SME and its Computer and Automated Systems Association. The papers present models for implementing computer-integrated manufacturing theories and applications.

Contact SME, Publication Sales, One SME Dr., P.O. Box 930, Dearborn, MI 48121, (313) 271-1500, ext. 418.

John Wiley & Sons has begun publishing a new journal "devoted to the systematic development of the theory necessary for the construction of intelligent systems." Wiley says its *International Journal of Intelligent Systems* includes "scholarly, peer-reviewed" articles on expert systems, knowledge representation, interactions between man and computer, and machine learning.

Contact Wiley at 605 Third Ave., New York, NY 10158, (212) 850-6000.

UPDATE

New and Improved MicroTEX

Addison-Wesley has informed us of an update to its MicroTEX typesetting package, reviewed by Hal Varian in our April issue. A new version, 1.5A1, has since been published and features the following changes:

MicroTEX now has drivers for all PostScript printers and phototypesetters, Hewlett-Packard LaserJet Plus and compatible printers, Imagen Impress laser printers, QMS Quic laser printers, Epson FX, MX, and RX printers, and IBM's Graphics Printer and Proprinter.

The package now lets you create and read FMT files.

Preview software lets you check your output on the screen and see what you're going to get.

It's smaller. A fully loaded version of "Plain TEX" fits on one 360K floppy disk; A-W says you can run MicroTEX on a two-floppy system.

It can run BibTEX and other big macro packages.

Most recent versions of LaTEX and AMS TEX are available to let users format work in predefined document styles.

MicroTEX with either a PostScript printer driver or a LaserJet Plus driver is $495; with an Epson or IBM driver, $369.95. Owners of older versions can upgrade to 1.5A1 for $50; owners of Personal TEX Inc.'s PCTEX can upgrade to the new MicroTEX for $100. For further information, contact Addison-Wesley Publishing Co., Reading, MA 01867, (617) 944-3700. ■

A·S·K B·Y·T·E

Conducted by Steve Ciarcia

APPLE IIE

Dear Steve,

I am an Apple IIe user looking for information in a few areas. First, I would like to find DOS 3.3 source listing and documentation.

I am interested in controlling a cutting tool from my computer. I am thinking of a machine with *x*, *y* coordinates and up-down control. This would be for light work, such as cutting thin cardboard.

I need information on an arithmetic processor for three-dimensional graphics operations. Where can I obtain information about the 9511 or 9512 APU?

Finally, I would like some information on three-dimensional digitizing equipment.

Thanks for your help.

JOSE LUIS DARIAS GARCIA
Caracas, Venezuela

DOS 3.3 source code can be obtained from these two sources:

Apple Assembly Line
P.O. Box 280300
Dallas, TX 75288
(214) 324-2050

Nibble
MicroSparc Inc.
42 Winthrop St.
Concord, MA 01742
(617) 371-1660

Nibble *magazine published the source code as part of the "Disassembly Lines" column by Sandy Mossberg.* Beneath Apple DOS *from Quality Software (6660 Reseda Blvd., Suite 105, Reseda, CA 91335) also contains source code information.*

I know of no products available that are the same as your cutting tool description. However, the mechanism you describe is functionally similar to some of the two-axis plotters available for the Apple from several manufacturers. If a knife with a freely swiveling blade were substituted for the felt-tip pen, you might have a workable system if cutting forces are extremely low. Suitable knives can be obtained from art and drafting supplies distributors. Some manufacturers of plotters are

Houston Instrument
8500 Cameron Rd.
Austin, TX 78753
(800) 531-5205

Mannesmann Tally
8301 South 180th St.
Kent, WA 98032
(206) 251-5524, ext. 5645

Roland DG
7200 Dominion Circle
Los Angeles, CA 90040
(213) 685-5141

Information on the 9511 and 9512 arithmetic processors can be obtained from

Advanced Micro Devices
P.O. Box 3453
Sunnyvale, CA 94088
(408) 732-2400

At least one company is manufacturing a high-speed plug-in arithmetic card for the Apple II–series computers. The MicroSPEED II uses an Intel 8231 math processor at 2 or 4 megahertz, depending upon the version (two are available). The manufacturer is

Applied Informatics Inc.
15104 St. Thomas Church Rd.
Upper Marlboro, MD 20772
(301) 627-6650

A source of image-digitization hardware and software for the Apple II series is

HAL
P.O. Box 293
Scotch Plains, NJ 07076

—Steve

FRANKLIN

Dear Steve,

I have a Franklin Ace 1200 with Franklin's version of VisiCalc known as AceCalc. While I was using AceCalc, I cleared the worksheet and saved a file instead of loading it. This literally wiped out the file. However, the catalog still shows the file as 28K bytes in size. Can I do anything to rescue or restore it?

ROBERT A. KELLY
Florham Park, NJ

If your copy of AceCalc uses the standard Apple DOS 3.3 file format and you did not use DIF as a data format, rescuing the file should be fairly easy (as long as you did not save additional data to that disk since your "accident"). If the DOS is radically different from DOS 3.3, you used DIF, or overwrote the original file with a subsequent file save, things will be much more difficult or impossible. The following suggestions assume a standard DOS and a non-DIF type of file format. The fact that the disk catalog still shows a 28K-byte file size (I assume it shows sectors and that you have translated to bytes) strongly suggests a fairly standard DOS 3.3. The erroneous file-size indication is the result of a bug in DOS 3.3 that results in an incorrect file-size indication if a file is shortened and then saved under the same name without first deleting it.

At least two versions of AceCalc were produced; most, apparently, had a customized version of Apple DOS 3.3. If you have one of the DOS 3.3 versions, the method below will rescue the file under the conditions stated.

Several utility programs are available that can be used to "undelete" files and otherwise manipulate the contents of disks. You will have to restore the catalog and the track-sector list for the file. I suggest that you obtain a book called Beneath Apple DOS *(Quality Software, 6660 Reseda Blvd., Suite 105, Reseda, CA*

(continued)

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

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

Due to the high volume of inquiries, personal replies cannot be given. All letters and photographs become the property of Steve Ciarcia and cannot be returned. Be sure to include "Ask BYTE" in the address.

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. 8

News about the Microsoft Language Family

Improved Microsoft® C Compiler Version 4.00 Is Now Available

ANSI compatibility: Microsoft C Compiler Version 4.0 provides increased support for the developing ANSI standard. **Library support:** Over 30 new library functions have been added, including UNIX™ System V functions vprintf, vscanf, and setvbuf. **More memory models:** Compact and huge memory models have been added for increased versatility, bringing the number of supported memory models to five. **Optimizations:** Elimination of common sub-expressions joins our list of optimizations to make your generated code tighter than ever before. **Source code:** Full start-up and exit source code is provided. In addition to these new features, Microsoft C Compiler Version 4.0 allows you to compile and optimize larger programs, get mixed source and disassembly listings, control floating-point math better, and use improved overlay capabilities. And MAKE, the program maintenance utility, helps ensure up-to-date program components by automatically recompiling and relinking to keep up with your source code changes.

The New CodeView™ Source Debug Utility Is Bundled with Microsoft C. All the power of SYMDEB plus full windowing orientation make CodeView the debugger you will want to grow into. See source code and disassembly interspersed. Use drop-down menus, multiple windows, independent graphics screen swapping, and a read-only source code editor to navigate through your code and locate logic errors more quickly than ever before. Exercise your code with the dynamic C expression evaluator instead of recompiling multiple test cases. Set conditional breakpoints. See registers and variables (even locals) change as you watch an animated trace program execution. Special offer for CodeView demo: Words can't say it all here, but our freely copyable demo disk is available for only $5. Take a test drive!

New Microsoft QuickBASIC Version 2.00 Makes Programming in BASIC Easier and Faster

Microsoft QuickBASIC has undergone a major transformation in its new Version 2.0 release. We think that it will change the way you program in BASIC. The Microsoft QuickBASIC programming environment features an integrated editor, compiler, and runtime.

The editor uses a Microsoft Windows-like interface for full screen editing with pull-down menus. The editor supports the Microsoft Mouse and the IBM® 43-line Enhanced Graphics Adapter. The faster compiler can be invoked directly from the editor, compiling Microsoft QuickBASIC programs directly into memory and bypassing the link step. If no errors are detected the program can start executing immediately. Both compilation errors and runtime errors will restart the editor and place the cursor on the troublesome line.

Debugging compiled programs is easier with Microsoft QuickBASIC 2.0. The TRON statement enables the new source display animated trace and step modes. The tracing features can be toggled on and off using the function keys.

Large BASIC program development is supported by an additional new method of separate compilation. User libraries of BASIC and assembly language routines can be loaded into the in-memory compilation and execution environment. Microsoft QuickBASIC 2.0 also supports stand-alone application development.

New Microsoft QuickBASIC language features include block IF/THEN/ELSE, Enhanced Graphics Adapter support including the new 640 by 350 graphics modes, and dynamic arrays that can now use all of available user memory.

For more information on the products and features discussed in the newsletter,
write to: Microsoft Languages Newsletter
16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717
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Look for the Microsoft Languages Newsletter every month in this publication.

91335) and a suitable utility program like Bag of Tricks, Copy II Plus, or Locksmith. The book explains how the disks are formatted and how information is stored on them. The utility programs permit modification of individual data bytes on the disk. These items are available through local computer dealers and those that advertise in publications like BYTE and Computer Shopper. *You should be able to fully recover your data as long as you have not saved any files to that disk since your inadvertent save of a blank file.*

The first thing you should do is copy the disk using a copy program that copies tracks rather than files. COPYA on the DOS 3.3 system master is such a program; FID on the same disk is not. Then work only with the copy in attempting to recover your data. I suggest first trying the FIXCAT program on the Bag of Tricks disk, instructing it to scan the disk for lost files. It will locate all sectors on the disk that contain valid data but aren't listed in the catalog. Once they are located, these sectors can be marked as "used" in the VTOC. You may have to do a bit of looking and patching with a sector editor to fully reassemble the missing file. If DIF was used, you may have to use a sector editor to change the file to a standard text file.—Steve

AT COMPATIBLES

Dear Steve,

I am currently using an IBM PC AT with 640K bytes of memory, a 1.2-megabyte floppy disk drive, a 20-megabyte hard disk, a Princeton HX-12 color monitor, and an Epson FX-185 printer/plotter. This machine is on loan to me, and I am using it for scientific computations.

In the near future, I would like to buy an AT-compatible machine. I was thinking of the Columbia microcomputer, but Columbia is out of business now. What machines do you recommend? Should I wait for the new 32-bit computers or the new reduced instruction set computers?

Also, would it be possible for me to attach an array processor to an AT (or AT compatible) without spending a large amount of money? If so, what programming languages should be used to get the most out of such a configuration?

GEZA SZONYI
Lexington, MA

If you haven't seen the November 12, 1985, and February 25, 1986, issues of PC Magazine, *you should get copies. Between these two issues, more than a dozen alternatives to the AT are reviewed and compared. I haven't had the opportunity to try any of these machines, but one of them should come close to your criteria. If you are using the machine to do a lot of number crunching, you should probably invest in the 80287 coprocessor (assuming your software can make use of it). I have seen three-dimensional rotation of complex molecules run on such a machine, and it is quite impressive.*

There will always be a trade-off between programming efficiency and run-time performance. Nothing beats good assembly language programming for speed, but it is intensely time-consuming. A good optimizing compiler is never as fast, but the time to develop applications is greatly reduced. FORTRAN is still used for many scientific applications; a good version for MS-DOS is available from

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(continued)

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I don't know of an array processor for the AT right now, though someone is bound to come up with one sooner or later.

IBM's RISC machine is now available. But remember that it does not run MS-DOS, so any packages that you now use on the AT will not run on this new machine. I understand that IBM will offer an 80286 board for the RISC machine, but this will not run any faster than a standard AT. The 32-bit machines are on the drawing board, but it is anyone's guess as to when they will appear in the marketplace. I understand that the 80386s will run three to five times faster than the 80286s. Since they will run the same MS-DOS software, this will provide an easier upgrade path than waiting for specific software for the RISC machine or developing your own.

I've always adopted the philosophy that it is better to jump on the computer bandwagon now than it is to wait. If you wait until next year, yet another development will be just over the horizon, and another one beyond that. If you get your feet wet now, you will be that much more knowledgeable and further ahead when the next generation of machines comes out.—Steve

CIRCUIT CELLAR FEEDBACK

LIQUID-CRYSTAL DISPLAYS

Dear Steve,

In some of your articles, you have made reference to LCDs. I am having great difficulty finding them at any price. I'm looking for a multiline dot-matrix LCD. I would also like to find a small keyboard with a QWERTY configuration similar to those on HP 70 hand-held computers. If you could steer me to a source of these items, I would be most grateful.

RIC BRANDT
Hamilton, OH

LCDs with fixed alphanumeric characters can be found in the hobbyist market from a number of sources. You will have difficulty finding the multiline dot-matrix variety in this market due to their price—they are expensive items.

Keyboards similar to that found in the HP 70 series are custom items, usually consisting of solid key caps that push down onto a membrane switch panel. Since these items are custom, most companies keep a supply on hand for repair. I suggest contacting such a company to purchase a keyboard assembly. If you can't find a company willing to sell you one, you can always pick up a relatively inexpensive compact keyboard from many mail-order electronics parts companies.

Two mail-order electronics firms that carry alphanumeric LCDs and keyboards are the following:

Digi-Key Corporation
P.O. Box 677
Thief River Falls, MN 56701
(800) 344-4539

Jameco Electronics
1355 Shoreway Rd.
Belmont, CA 94002
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For information on dot-matrix LCDs, contact

(continued)

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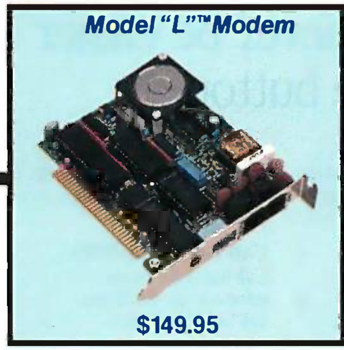

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—Steve

Ultrasonic Ranging

Dear Steve,

I recently became interested in building your ultrasonic ranging system described in the October 1984 BYTE, so I bought the kit from Micromint. I have scoured back issues of BYTE, Radio Shack stores, parts stores, the Canal Street area of New York City, and every other source that I can think of. But so far I have been unable to locate the UXD LCD that was described in figure 10 as being available from Liquid-Crystal Displays Inc. Would you please let me know this company's address?

I thought that I would try the LCD version of your project so that I could isolate mistakes that I may make in wiring from errors in communication between the sonar unit and my Osborne computer. I want to use the device to measure and price 1000 Christmas trees that we want to sell to raise money for my daughter's school.

Jeffrey T. Elliot
New York, NY

I don't have a current source for the LCD unit mentioned in the article, but you should be able to use the Amperex LC513040-301.15/1S sold by Digi-Key as part no. LCD003. The address is

Digi-Key Corporation
P.O. Box 677
Thief River Falls, MN 56701
(800) 344-4539

—Steve

Speech Synthesis

Dear Steve,

I have been following your articles on speech synthesis and recognition in BYTE for several years, hoping to come across something practical that can help me in my job as a speech pathologist. I teach speech to deaf children.

Since I have an Apple IIe in my clinic room, I ordered your Lis'ner 1000 board (November 1984) and have had fun using it with my deaf kids. You wouldn't believe how they light up when they see the Lis'ner 1000 recognize their speech and the words flash on the screen! Although

(continued)

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the Lis'ner doesn't really give them any articulatory feedback, except for right or wrong. I am using it to get them used to computers in speech therapy while I wait to find a visible speech display system that can give them useful feedback on their production of consonants and vowels. Of course, several systems are commercially available now, but I am not particularly impressed with their performance, and the price is prohibitive.

To date, I think the system you described in your March 1982 article ("Use Voiceprints to Analyze Speech") appears to do the best job of visually displaying critical consonant-vowel information that deaf children could use as articulation models.

Could the system described in March 1982 be easily modified to display spectrograms on an Apple IIe monitor in place of an oscilloscope?

Would it be possible to use the Lis'ner 1000 to visually display speech waveforms?

CHARLES FRAME
Oneida, WI

The voice analysis system described in March 1982 was an experimental system designed solely to test and experiment. It was never intended to be, nor is it, a commercial product. The system described uses an oscilloscope, which is not suitable for display of the test data on an Apple system. The only information available is contained in the article.

It would be reasonable to use the data from the Lis'ner 1000 to display speech waveforms using the high-resolution-graphics capability of the computer, although not in real time. The chief requirements for using the system in this way would be a knowledge of 6502 assembly/machine language, microcomputer interfacing, and the Apple hardware. Given the extremely specialized nature of your application, doing it yourself may be the most practical approach.

If you are unable to handle the hardware/software required, I suggest contacting local users groups. These groups frequently contain highly skilled assembly language programmers and hardware interfacers who would be willing to assist you.

A system to display voice waveforms can be made from a microphone, a suitable adjustable preamplifier/amplifier, and an oscilloscope. A bit of research in a local library should provide specific circuits and methods.

Some additional sources of information and inspiration you might find useful:

An article in the April 1984 issue of BYTE by Richard C. Hallgren ("Putting the Apple II Work, Part I: The Hardware") describes a high-speed data acquisition and analysis system for the Apple. This is a more general form of what you are trying to do, minus the display. This issue has several articles on real-time data acquisition that contain valuable information.

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

Lancaster, Donald E. Don Lancaster's Micro Cookbook, Vol. 2 *(Howard W. Sams, 1983)*

Lancaster, Donald E. Assembly Cookbook for the Apple II/IIe *(Howard W. Sams, 1984)*

Sather, James. Understanding the Apple IIe *(Quality Software, 1985)*

Titus, Jonathan S., David Larsen, and Christopher A. Titus. Apple II Interfacing *(Howard W. Sams, 1981)*

Titus, Jonathan S., Christopher A. Titus, and David Larsen. Microcomputer–Analog Converter Software and Hardware Interfacing *(Howard W. Sams, 1978)*

Goldsbrough, Paul, et al. Analog Electronics for Microcomputer Systems *(Howard W. Sams, 1983)*

—Steve

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

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

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

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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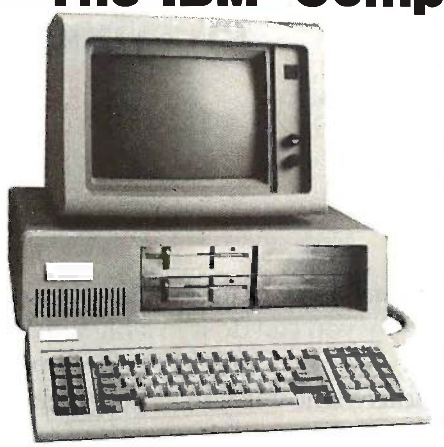

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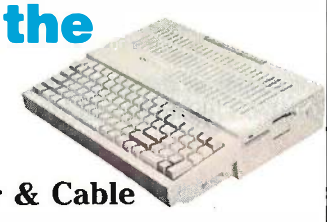

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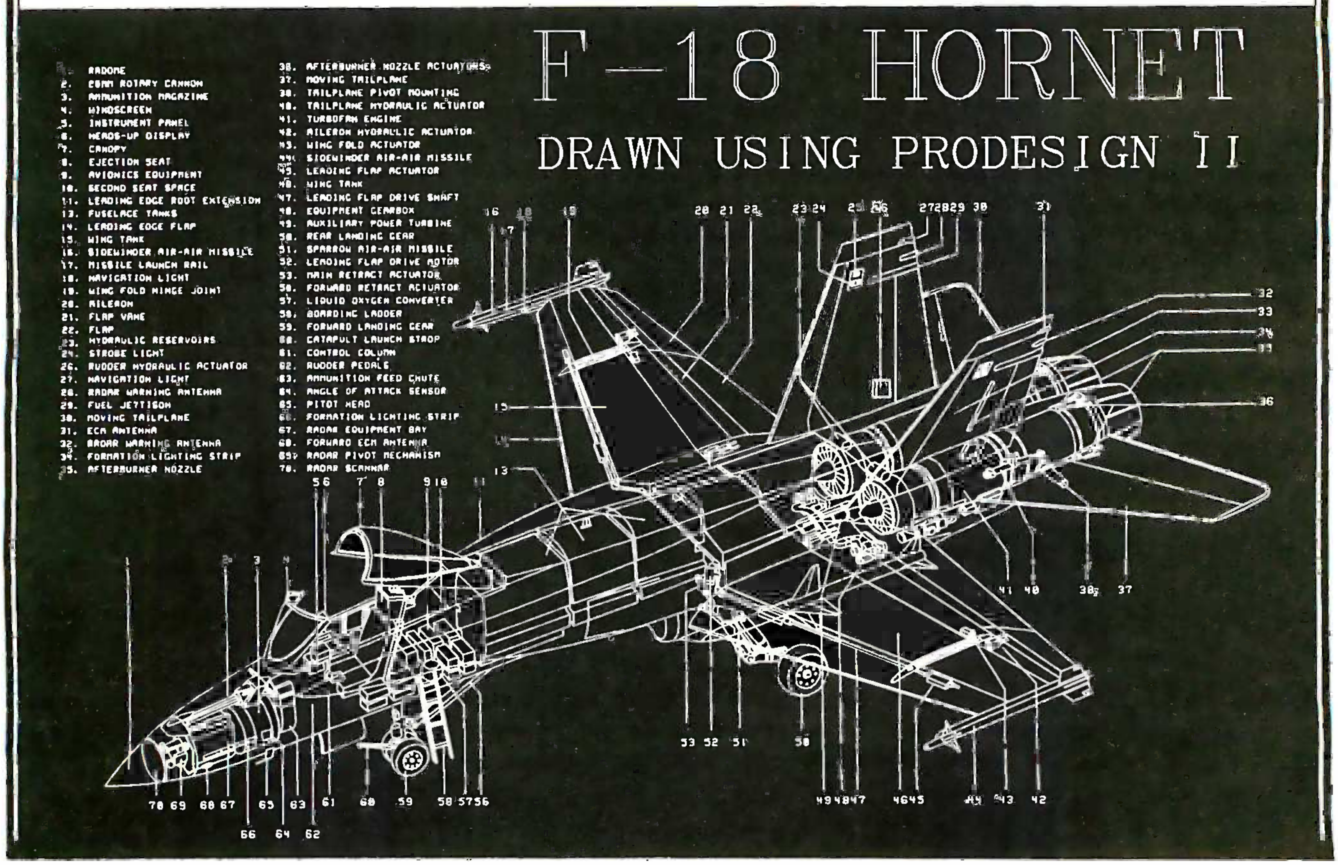

THE C++ PROGRAMMING LANGUAGE
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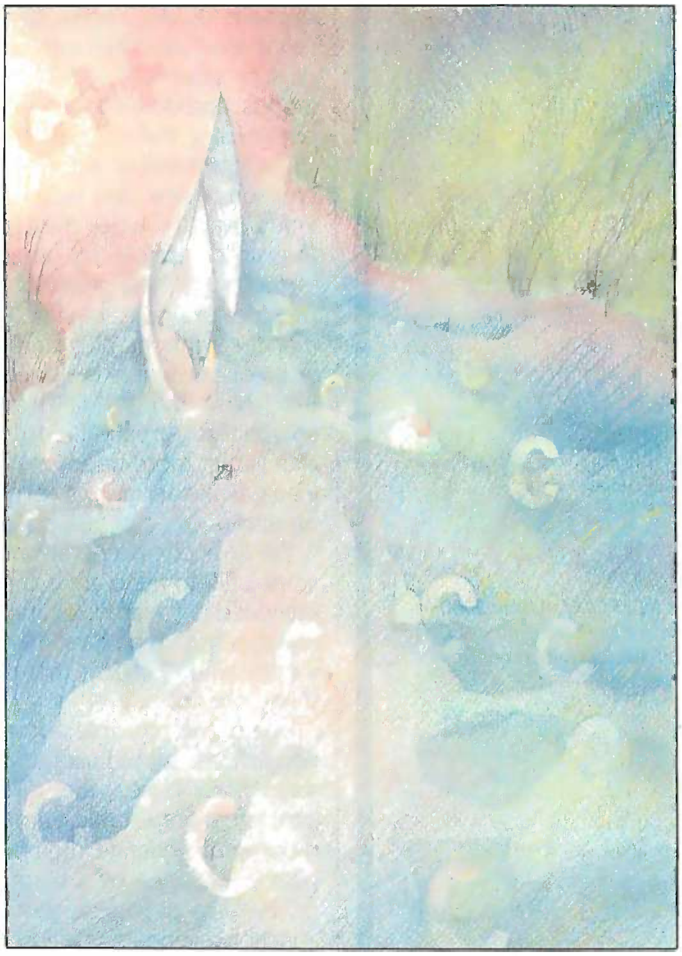

THE C++ PROGRAMMING LANGUAGE

Reviewed by
G. Michael Vose

One of the tenets of evolutionary theory states that changes in the environment cause subtle mutations in an organism that transform it into a new organism. The changing nature of the hardware environment of computers causes an analogous evolution of programming languages. Bjarne Stroustrup's *The C++ Programming Language* describes one recent language mutation.

Following the example of its parent, Brian W. Kernighan and Dennis M. Ritchie's *The C Programming Language* (also known as K&R or the "white" book), this book defines the superset of C called C++. Both books provide multiple-chapter tutorials for their respective languages as well as the languages' official reference manuals. Both contain examples and exercises for readers to solve.

Stroustrup's book assumes a familiarity with C (referring the beginning reader to K&R) but is nearly 100 pages longer than the white book. C++ adds considerably to the complexity of an already obtuse lexicon. Furthermore, C++ provides the tools to allow an object-oriented approach to programming in C.

Evaluating a book like Stroustrup's is difficult because microcomputer implementations of C++ are just becoming available (see the What's New section). I have no concrete experience with the language and no facility for using the tutorial sections of the book. Therefore, the judgments I can make are limited to two areas: Does the book adequately describe the concepts of C++, and do the C++ extensions seem useful? The historical significance of both the book and the language will have to wait for the judgment of some future reviewer.

People familiar with C instantly recognize the significance of the name C++. C's increment operator is symbolized using two plus signs (++). The suggestion is that C++ increments the power of the language, and this is certainly true. But for many C programmers, adding new constructs takes a back seat to fixing some of the awkward aspects of the original language. The authors provide some of these fixes.

Programmers enjoy using C because of the freedom of expression it provides due to a rich set of operators and great flexibility in declaring and manipulating data types. C++ increases this freedom substantially by offering additional data types and constructs that permit programmers to more easily build complex data structures (a process known as data abstraction). The emphasis in C++ is on types and structure.

(continued)

ILLUSTRATED BY MARGERY MINTZ

For example, you create objects by using the class declaration. Objects have common characteristics, and the definition of objects in a class specifies how they behave, how they get created and destroyed, and how they can be used and manipulated. Therefore, a class is a type, but a type defined by the programmer. While an int or a char have definitions imposed by the compiler, a class and the objects that are instantiations of that class are under your control.

Classes have many unique characteristics; the internals of a class can be made invisible to the rest of the program or made public, known to the program (a public class is just a structure); class internals can be hidden from the rest of a program but still known to data types declared as friends; and derived classes permit adding to a class without revising the source code or recompiling.

The emphasis of the extensions of C++ is on the easy creation of new data types. Secondarily, C++ classes provide a way to "hide" data to make it invisible, and therefore uncorruptible, by other parts of a program.

How might these powerful new types be used? Stroustrup provides examples of simple classes that manipulate sets, manage symbol tables, and manipulate a stack. You might well wonder if there is a price to pay for this ability to create new types and if it will lead to programs voluminous in source text. Apparently not, according to Stroustrup, who claims that more freedom of expression in creating types leads to economy of expression and slightly shorter programs.

The C++ compiler is actually a translator that uses a C++ source file to generate a C source file that can in turn be compiled into an executable file. The C++ translator features strict type checking at the translation stage, offering the kind of checks that previously required a separate utility like lint.

One of the principal advantages of C++'s data abstraction richness is modularity. Since you can build objects, software "black boxes" that take an easily defined input and generate a predictable output, teams of programmers can more easily generate large programs. AT&T's new Ada compiler was written by a team of programmers using C++.

C++ also provides operator and function overloading. Function overloading allows the multiple definition of a function. You can define the function foo( ) so that it acts differently when passed an integer argument than when passed a character argument. Overloaded operators permit the definition of how an operator affects a data stream. For example, addition of integer and real numbers is defined in C++, but addition of complex numbers is not. You can overload the addition operator by declaring its effect on the combining of a real number and a complex number with syntax similar to that of a data declaration.

FIXING C

For many programmers, the intrinsic object orientation of C++ is less important than its streamlining of C. As the theme articles of this issue relate, object-oriented programming as a paradigm for conceptualizing problems is still

(continued)

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in its infancy. Smalltalk showed the way for an object-oriented approach to programming, but implementations of it and other object-oriented languages have been too slow to be useful or are restricted in some other way.

Does C++ fix enough of C's problems to warrant its adoption independent of its object-oriented extensions? Probably not. C++ does provide for single-precision floats, adds enumerated and constant types, and comes with a stream-oriented I/O library that simplifies I/O for UNIX programmers (unfortunately, the stream.h library itself is written in C++ and cannot, at present, be used in regular C programs). But in order to be a superset of C, C++ had to retain the original syntax and organization of its predecessor; C++ could not differ markedly from C and still translate existing programs.

There are significant lexical improvements in C++. Unlike macros, the constant data type follows normal C scoping rules. Two new keywords, new and delete, eliminate the need to use malloc( ) and free( ), simplifying the management of memory. Using classes eliminates the need for typedefs. C++ even lets you specify default values for arguments to a function so that the function can be called without argument values.

PURPOSE SERVED

As a study of sophisticated data structures, *The C++ Programming Language* makes interesting reading. For example, C++ permits the use of virtual functions, those that use the same name with the proper function chosen by the program according to an input parameter. A class Shape using a function Draw( ) might have virtual functions for the derived classes of Shape called Circle and Square. Each of these classes has its own function Draw( ), and the program employs the one necessary to do Circle or Square, depending on which is called.

A couple of things confused me as I delved into this book. First, Stroustrup calls attention to a new stream I/O library that comes with C++ and uses its conventions in his example programs right from the beginning of the book. Without a more detailed explanation of the stream I/O functions (which doesn't occur until the final chapter), I had trouble following the examples. While the stream I/O syntax of C++ is much cleaner than that of C, I missed not seeing familiar functions like printf( ) in the early examples. Second, I found Stroustrup's use of the jargon of C++ (classes, friends, references, derived classes) distracting because he tends to use these terms before defining and explaining them.

Another legitimate question to ask about this book is, Will AT&T try to push C++ as the next incarnation of C? If so, will the rest of the world follow? It seems more likely that the world will follow the ANSI/ISO standard that is nearing completion and that may be in place by mid-1987. The standard does provide some of the extensions of C++, but it falls far short of implementing its major facilities, like classes and stream I/O. C++ may turn out to be only an interesting curiosity, not the next evolutionary stage of C.

However, C programmers embarked on an object-

(continued)

oriented programming odyssey and others interested in object-oriented languages should investigate this book.

Because the style of Stroustrup's exposition approximates that of his colleagues Kernighan and Ritchie, I expect that there will be an outpouring of books on C++ if it catches on, just as there has been on C. A rich and complex language needs much explanation.

G. Michael Vose is a senior technical editor at BYTE *(One Phoenix Mill Lane, Peterborough,* NH 03458).

ADVANCED PROGRAMMER'S GUIDE TO UNIX SYSTEM V

Reviewed by Gary D. Kendall

Advanced Programmer's Guide to UNIX *System V* by Rebecca Thomas, Lawrence R. Rogers, and Jean L. Yates summarizes material also found in the *UNIX System Administrator's Manual, Text Processing Guide, Program Development Tools Manual,* and the *System Utilities Manual.* If you have access to these manuals, you may not be interested in this book, although the examples may prove helpful to you. But if you are in the unfortunate position of having to work on a UNIX system without benefit of the accompanying manuals, this book will give you the information you need to develop useful programs on a UNIX system. Although the authors deal with some aspects of UNIX that could be considered advanced, such as signals, named pipes, semaphores, and shared memory, the abundance of program examples makes the book a good tutorial introduction to programming on UNIX System V.

From reading the preface, I have the impression that most, if not all, of the book, including the sample code, was written by Lawrence Rogers with Jean Yates as technical consultant, and that Rogers is somewhat new to UNIX. I could find no mention of Rebecca Thomas anywhere (except on the cover). It also seems that Rogers's programming experience is based in FORTRAN. This is evidenced by his use of nested if. . .else statements instead of a switch, by his heavy use of subscripts as array indexes rather than pointers, and by his use of the word "subroutine" when making reference to a function. I found his style of coding very difficult to read at best.

TOPICS COVERED

The book explains the operation of the UNIX kernel and the structure of the file system. Yet the diagram on page 19 of the book, which illustrates the mounting of a file system on a directory, is in error. The mount directory (/usr) is shown to belong to the file system being mounted, when actually it is a part of the root file system. Later, in the section describing the sequence of events from boot to log-in, there is no mention of the execution of the /etc/rc, /etc/profile, and /etc/login scripts. This is an unfortunate omission, since the user can modify these scripts to include such things as the mounting of file systems, the initialization of demons, and the maintenance of spooling

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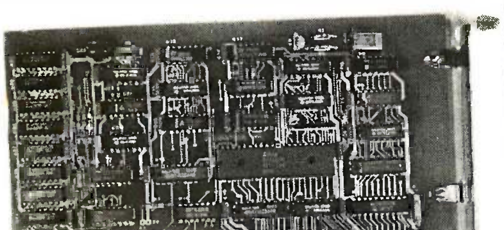

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directories and log files.

There are chapters on the interactive use and programming of the shells, /bin/sh and /bin/csh. The sample scripts should be read carefully where the command substitution operator (`) is involved. At first glance, these characters appear to be single quote marks ('), but a close examination shows the difference. A different choice of font for the sample code could have removed this ambiguity, because the font used in the text portions clearly shows the difference. Moreover, on page 527, figure 9.L.3 is purported to be a csh script but is actually written in the language of sh (the Bourne shell).

The rest of the book deals with the use of the vi and ex text editors, the C compiler, and the make and ar utilities for creating software tools. Thomas, Rogers, and Yates expound some design philosophies in UNIX programming, which should help you in the creation of error-free programs, but they do not always follow them. The authors, however, always follow the "one exit" philosophy (often associated with structured programming); unfortunately, it's at the expense of readability of the code. Moreover, the authors state that software tools should handle multiple file specifications to encourage the use of the shell's filename expansion metacharacters, but the program for line numbering accepts only one file argument and cannot be made to read the standard input, so it cannot be used as a "filter" in a pipeline. There are chapters covering the use of the standard library functions and system calls, with emphasis on the new System V interprocess communication features. The examples of how to use these will be a boon to System V neophytes and may prove helpful to experienced UNIX programmers also.

While this book contains some very worthwhile information, I don't recommend it as a substitute for the full set of System V documentation. In conjunction with the UNIX documentation, however, it would be very appropriate as a tutorial guide to UNIX programming.

Gary D. Kendall (Creative Computing, 96 Forest St., Danvers, MA 01923) is a consulting systems analyst/programmer who specializes in operating systems.

MIND OVER MACHINE

Reviewed by Stan Czarnik

In *Mind Over Machine*, Hubert and Stuart Dreyfus contend that traditional digital computers can never be programmed to produce genuine artificial intelligence because they cannot replicate intuition. Educators and business people who believe otherwise, they claim, are in for disappointment, if not catastrophe. The argument thus feeds on a mix of pessimistic prognosis and it-ain't-gonna-work-anyway philosophy.

Common Sense and Expertise

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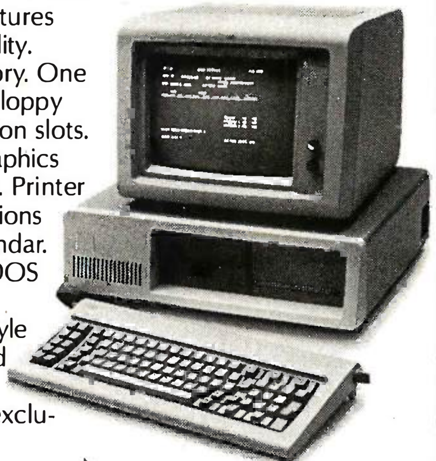

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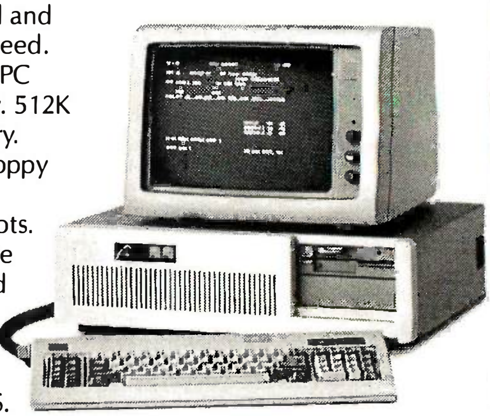

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fashion. On/off, yes/no, true/false—any kind of digital symbolic representation can be processed in a conventional computer with swift and sure logical precision. *Mind Over Machine* is an elaboration of the idea that while human understanding avails itself of the power of logical reasoning, logical reasoning fails to account completely and consistently for how people actually think.

For example, consider everday visual identification. Recognizing the face of a friend in a crowd instantaneously seems to require no conscious analysis of the presence or absence of individual physical facts or traits. Spotting someone you know is, apparently, just that. Recognition does not follow neatly logical chains of reasoning, at least none that we know of. According to the authors, this involves no little packages of binary information, no computerlike processing at all. What occurs, in fact, is an intuitive leap from one holistic state of being out in the real world to an equally holistic counterpart stored as an image in the mind and formed from past experience. Traditional computational techniques cannot easily simulate this kind of mental picture matching. If the limits of logic are the limits of AI, then conventional AI is in for a long hard climb. The formal representation of knowledge that resists formalization is a complicated and difficult task.

Professional expertise is another example. The authors explain why the mechanization of human expertise with conventional AI technology is neither possible nor desirable. Imagine a seasoned driving instructor with a new student. The rules of the road are systematically described and explained: Don't speed, don't pass on the right, don't go through red lights, and so on. Now imagine the same instructor rushing an injured child to the hospital: He passes on the right, goes through all the red lights, speeds like crazy, and gets the car to the emergency room without a scratch.

So how does he do it? The Dreyfuses would say that our anxious expert driver who knows all the rules is not following any rules. He's just driving, with most of his behavior guided not by reference to a calculated collection of factual material on automobiles and traffic laws, but by intuition. And so it is with all human experts, from chess masters to virtuoso jazz pianists. There is, the authors claim, a qualitative difference between the rule-following behavior of any novice, like someone learning to use a typewriter, and how any true expert implements his or her expertise. Consider an experienced touch-typist zipping along at 60 words per minute while thinking about something entirely different.

MICROPROCESSING THE MIND

The final chapters of the book focus on the social and pyschological ramifications of computerized expertise. The automation of education receives first priority: The authors sense a serious danger here. If this trend is permitted to continue in our schools, we can look forward to a twenty-first-century population of maladjusted logic choppers. To whatever extent digital computers are allowed to replace human teachers, the chances of students going beyond

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the mechanical rule-following phase of instruction and on to genuine mastery and expertise may deteriorate. Logic in, logic out, and nothing more: "Thinking like a computer will retard passage to the higher levels of proficiency and expertise." The problem of Why Johnny Can't Read may become Why Johnny Has No Expert Intuition. But how many concrete cases of computer retardation are the Dreyfuses able to cite? Not one.

They argue that veteran business professionals do not typically reason their way through predicaments in any purely detached, objective, structured manner. The decision-making process is driven not by logic but by a close "intuitive understanding" of the problem at hand. Since computerized expertise can be neither involved nor intuitive, it follows that automated decision support systems may not improve but may actually "degrade performance" and encourage "regressive thinking." Yet here again, how many real degraded performances and regressive meditations can the authors find? None.

INTO THE FUTURE

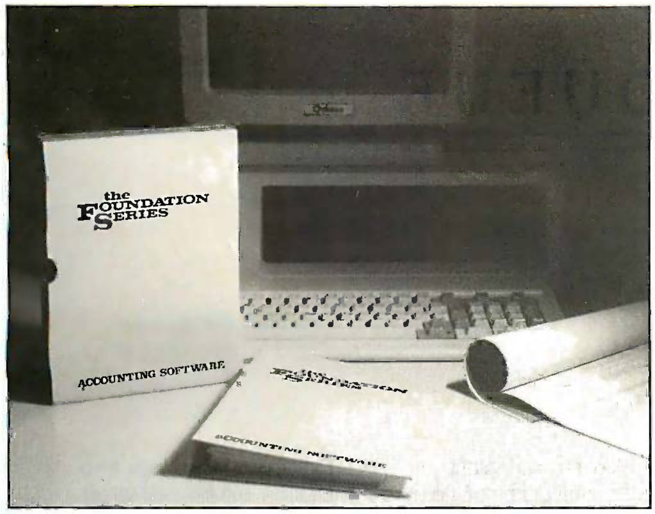
Intuitive forms of judgment and comprehension do exist. But the question remains, What is intuition and how does it work? With the exception of a few pages, the authors tend to avoid the issue. The closest they come amounts to saying that since human thinking seems often to involve holistic visual imagery, then perhaps the mind is like a holographic pattern recognizer. Without rules, features, or descriptions, we sense similarity by matching mental pictures. This accounts for the instantaneousness of so much intuitive thought. *Mind Over Machine* makes it plain that experimentation is only beginning to shed light on how a holographic mind might operate.

The Dreyfuses are careful to leave the back door open for massive parallel networks and the "connectionist" approach to computer architecture. The basic point: Computational models that permit many things to happen at once in a dynamic weblike configuration in which relations among elements are changing seem much closer to how the brain functions than traditional von Neumann designs.

It is of the utmost importance to note that *Mind Over Machine* is not about "what computers can't do." Not quite. It's mostly about what *conventional* computers can't do and a well-worded reflection on the problems AI researchers have been talking about for a long time. Hubert and Stuart Dreyfus successfully patch together a "sad history of artificial intelligence." However, the authors cannot extend their skepticism into the future. To articulate the limitations of traditional AI may serve to accelerate development in heretofore exotic technical areas.

The authors believe that current AI has been brought to a standstill, but their book itself contains evidence that the interlude may be coming to an end. *Mind Over Machine* is a crucially important book, and no one interested in the destiny of artificial intelligence, or our technological way of life in general, can afford to miss it.

Stan Czarnik is a teacher, musician, and technical writer. He can be reached at 2716 West Evergreen Ave., Chicago, IL 60622. ■



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UNDERSTANDING DATA COMMUNICATIONS—A PRACTICAL GUIDE, various sites throughout the U.S. Data-Tech Institute, Lakeview Plaza, P.O. Box 2429, Clifton, NJ 07015, (201) 478-5400. *August*

APPLYING MACHINE VISION TO YOUR MANUFACTURING PROCESS: A HANDS-ON WORKSHOP, Cambridge, MA, and Minneapolis, MN. Joanne Rogers, Society of Manufacturing Engineers, One SME Dr., P.O. Box 930, Dearborn, MI 48121, (313) 271-0039. *August–September*

DATA COMMUNICATIONS: NETWORKING, PROTOCOLS, AND COMPATIBILITY; LOCAL NETWORKS; TELECOMMUNICATIONS; and related courses, various sites throughout the U.S. Datapro Research Corp., Educational Services, 1805 Underwood Blvd., Delran, NJ 08075, (800) 328-2776. *August–October*

WRITING PROCEDURES, POLICIES, AND DOCUMENTATION, Boston, MA. Mary Ann Cluggish, Information Mapping Inc., 275 Wyman St., Waltham, MA 02154, (617) 890-7003. *August* 4–8

1986 NATIONAL PROFESSIONAL ELECTRONICS CONVENTION, Tropicana Hotel, Las Vegas, NV. NPEC '86, 2708 West Berry St., Fort Worth, TX 76109, (817) 921-9061. *August* 4–9

INTERNATIONAL CONFERENCE ON COURSEWARE DESIGN AND EVALUATION (ICCDE), Tel Aviv, Israel. Benjamin Feinstein, ICCDE Organizing Committee, Israel Association for Computers in Education, P.O. Box 13009, Hakirya Romema, Jerusalem 91130, Israel, telephone: 521930; telex: 361931 HUAGR IL, ATTN FEINSTEIN. *August* 8–13

24TH ANNUAL CONFERENCE OF THE URBAN AND REGIONAL INFORMATION SYSTEMS ASSOCIATION: WHAT'S THE DIFFERENCE? Marriott Hotel, Denver, CO. URISA, 319 C St. SE, Washington, DC 20003, (202) 543-7141. *August* 9–14

ADVANCED RECORDS MANAGEMENT, Washington, DC. Darold Aldridge, Continuing Engineering Education, The George Washington University, Washington, DC 20052, (800) 424-9773; in DC, (202) 676-6106; in Canada, (800) 535-4567. *August* 11–12

DESIGN AND MANAGEMENT FOR EFFICIENT SOFTWARE DEVELOPMENT, Milwaukee, WI. John T. Snedeker, Center for Continuing Engineering Education, University of Wisconsin-Milwaukee, 929 North Sixth St., Milwaukee, WI 53203, (414) 224-4193. *August* 11–15

NATIONAL CONFERENCE OF THE AMERICAN ASSOCIATION FOR ARTIFICIAL INTELLIGENCE, University of Pennsylvania, Philadelphia, PA. AAAI-86, AAAI, 445 Burgess Dr., Menlo Park, CA 94025-3496, (415) 321-1118 or 321-3123. *August* 11–15

THIRD INTERNATIONAL ROBOTIC SYSTEMS EDUCATION AND TRAINING CONFERENCE, and MACHINE VISION FOR EDUCATORS: A HANDS-ON CLINIC, Plymouth, MI. Mary Dombrowski, SME Special Programs Division, Society of Manufacturing Engineers, One SME Dr., P.O. Box 930, Dearborn, MI 48121, (313) 271-1500, ext. 392. *August* 11–15

MACWORLD EXPO, Bayside Exposition Center, Boston, MA. Mitch Hall Associates, P.O. Box 155, Westwood, MA 02090, (617) 329-7466. *August* 14–16

FOURTH ANNUAL HAM & CHIP FLEA MARKET, La Salle University parking lot, Philadelphia, PA. Philadelphia Area Computer Society, 20th and Olney Ave., Philadelphia, PA 19141, (215) 951-1225. *August* 16

SIXTH ANNUAL NOTRE DAME SHORT COURSE SERIES: COMPUTERS IN BIOLOGY, Notre Dame, IN. Ronald A. Hellenthal, Biocomputing Short Courses Coordinator, Department of Biological Sciences, University of Notre Dame, Notre Dame, IN 46556, (219) 239-7255. *August* 17–22

EFFECTIVE ANALYSIS AND DESIGN OF INFORMATION SYSTEMS, Worcester, MA. Kathy Shaw, Office of Continuing Education, Worcester Polytechnic Institute, Higgins House, Worcester, MA 01609, (617) 793-5517. *August* 18–20

ACM SIGGRAPH 86: 13TH ANNUAL CONFERENCE ON COMPUTER GRAPHICS AND INTERACTIVE TECHNIQUES, Dallas Convention Center, Dallas, TX. Conference Management, Smith, Bucklin and Associates Inc., 111 East Wacker Dr., Chicago, IL 60601, (312) 644-6610. *August* 18–22

INTRODUCTION TO TELECOMMUNICATIONS, Cambridge, MA. Charlotte Scannell, Lesley College Graduate School, Division of Education and Special Education, 29 Everett St., Cambridge, MA 02238-9990, (617) 868-9600. *August* 18–22

COMPUTERFEST '86, Dayton, OH. Computerfest '86, Dayton Microcomputer Association, 143 Schloss Lane, Dayton, OH 45418-2931, (513) 268-7225. *August* 23–24

TIDEWATER VIRGINIA 11TH ANNUAL COMPUTER FAIR–RADIO AMATEUR HAMFEST, Pavilion, Virginia Beach, VA. Manny Steiner, 3512 Olympia Lane, Virginia Beach, VA 23452, (804) 340-6105. *August* 23–24

RED ROSE FOURTH ANNUAL COMPUTERFEST, Guernsey Sales Pavilion, Lancaster, PA. Computerfest Committee, P.O. Box 5029, Lancaster, PA 17601. *August* 31 ■

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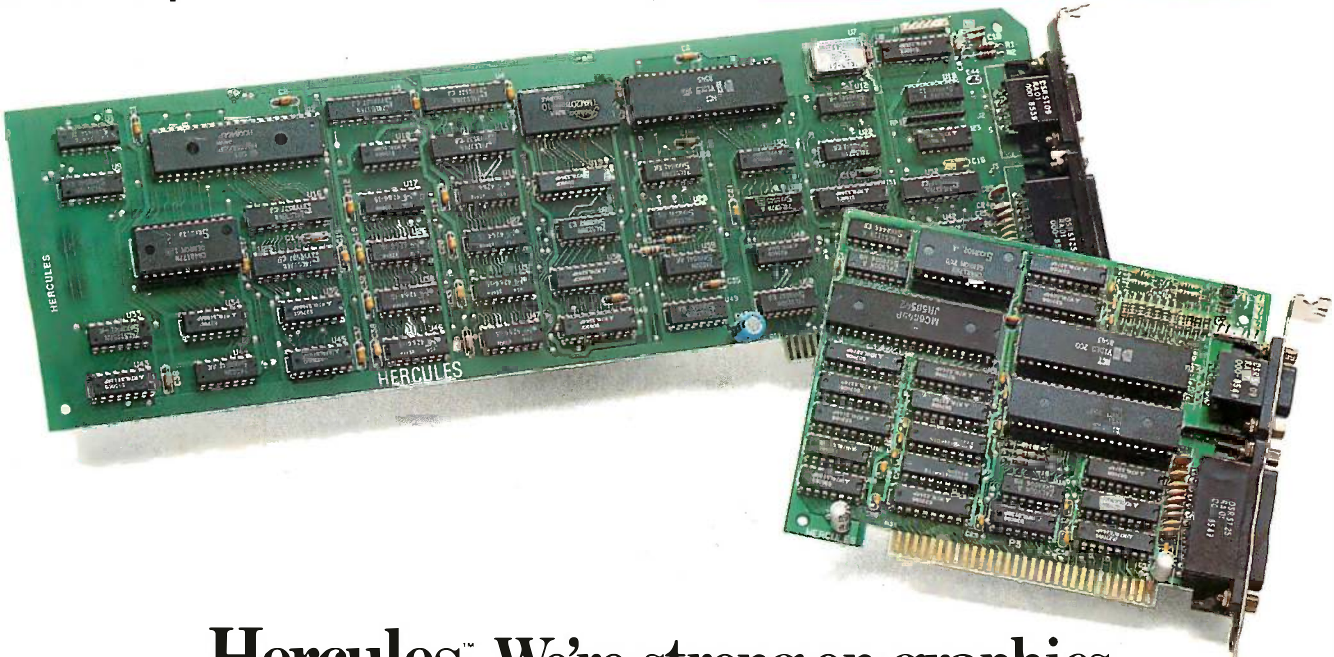

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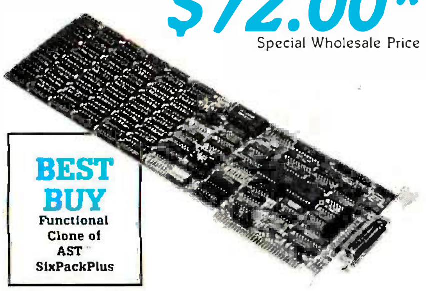

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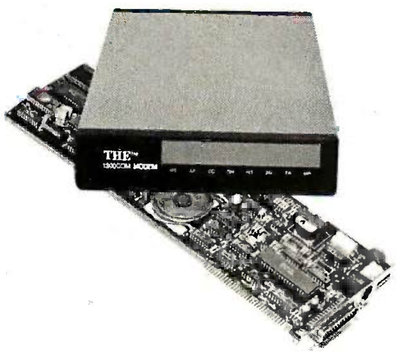

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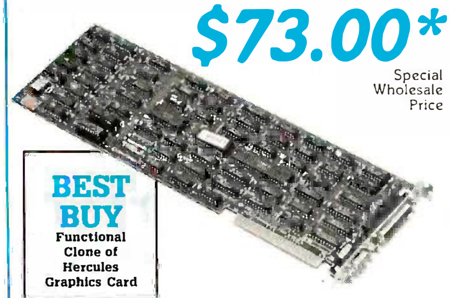

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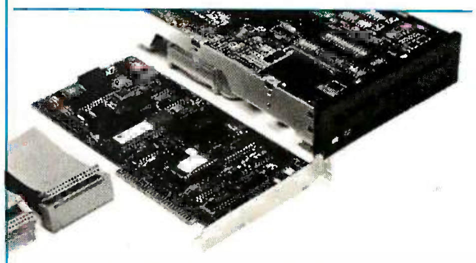

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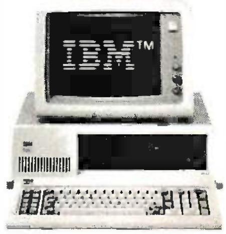

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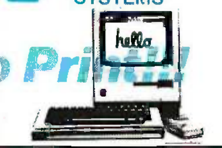

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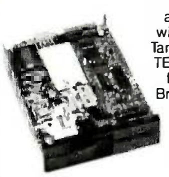

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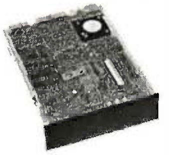

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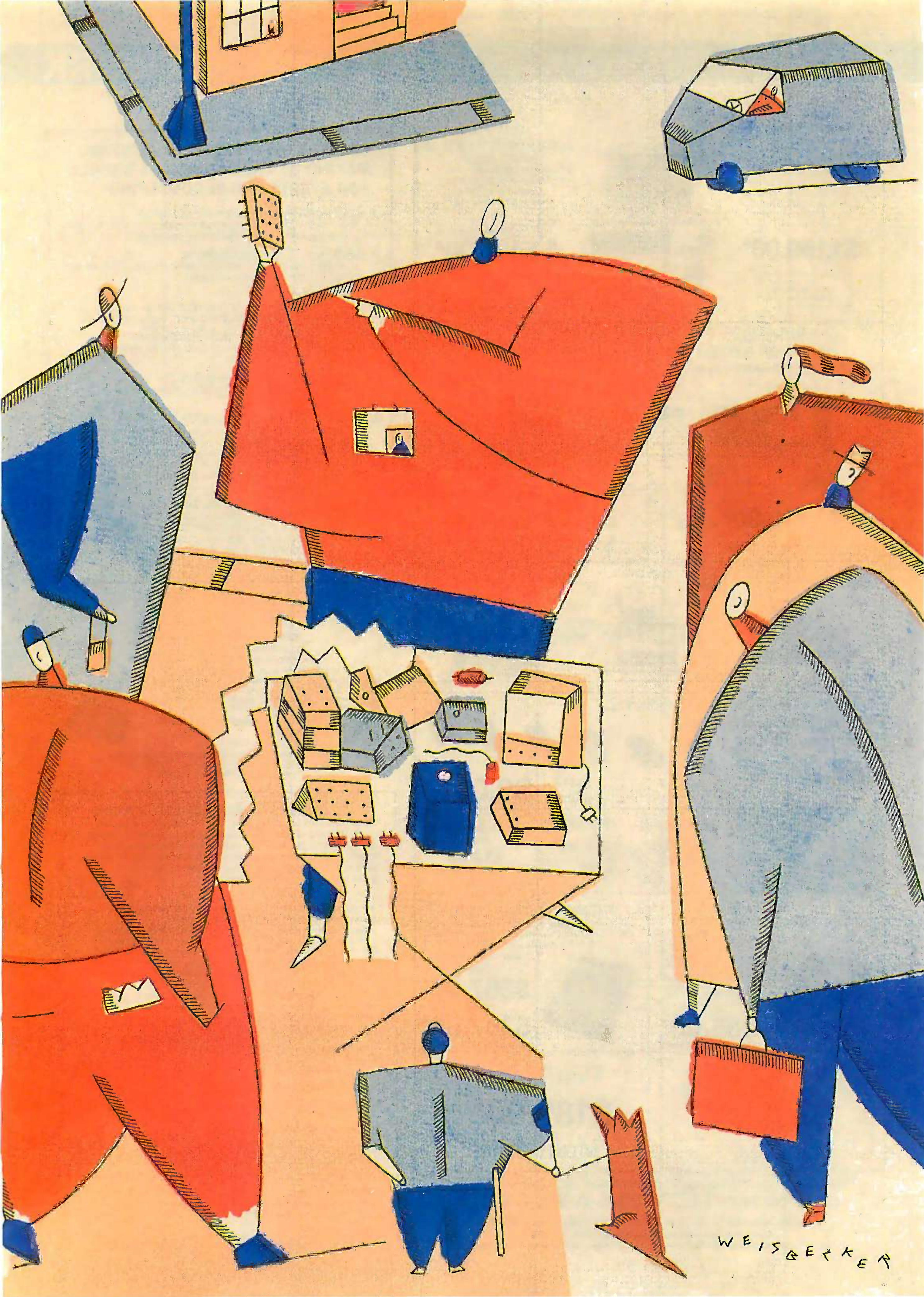
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Features

SUPPOSE YOU WERE ABOUT TO START on a long car trip, but the road atlas in the trunk was soggy and all you could salvage was a large table of distances between cities. Rob Spencer tackles this interesting problem in "Similarity Mapping" by using a Microsoft BASIC program for the Macintosh that creates "maps" from distance or difference data.

Two features this month are conclusions of two-part articles. Steve Ciarcia concludes his discussion of parallel interfacing in the Circuit Cellar by looking at a number of interface adapters and suggesting applications for them. Steve doesn't have the space to give a complete functional description of each adapter. Instead, he points out their significant differences. Steve hopes this two-part article will answer many of the interfacing questions he receives. In part 2 of "The Definicon 68020 Coprocessor," Trevor Marshall, Christopher Jones, and Sigi Kluger focus on the software available for the DSI-020 coprocessor board for IBM XTs, ATs, and work-alikes.

In honor of BYTE's 10th anniversary, a reception was held at the Boston Computer Museum. The guest speaker was Dr. C. A. R. Hoare, who chose the topic "Mathematics of Programming." It is Dr. Hoare's thesis that programmers should follow mathematical laws in the construction of programs. This type of construction would promise benefits in systems software, safety-critical programs, silicon design, and standards.

Finally, in this month's Programming Insight, "Polar Normal Distribution," Alain Latour explains the "polar method" of generating normal deviates and evaluating the cumulative probability of a normally distributed random variable.

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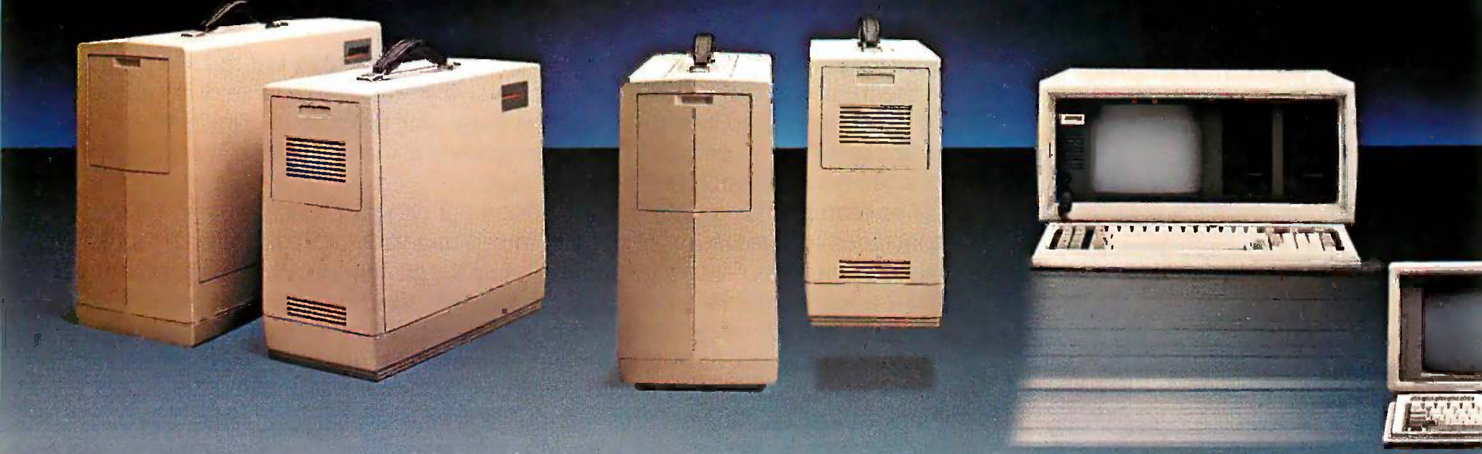

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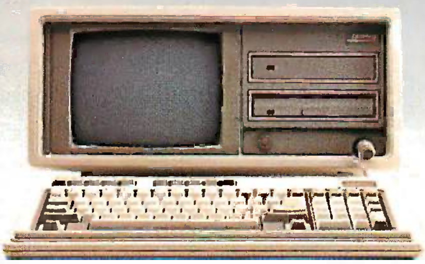

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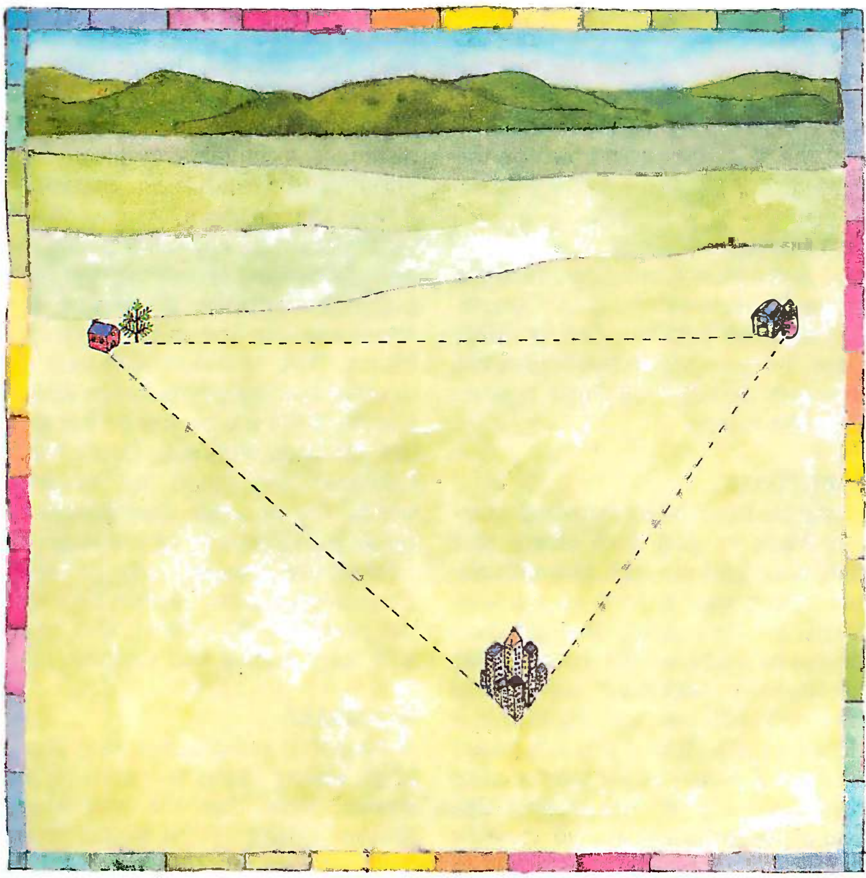
BY ROB SPENCER

SIMILARITY MAPPING

A Macintosh program that creates "maps" from tables of distance data

Imagine that you're about to start a long car trip, but you can't find the maps. After a frustrating search, you find a road atlas in the trunk of the car—but it's soggy and torn, and only the last page is legible. All you have on that page is a big table of distances between cities. Can you recreate a good map from that distance table?



In another scenario, let's say you're a market researcher about to make a presentation. You have lots of data from supermarket taste tests in which people tried to tell the difference between your brand of soft drink and the other major brands. Is there a succinct and accurate way to present all these results without showing a huge table of numbers?

Finally, suppose you design printed circuit boards. You know what chips you need to do the job and how they're connected. Is there a method that will suggest the layout of the board so as to minimize signal path distances and the need for jumpers?

These problems have a common theme: They start with a large set of known *distances* (or, conversely, *similarities*), and they seek a graphic solution in the form of a *map*. In this article I'll present an algorithm and a program to solve such problems. The technique is called *multidimensional scaling*, but I prefer the term *similarity mapping*.

I wrote the program Mapper in Microsoft BASIC 2.0 (binary version) for the Macintosh, and it demonstrates the language's avoidance of line numbers, reference by name, potential for Pascal-like structure, and use of the Mac's mouse-driven menus, dialog boxes, and buttons.

OVERVIEW OF THE METHOD

Similarity mapping has four major parts: input of the data, generation of

(continued)

Rob Spencer (4230 Fieldgate Dr. #5, Mississauga, Ontario, Canada L4W 2M5) is a biochemist at Syntex Inc.

ILLUSTRATED BY FRANK BOZZO

Table 1: *The distances between nine major U.S. cities.*

	Boston	N.Y.	D.C.	Miami	Chicago	Seattle	S.F.	L.A.	Denver
Boston									
New York	206								
Washington, D.C.	429	233							
Miami	1504	1308	1075						
Chicago	963	802	671	1329					
Seattle	2976	2815	2684	3273	2013				
San Francisco	3095	2934	2799	3053	2142	808			
Los Angeles	2979	2886	2631	2687	2054	1131	379		
Denver	1949	1771	1616	2037	996	1307	1235	1059	

```
"Intercity distances"
9
Boston, NY, DC, Miami, Chicago, Seattle, SF, LA, Denver
206
429,233
1504,1308,1075
963,802,671,1329
2976,2815,2684,3273,2013
3095,2934,2799,3053,2142,808
2979,2786,2631,2687,2054,1131,379
1949,1771,1616,2037,996,1307,1235,1059
```

Figure 1: *The data file Cities, based on the information contained in table 1 and used by the program Mapper.*

an initial map, iterative refinement of that map, and generation of the display. These can be seen directly in the first main section of the program, which consists of eight sequential subroutine calls followed by a WHILE . . .WEND loop. Some of these subroutines, like Initialize and InputData, are part of any program. Some deal with more Macintosh-specific things: SetMenus, WaitForMenu, and HandleMenus. Two are for screen display: ShowTable and ShowMap. The *heart* of the algorithm and all of the mathematics are in the remaining subroutines, InitializeMap and RefineMap.

I'll go through the program in order, using the soggy road atlas problem as an example. The input data (table 1) consists of the distances, in miles, between nine U.S. cities. Since you know what the final map should look like, it's easy to tell if the program is working.

INITIALIZE

The first subroutine in Mapper, Initialize, sets up the screen (WINDOW, CALL TEXTFONT, etc.), defines several variables (R and Criterion are the most interesting; I will discuss them later), and defines the plotting functions (DEF FNPx, DEF FNPy) in a way that makes it easy to manipulate the map after it is drawn on the screen.

SETMENUS

The SetMenus subroutine creates a single pull-down menu titled Control. It has three options: Change Map, Show Table, and Quit. You control the program by selecting these options with the mouse.

INPUTDATA

Using the InputData subroutine, Mapper reads its data from simple text files. You can write such files with any word processor as long as you save them as "text only." The program begins by asking you to choose a data file from the "minifinder" box created by the FILES$ function. Figure 1 is a data file called Cities, which is based on table 1. Note that between *n* cities there are $n \times (n-1)/2$ distinct distances, as assigned to the variable NumPairs. (Thus, the nine cities in table 1 have 36 distances.) The names of the cities are assigned to Label$( ), and the distance between the *i*th and *j*th cities to both d(i,j) and d(j,i).

INITIALIZEMAP

As in many iterative techniques, the speed and stability of convergence to a final answer depend on having a good initial guess. The method I've used is an exercise in geometry as illustrated in figure 2. First, the program InitializeMap searches the distance table for the two most distant points; in the example these are Miami and Seattle, which are 3273 miles apart. These points now define the horizontal axis, and they're labeled j1 and j2 (figure 2a).

The program searches the distance table again for the next most distant point, in this case Boston, which is labeled j3. Boston is given the map coordinates (x(j3), y(j3)) such that the triangle formed by these three cities has sides of the correct lengths (figure 2b). Note that the program places Boston *below* the Miami–Seattle line; this is because the Macintosh, like most microcomputers, defines $(x,y)=(0,0)$ to be in the upper left corner of the screen. You can change the orientation and scaling of the map later; remember that the input data is just distances and there's no information about north, south, east, or west.

Now the program assigns *all* the other points. It assigns the *i*th city just as it did Boston, except that the city's placement above or below the Miami–Seattle line is no longer arbitrary. The decision is based on whether the distance between Boston and the point *p* is greater or less than the distance between Boston and (i)(below) (see figure 2c). In other words, the program uses Boston to break the symmetry of the map.

Finally, the program shifts the coordinates of all points so that (0,0) is at the center of the screen. This helps with later scaling and rotation.

SHOWMAP

A frequently called subroutine, ShowMap, simply draws the map on the screen. Note that the map coordinates x(i),y(i) of the points retain their units—in this case, miles. This is so that calculated distances and errors will have familiar units. The program does the conversion to screen units (i.e., pixels) with the functions FNPx and FNPy. The initial map from our example is shown in figure 3.

REFINEMAP

The iterative refinement of the map is done by the subroutine RefineMap. RefineMap consists mostly of a WHILE. . .WEND loop that calls the subroutine IterateMap to do the math; checks to see if you have selected a menu item, and, if so, goes to deal with it; draws the new map; and checks for convergence and exits appropriately. The map has converged if two successive iterations produce average errors differing by less than the variable Criterion, which I set at 0.2 percent.

ITERATEMAP

In forming the initial map, I gave the three most mutually distant points (Miami, Seattle, and Boston) special status; they were fixed, and all the other points were assigned relative to them. Now, in iteration, all of the points are allowed to move to minimize the error between the input distances d(i,j) and the calculated distances based on the current map coordinates. An analog computer equivalent of this would involve putting pegs in a pegboard at the initial guess coordinates, connecting each pair of pegs with a spring cut to the length d(i,j), cutting the pegs free from the board, and letting go! When the oscillations died down, you'd have a minimum-error map.

In IterateMap, moving the points is done in two nested FOR. . .NEXT loops by using the variables Dx(i) and Dy(i) to add up, as vectors, all the errors between each pair of points. These resultant vectors are then multiplied by R and added to the coordinates. Figure 4 shows the changes this makes in the first iteration; the cities move in various directions for various distances, all movements serving to improve the map. The constant R is analogous to the "stiffness" of the springs in the analog model. If R is too big (in my experience, more than about 0.2), the springs are too stiff, and the map will oscillate and may not converge. If R is too small, convergence will be very slow.

MANIPULATING THE MAP

Even though the map has converged, you may want to change it for presentation purposes or see the results in tabular rather than graphic form. The subroutines called in the final WHILE . . .WEND loop of the main program allow for this.

When you look at a road map, you usually put north at the top and west at the left—but, as mentioned above, there's nothing in the distance table data to suggest an absolute orientation. When you select Change Map from the menu, a panel appears (via subroutine ShowPanel) that allows you to reorient the map. Figure 5 shows this panel and the final map, after rotation (by 205 degrees) and ex-

(continued)

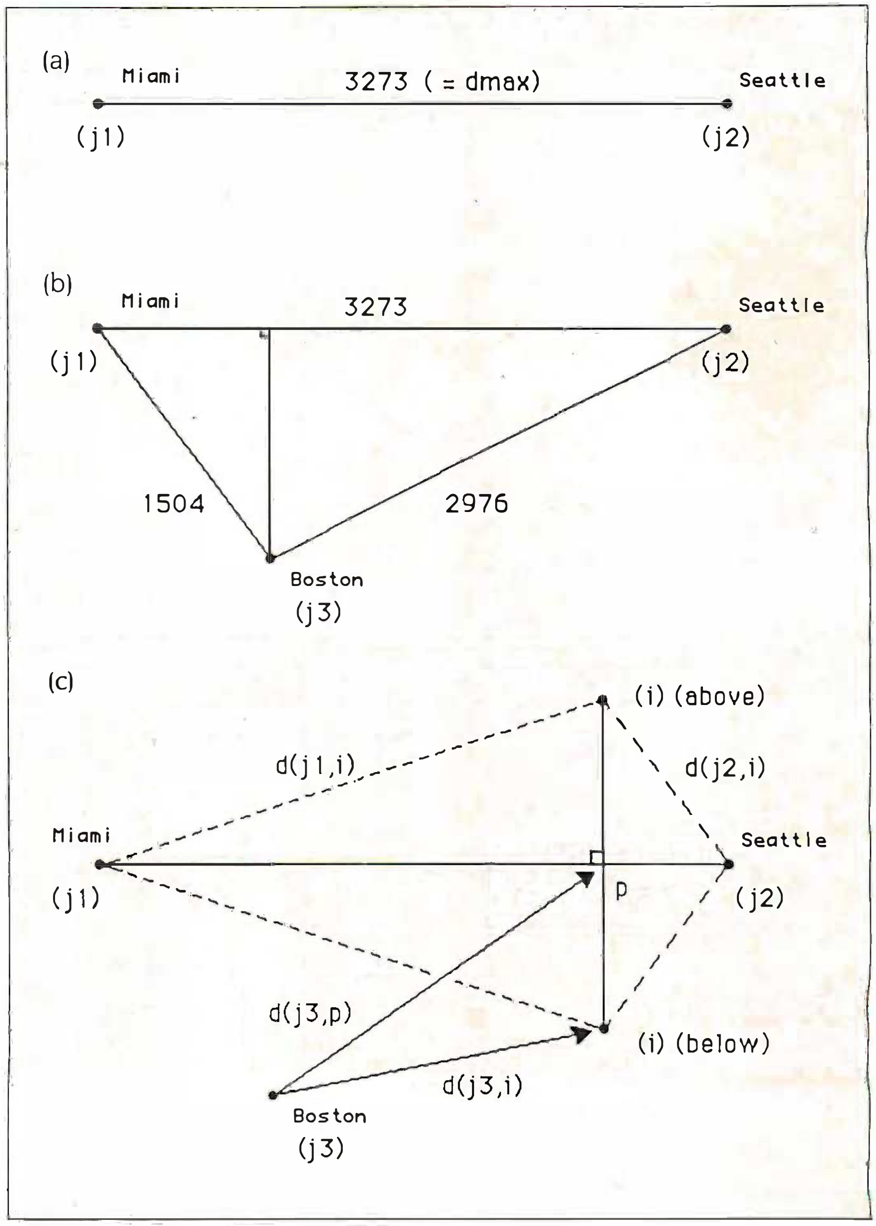


Figure 2: *The geometry used to construct the initial Cities map. (a) Mapper uses the pair of points that are the farthest apart to define the x axis. (b) It then places the next most distant point so that the triangle formed has sides corresponding to the correct distances. (c) Finally, the program places all other points relative to the first three.*

pansion to fill the screen.

The menu option Show Table gives the original distance table as well as the distances calculated from the map coordinates; it also shows the root mean square error, which for the Cities example is 33 miles.

I have not put any printer output statements in the program, but Command-Shift-3 will send a screen snapshot to disk, Command-Shift-4 will send it to the printer, and you could easily make a printed table by changing the subroutine ShowTable to have LPRINT instead of PRINT, or with PRINT#2 where file #2 is opened to the screen or the printer.

MISSING DATA AND ERROR LOCATION

Remember the soggy road atlas? Imagine further that even the distance table is torn up and that some of the distance values are missing. One bonus of similarity mapping is that it can give reasonable estimates *even for missing data.* Mapper makes provision for this: If any input distances are negative, the program treats them as unknowns in the iteration process. For example, if the data file lists the Washington, D.C., to San Francisco and the Chicago to Los Angeles distances (2799 and 2054 miles, respectively) as −1, and you run the program, the map converges normally. The calculated distances are 2804 and 1974 miles, errors of +5 and −80 miles, or +0.2 and −3.9 percent. If too many values are missing or the map isn't as intrinsically flat as in the Cities example, the initial map determination or convergence may fail.

Another advantage of similarity mapping is that it can find the likely sources of error in appropriate data sets. What if one input distance is very wrong—how could you find out which one? The program can easily be changed to show all the differences between input and calculated distances. A single difference that is much larger than the average might be due to experimental error. This sort of error finding might be useful in surveying, where the expected errors are small.

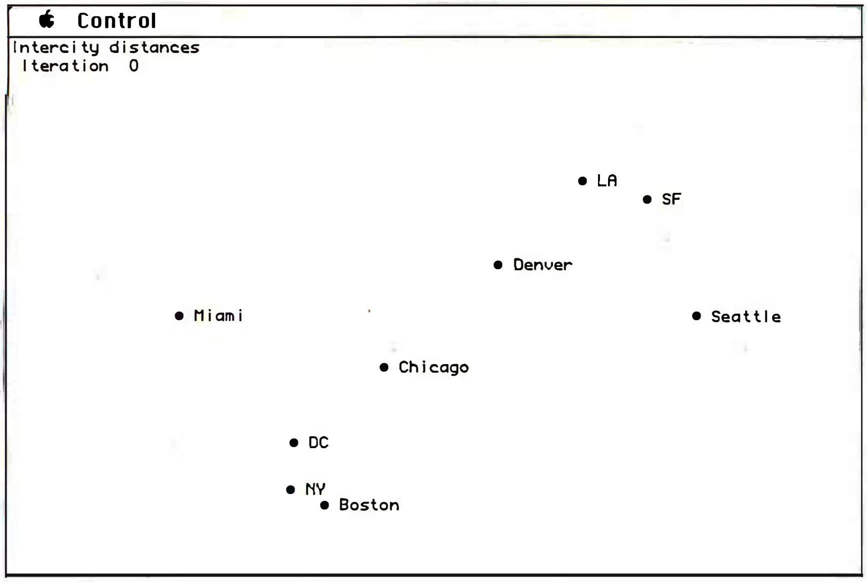


Figure 3: *The initial map drawn by Mapper using the Cities data file.*

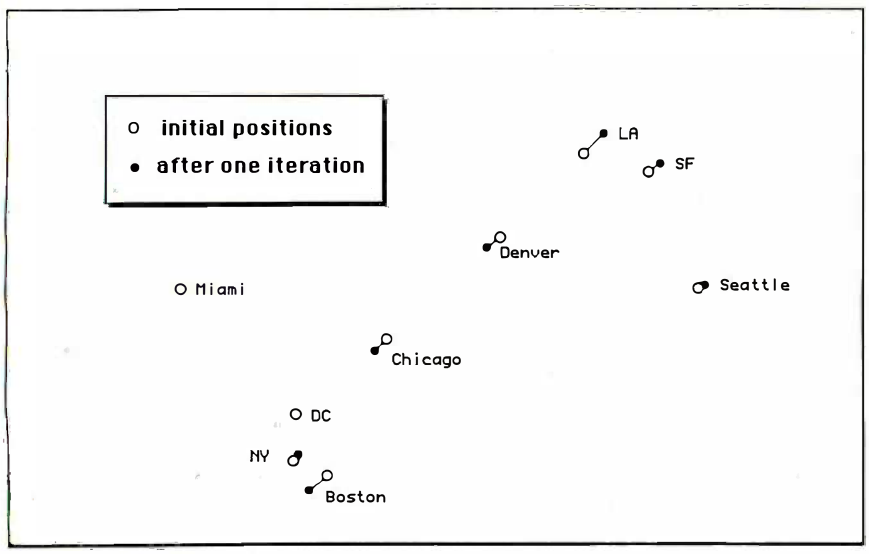


Figure 4: *The Cities map during iteration, showing the movements of the cities between the initial map (open circles) and the first iteration (filled circles).*

OTHER EXAMPLES: DEFINING DISTANCE

At the beginning of this article, I suggested three applications. The Cities example is quite intuitive, since we expect that the distances in the table should produce a good, flat map, and we're comfortable with distances measured in miles. How about the other examples? How do you define "distance" in the soft-drink marketing case or the circuit board design problem? Why should either of these produce a flat map?

How you define distance depends on the type of data available. In the marketing case, suppose that you ask the customers, "Which soft drink is Brand A?" and let them taste two unlabeled cups of Brand A and Brand B. The "distance" between Brands A and B could be defined as $d(A,B) = 200 \times (n/N - 0.5)$, where n is the number of times that Brand A was correctly identified in N trials. If the two brands taste very different, n will approach N and $d(A,B)$ will approach 100. If the brands are indistinguish-

(continued)

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Two-dimensional maps are the easiest to display and to reproduce.

able, *n* will be *N*/2 (i.e., random) and *d*(*A,B*) will be zero. Such "distances" can be used directly in similarity mapping. The final map will not have any meaning in the north-south-east-west sense, but it will quickly and easily show which brands are closest to each other in taste.

In the circuit board design problem, you might define distance as follows: If two chips are directly connected, let their distance be 1/*n*, where *n* is the number of connections between them. If they aren't directly connected, let their distance be the minimum sum "hopscotch" distance required to bridge them through other chips that *are* directly connected. On the final map, after appropriate scaling, you can interpret the distances as centimeters or inches of circuit board.

As for the question of map "flatness": There is no reason why either of these latter examples should result in a low-error two-dimensional map; we are just forcing them to do so. Two-dimensional maps are simply the easiest to display and reproduce. In trying many examples with this program, I've found that final errors are often in the 15 to 20 percent range. If the final error were much larger, I'd be concerned that too much information was being lost by forcing the distances to lie in the plane.

Other Applications and References

The book by Schiffman, Reynolds, and Young (reference 1) is an excellent general reference. It has many diverse examples and discussions of algorithms and error analysis. Tobler and Wineburg (reference 2) and Kendall (reference 3) present some fascinating applications in archaeology and sociology in which distances defined by historical records of marriage or trade are used to recreate maps of ancient Assyria and Oxfordshire. Fitch and Margoliash (reference 4) tabulate the "minimum mutation distances" between different species for the protein Cytochrome C. I've given the final map resulting from their data in figure 6. Distances on this map are a measure of similarity of DNA sequences, that is, genetic similarity.

(continued)

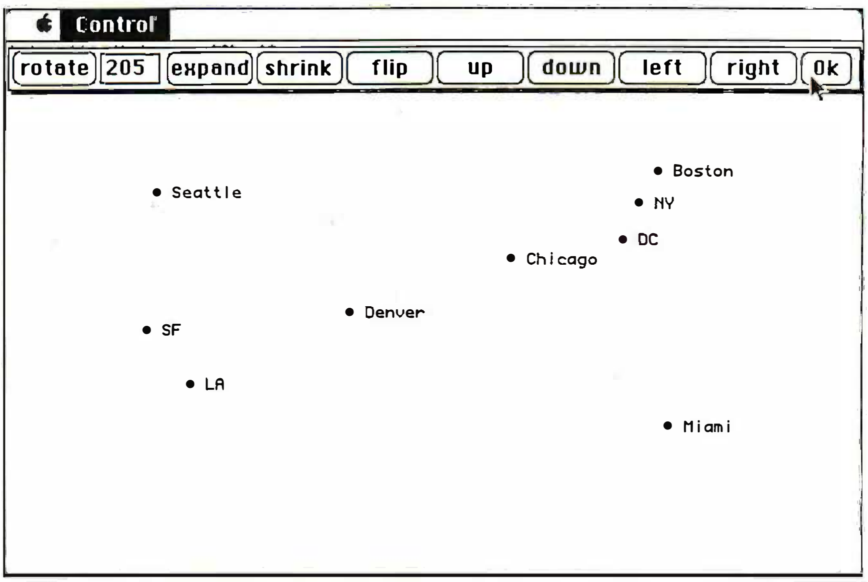

Figure 5: *The final Cities map, after convergence, rotation, and expansion. Note the panel at the top of the screen, with buttons that let you adjust the map size and orientation.*

It's easy to see at a glance how the birds are closely related to each other and distant from the others, how close the primates are, and how the mammals form a broad group from horses to humans. Streich, Dove, and Franke (reference 5) discuss the use of a similar mapping technique in medicinal chemistry.

Finally, similarity mapping can be compared to cluster analysis, a technique I discussed in an earlier BYTE article ("Cluster Analysis," September 1984, page 129). Both techniques have the same general goal: simple graphic presentation of large amounts of data. In cluster analysis the input data is often tabulated characteristics and the output is a dendrogram (tree diagram). In similarity mapping the input data is distances and the output is a map.

The two techniques are not mutually exclusive, however, and either may be applied to a given set of data. For example, the data used to create the map in figure 6 was used by Fitch and Margoliash to build a dendrogram. Similarly, internode distances taken from my cluster analysis article produce the map of figure 7 when run through similarity mapping. In this figure, nearby points represent microcomputers that are similar to each other in features such as price and amount of memory.

The same conclusions that can be drawn from the "Cluster Analysis" dendrogram (figure 1 of that article) are apparent in this map. In addition, you might conclude from the map that the Apple IIe and the TRS-80 Model 4 are in the "middle" of the space defined by the other computers. On the other hand, cluster analysis does not "squeeze out" information by forcing points to lie on a map. Experiment with both techniques and choose the one that suits your data or the presentation that you prefer.

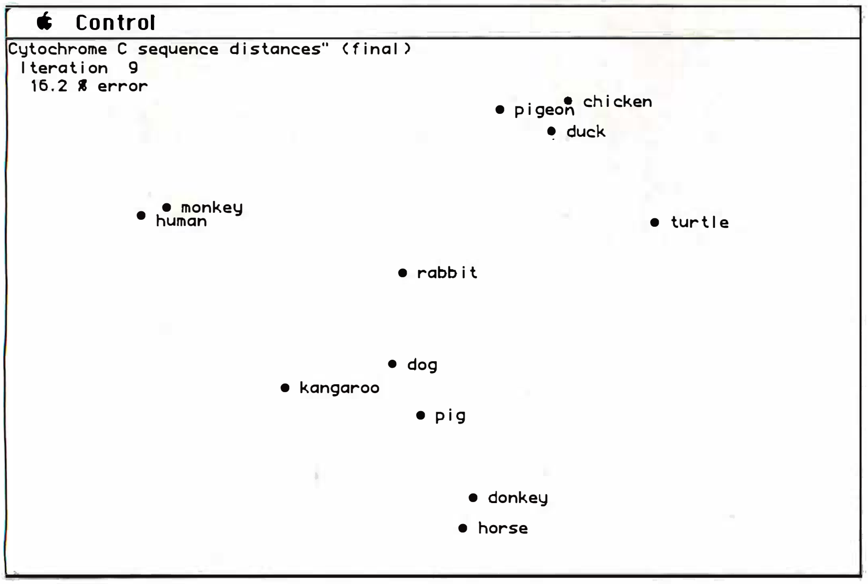

Figure 6: *A Mapper application drawn from biology. The "distance" between any two species relates to the similarity between the genetic sequences of the protein Cytochrome C found in the species. Note how the birds and mammals are widely separated.*

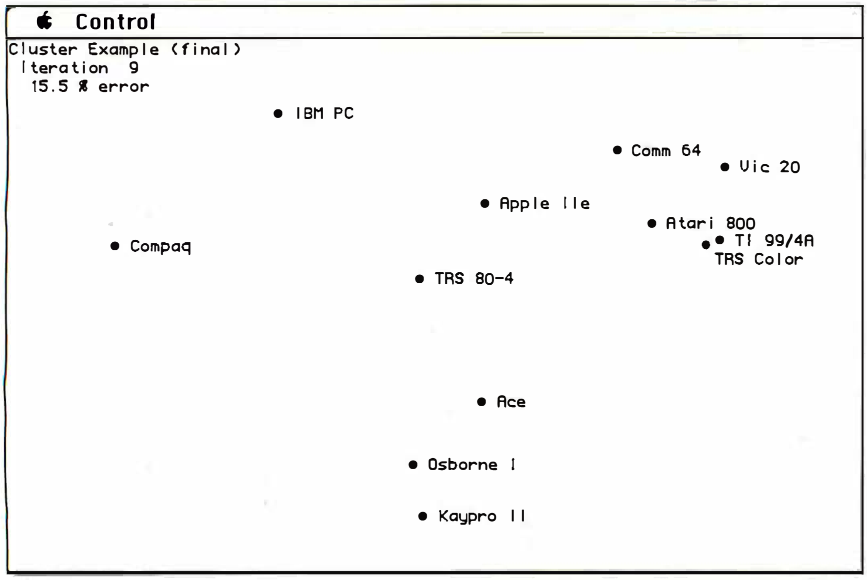

Figure 7: *A similarity map of microcomputers in which the "distance" represents similarity in terms of price, amount of memory, and so on. In a previous BYTE article ("Cluster Analysis," September 1984), this data was expressed as a dendrogram (tree diagram) created by cluster analysis.*

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3. Kendall, D. G. "Construction of Maps from 'Odd Bits of Information'." *Nature* 231, 1971, pages 158–159.
4. Fitch, W. M., and E. Margoliash. "Construction of Phylogenetic Trees." *Science* 155, 1967, pages 279–284.
5. Streich, W. J., S. Dove, and R. Franke. "On the Rational Selection of Test Series 1. Principal Component Method Combined with Multidimensional Mapping." *Journal of Medicinal Chemistry* 23, 1980, pages 1452–1456.

Editor's note: Mapper is written in Microsoft BASIC 2.0 *(binary version) for the Macintosh. The source code,* MAPPER.BAS, *is available in a variety of formats; see page* 405. *Also available are* CITIES.DAT, CYTOC.DAT, *and* MICROS.DAT, *data files for the examples given in this article.* ■

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PARALLEL INTERFACING: A TUTORIAL DISCUSSION

PART 2: APPLICATIONS

BY STEVE CIARCIA

Steve discusses various adapters and possible uses for them

Last month, I described circuits that use LSTTL (low-power Schottky transistor-transistor logic) and ALSTTL (advanced LSTTL). While these are workable, it is frequently easier and more advantageous to use a single LSI interface adapter instead of many smaller packages.

Interface adapters come in many forms: disk controllers, CRT controllers, ACIAs (asynchronous communications interface adapters) and USARTs, and various parallel I/O adapters. These devices are all programmable. You can alter their functions and the way they perform those functions, within reasonable limits, under software control.

As I indicated last month, this discussion is about parallel interfacing. I will thus confine myself to parallel I/O interface adapters. I will not, however, attempt a complete functional description of the parts that I mention. This would take up too much space. Instead, I'll point out some of the more significant differences between them. (The manufacturers' data sheets should be consulted if you need more detailed information.)

ALPHABET SOUP

When discussing parallel peripheral interface adapters, we encounter more alphabet soup. The 6820, 6821, and 6520 are PIAs (peripheral interface adapters). The 6522 is a VIA (versatile interface adapter), the 6822 is an IIA (industrial interface adapter), the 8255 is a PPI (programmable peripheral interface), and the Z80 family's Z8420 is a PIO (parallel input/output controller). [*Editor's note: Figures included in this article show pin-outs and functional block diagrams for five popular parallel interface* LSI *chips.*]

While these various devices have many similarities, each has unique qualities and capabilities that suit it to certain situations better than the others. They could all be programmed for single-package solutions to the keyboard-input/printer-output functions described last month.

We use interface adapters for several good reasons. They act as buffers for the system bus during output. While drive capability may be somewhat enhanced, a more important function is protection: The adapter helps isolate the system from outside problems. Although the external problems, if serious enough, may permanently damage the adapter, the computer system

(continued)

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would continue to function.

If outside devices were tied directly to the bus, this protection would be missing. If a peripheral device were tied directly to the microprocessor system bus, a failure in that device could seriously damage many of the components found in the microcomputer.

Interface adapters can also be used to compensate for timing differences between the computer system and slower peripheral devices, like printers, or relatively slow special-purpose integrated circuits. They are also versatile, and inputs and outputs can often be redefined at will without any hardware changes. Inputs can become outputs, and vice versa. The way the system functions can be altered readily to meet changing needs.

While most distinct functions of LSI programmable interface adapters can be implemented using LSTTL integrated circuits, the ability to accommodate changing circuit requirements without hardware modifications gives interface adapters an advantage in applications where such capability is either desirable or a requirement. Also, using a single package rather than many SSI and MSI chips can greatly simplify printed circuit layouts and shorten design time.

Z8420 PIO

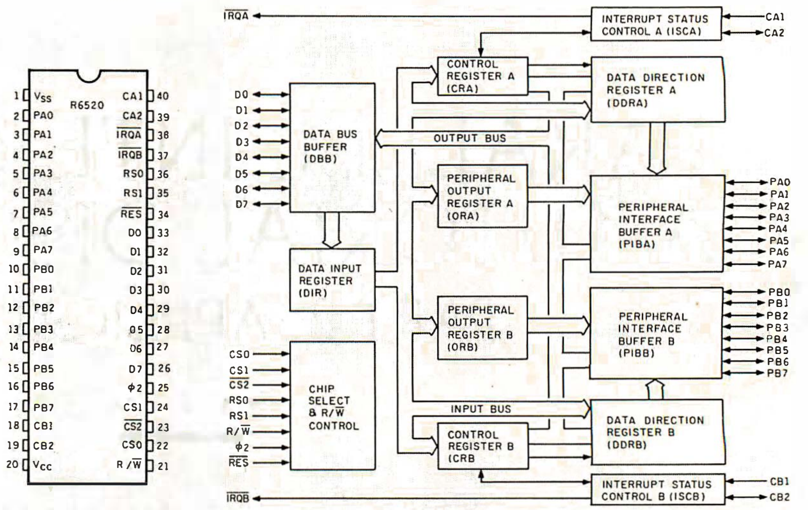
A member of the Z80 family of microprocessors and support circuits, the Z8420 PIO differs from the rest of the parallel interface adapters discussed in this article in that its design dictates that all transfers of data through it are interrupt-driven. Its two I/O ports, which are designated A and B, each consist of eight data lines and two handshaking lines. Four distinct operating modes determine how the ports are configured.

In mode 0, all eight data pins of a port are configured as outputs; one handshaking pin is an output, and the other is an input.

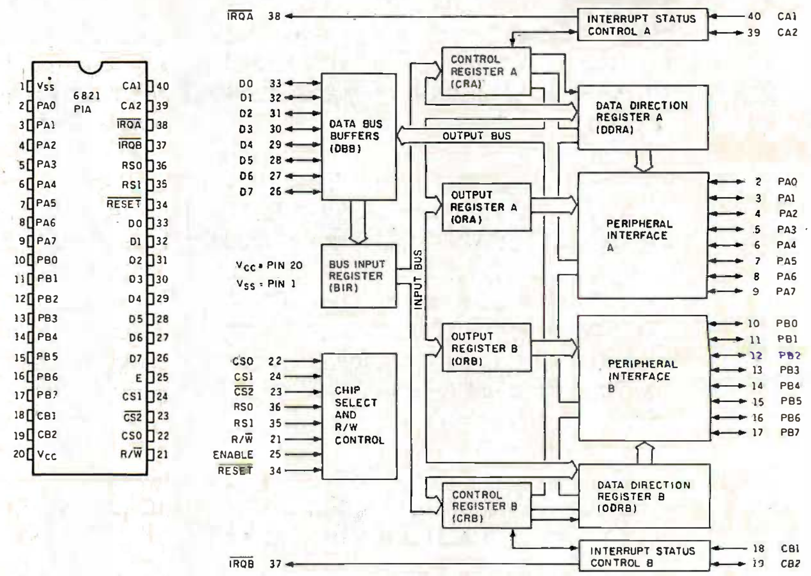
In mode 1, all eight data pins of a port are inputs, and the handshaking lines are used as in mode 0.

Mode 2 employs the A port data lines, plus the handshaking pins for both ports, for bidirectional data transfers.

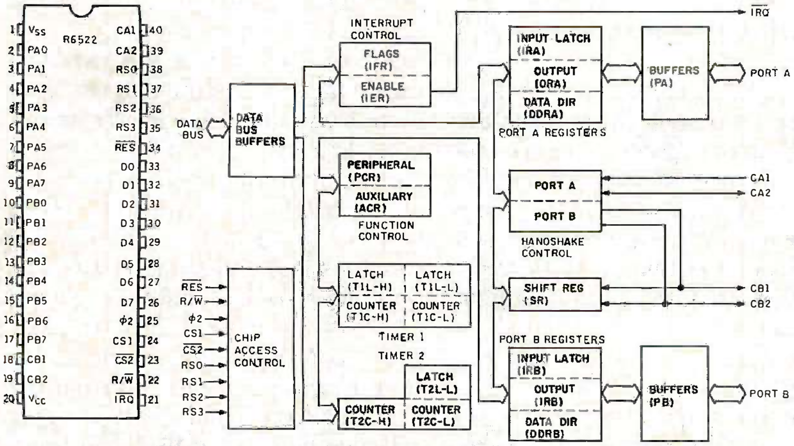
Pin-out and functional block diagram of the R6520 PIA.



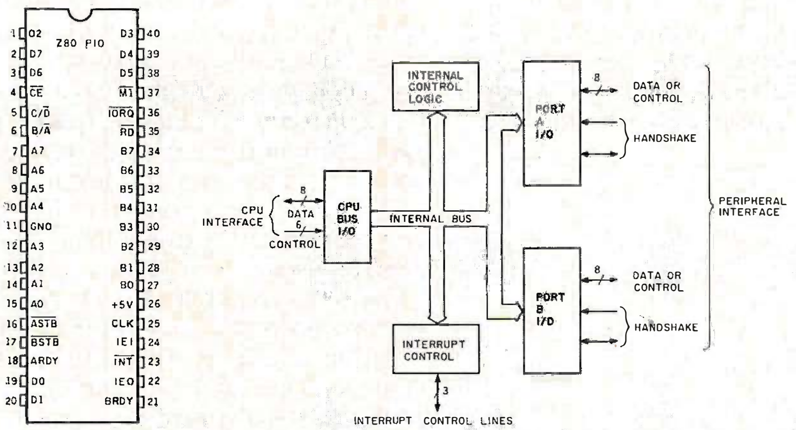
Pin-out and functional block diagram of the 6821 PIA.



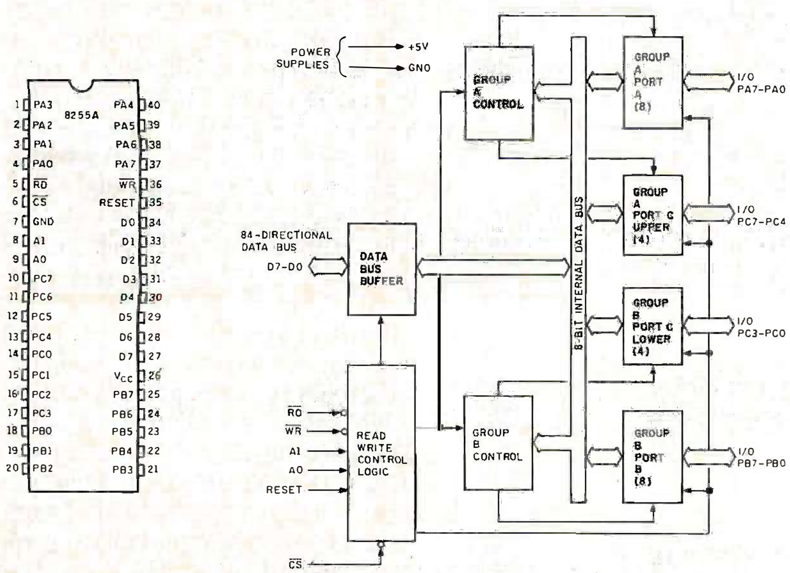
Pin-out and functional block diagram of the R6522 VIA.



Pin-out and functional block diagram of the Z8420 PIO.



Pin-out and functional block diagram of the 8255A PPI.



In mode 3, each individual data I/O pin is defined as either an input or an output. A mask register determines when input conditions generate an interrupt.

Because of the versatility of its interrupt capabilities, including extensive prioritizing, this integrated circuit is an excellent choice for a Z80 system when many sources of interrupts are incorporated and they must be carefully ordered and controlled.

8255 PPI

One of the earliest interface adapters on the market was Intel's 8255 PPI. This is also available from National Semiconductor and NEC. It was designed originally by Intel for use in 8008 and 8080A systems (which gives away its age).

The 24 I/O pins are grouped as three ports, designated A, B, and C. Three modes govern how these ports function. In general, the A and B ports are data ports, while the C port can be either a data port or a control port, depending upon the operating mode selected. The A and B ports can each be programmed as all inputs or all outputs (they are not programmable on a line-by-line basis, as are the ports of some other adapters).

In mode 0, each port is divided into two groups of four pins; each group of four pins is definable as all inputs or all outputs.

In mode 1, the A and B ports can be defined individually as an input port or an output port. In this mode, the upper half of port C handshakes for port A; the lower half handshakes for port B.

Mode 2 uses the eight port A lines as a bidirectional port, with five lines from port C used for handshaking and control.

The I/O pins of this IC are functionally similar to the B port of 6500- and 6800-series PIAs. N-channel transistors connect to both ground and the positive supply when a pin is configured as an output. Thus, when high, the outputs get to TTL levels (2.4 volts minimum) without pull-ups; to get to CMOS thresholds, the pull-ups (which are typically 10 kilohms) are then required.

(continued)

This IC can be especially useful where the largest possible number of I/O lines is required: It has 24 lines, whereas the other adapters discussed in this article have only 20.

6821 PIA and Friends

These interface adapters (6820, 6821, 6822, and 6520) differ primarily in the characteristics of their A and B ports. Except for the types of external devices that they are designed to interface to, these adapters are nearly identical.

They all contain six registers occupying four addresses: Each port has one control register, one data-direction register, and one data register. The data-direction register for each port shares an address with the port's data register. The active register is selected by the status of a bit in the port's control register.

If the bit is clear, the data-direction register is selected; if the bit is set, the data register is accessed. The data-direction register for the A port is usually referred to as DDRA; the corresponding register for port B is called DDRB. The state (0 or 1) of each individual bit in the data-direction register determines whether the corresponding pin in the data register is an input or an output. If the bit in the data-direction register is a 0, the corresponding data-register pin is an input. If the bit in the data-direction register is set, the corresponding data-register pin is an output. This line-by-line programmability gives PIAs great versatility.

Each port has two handshaking pins. The pins for the A port are designated CA1 and CA2; for the B port, CB1 and CB2. CA1 and CB1 can be used only as inputs: An active transition on either pin sets a flag in the corresponding control register and will cause interrupt output IRQ-A or IRQ-B to go low if that interrupt is enabled. CA2 and CB2 can each be configured as either input or output, and both are able to generate interrupts when used as inputs. The configuration of the control pins is determined by the settings of individual bits in the control registers.

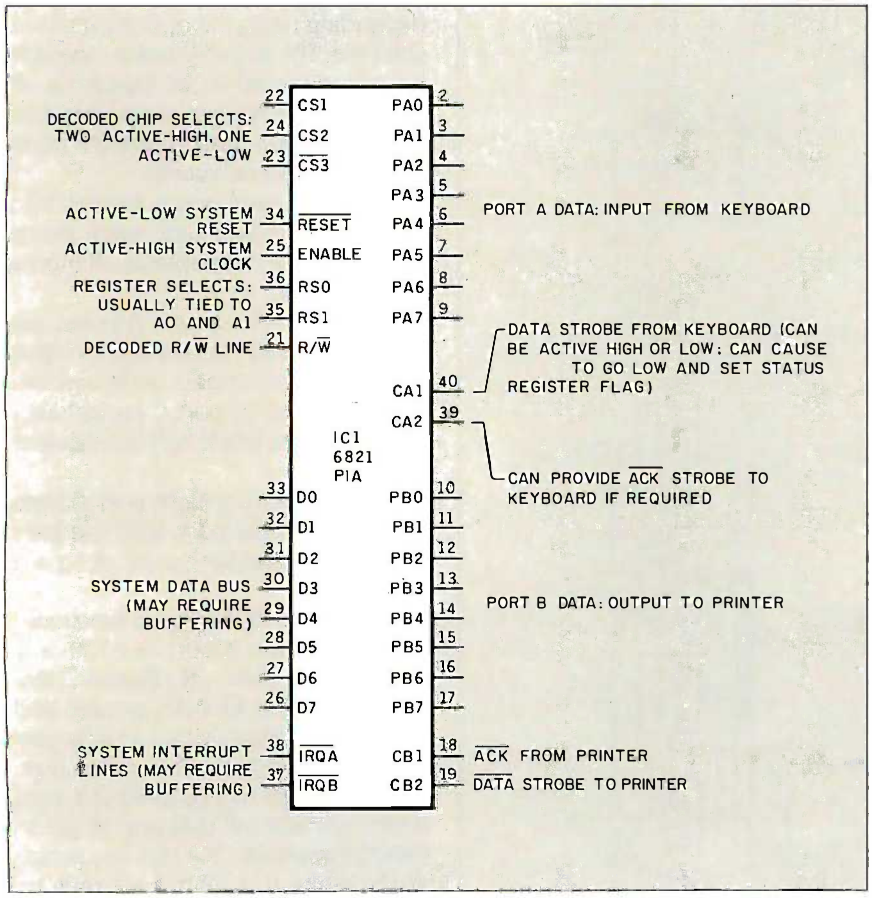


Figure 1: *Using a* PIA *for keyboard-input and printer-output interfaces.*

The two ports of a PIA, while in many ways similar, differ significantly in the way they are implemented. Each line of the A port has an n-channel transistor between the pin and ground and a passive pull-up resistor between the pin and the positive supply. While this enables the port, when used as outputs, to drive CMOS without external pull-ups, it prevents the port, when in the output state, from sourcing more than a tiny trickle of current. The A port is thus not suited to driving NPN transistors or other components requiring source current.

The B port has an active transistor between the pin and ground and another between the pin and the positive supply. Thus, while the B port pins can source current to drive, for example, NPN transistors, they get only to TTL levels when used as outputs. If higher levels are required, such as when driving CMOS, external pull-ups must be used.

The 6820 and 6821 PIA designations are frequently used interchangeably, but significant differences are found, and the 6821 is the only one of the two in the current Motorola 6800-series microprocessor data catalog. Each pin of the A port of a 6821 is specified as capable of driving two TTL loads when used as an output and imposes a maximum of one and one-half TTL loads when driven as an input. The corresponding figures for the 6820 are much lower. Thus, the 6820 is preferred when a component with limited drive capability is driving the A port. When higher-output drive capability is required, the 6821 is the one that should be used.

The 6822 is similar to the 6821, except that all outputs are open-drain and capable of withstanding voltages as high as 18 V (although Motorola specifies a maximum normal working voltage of 15 V). The IIA can thus be used to interface with devices operating at levels substantially higher than standard 5-V logic.

Many specialized laboratory instruments and industrial machine tools output BCD data with levels ranging from near ground to as high as 12 to 14 V. These devices are easy to interface using this part. As the designation "industrial interface adapter" implies, the high-voltage capability and large noise margins of this device can be quite useful dealing with the typically high noise and interference levels in an industrial setting.

The 6520 differs only slightly from the 6821. The 6520 outputs are specified to drive one TTL load, whereas the 6821 is specified at two TTL loads. The 6520's A port inputs impose one TTL load on a driving circuit rather than the one and one-half load maximum for the 6821's A port. Otherwise, the two parts are essentially identical.

6522 VIA

The 6522 is in many ways merely an enhanced 6520. The drive levels and loading of the A and B ports are essentially identical, as are the pin designations for the ports. The 6522 has 16 internal registers occupying 16 addresses and uses four register-select lines instead of two. Only one active-high chip select is provided, and there is only one interrupt output instead of two.

The additional registers control a number of other functions: the T-1 one-shot 16-bit timer/counter that decrements with the phase 2 system clock, plus a second counter, T-2, that can decrement with each time-out of the T-1 timer or with each negative transition on pin PB6.

The T-2 counter is capable of counting pulses from an external source. The chip can generate a square wave on pin PB7, whose frequency is determined by the T-1 counter. A bidirectional 8-bit shift register makes simple serial I/O possible. In addition, the programmed handshaking capabilities of the ports are enhanced, and the 6522 has the ability to latch input data under the control of an external device.

APPLICATIONS

In general, it is easiest to match the microprocessor to the interface adapter by chip series. With a Z80, use a Z8420 PIO. With a 6809, use a 6821, and so on. The 6500- and 6800-series microprocessors and interface adapters can usually be freely mixed without timing or other problems. But you can use an 8255 adapter in a 6502-based system if you decode separate active-low READ and WRITE strobes and provide an active-high RESET signal.

A 6522 VIA is found in the 8088-based Victor 9000 PC and in the 68000-based Macintosh, which also uses a Z80-series dual serial-interface

(continued)

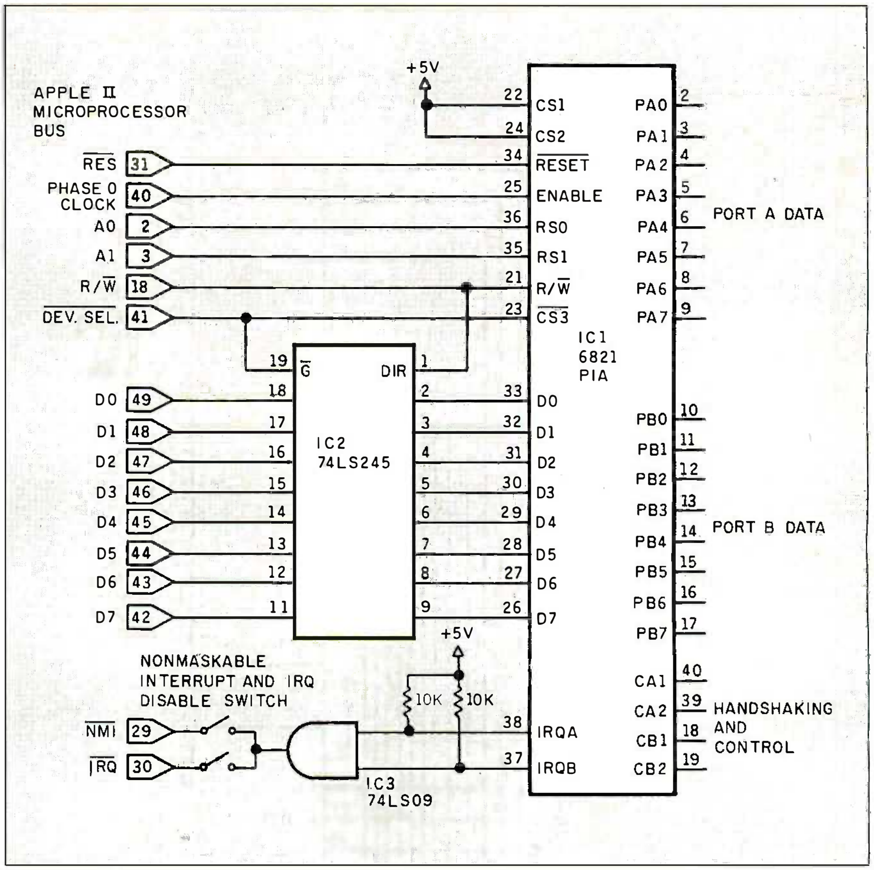


Figure 2: *The essential PIA interface. (This example is from an Apple II computer.)*

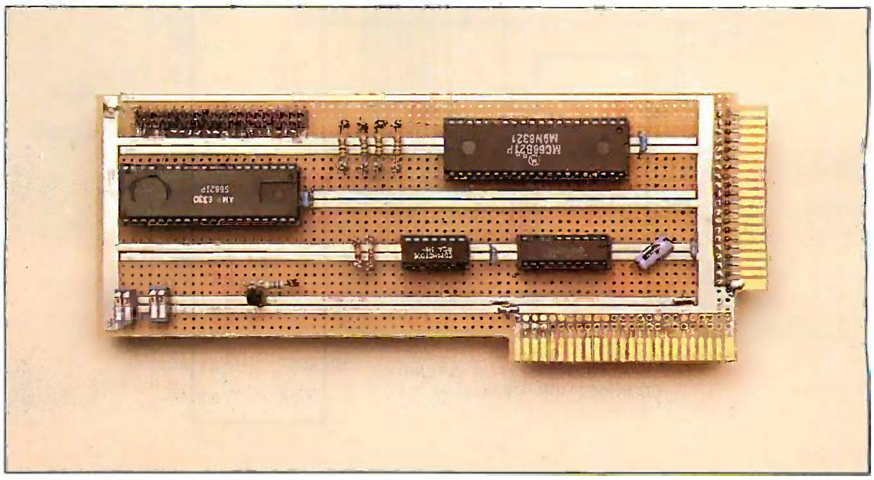


Photo 1: A *dual PIA card for the Apple II computer.*

chip. A great deal of intermixing can be done if circuit characteristics and component capabilities are compatible. It's often best to use a familiar part if it will do the job satisfactorily, rather than switching to an unfamiliar component with an insignificant performance increase.

In the 6500/6800 family, the 6522 should be used only if its enhancements over the 6821/6520 are useful. The built-in timer/counters and extended handshaking abilities of the 6522 can be useful, but the part is more complex and expensive than the 6821, and its timing requirements are more critical.

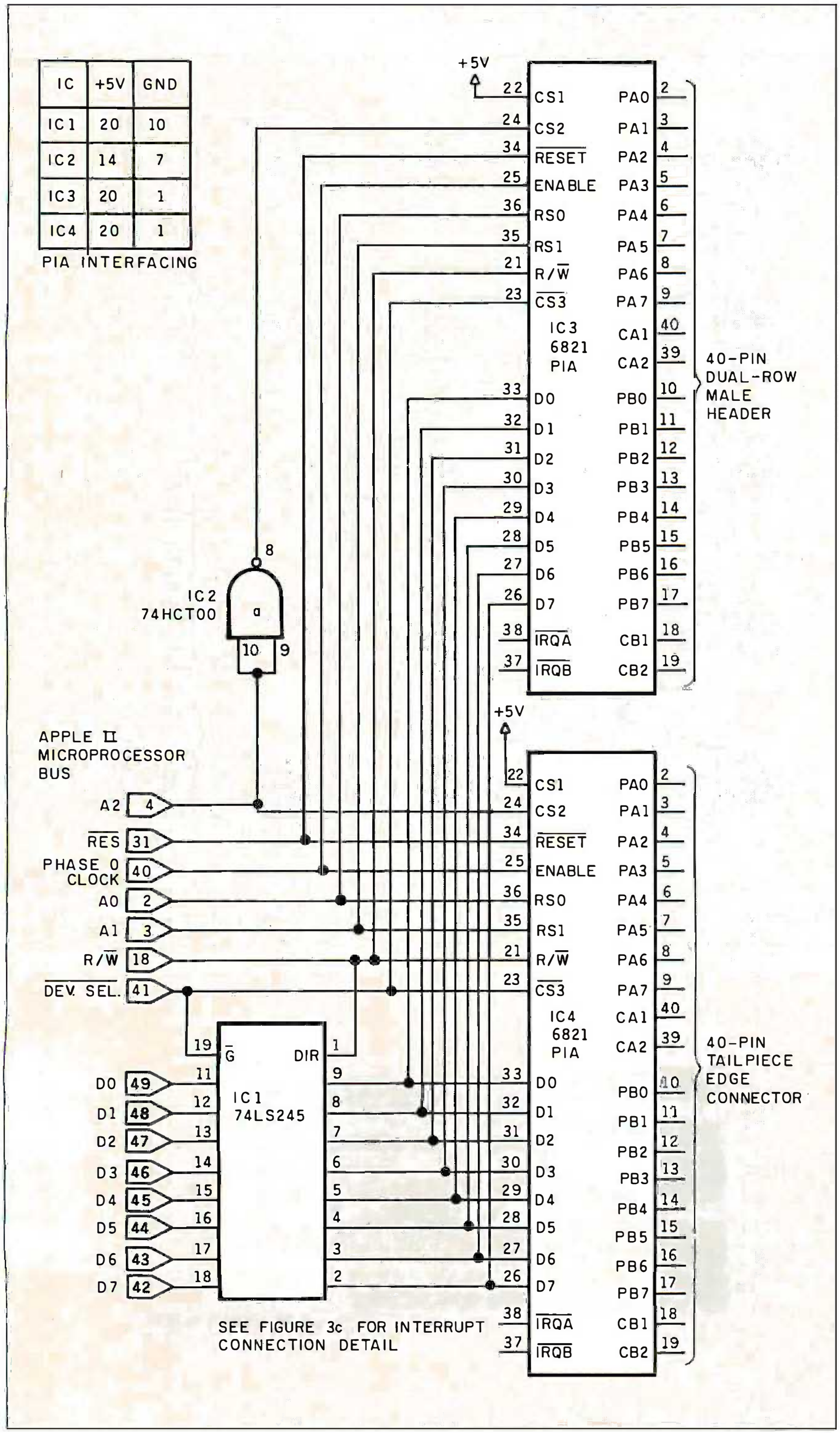


Figure 3a: A *dual* PIA *interface for the* Apple II *computer.*

INTERFACING WITH THE 6821

Any of these interface adapters can be used to replace the LSTTL circuits outlined last month in part 1 (figures 2–5), with functionally similar results. They can generate the handshaking signals necessary for printer interfacing automatically, in hardware. Any of them can be used for keyboard input and printer output by programming the appropriate handshaking.

The hardware example described this month uses the 6821 since its configuration for this purpose is relatively straightforward and easy to describe. The Z8420 and 8255 could also be used, of course, but the configuration procedure would be more complex.

Figure 1 shows the A port of a 6821 used to interface a keyboard. The keyboard's data outputs drive PA0–PA7 on the PIA, configured as inputs. The keyboard data strobe is connected to CA1, and CA2 can be connected with a keyboard input, if that is required. A transition on CA1 will set a control-register flag and can be used to cause a processor interrupt via output IRQ-A. If the interrupt output IRQ-A is left unconnected, keyboard I/O can be handled through polling. The details of the chip-select decoding were outlined last month in figure 2a on page 88.

Figure 1 also shows port B of a PIA being used to drive a parallel printer. PB0–PB7 drive the printer data lines. CB2 generates the DATA strobe (active-low) one clock cycle after the data is written to the B port. The ACKnowledge from the printer triggers CB1. This will set a flag in the B port control register, and, if IRQ-B is connected to the processor-interrupt line, the ACKnowledge from the printer will cause a processor interrupt. Output to the printer can be controlled either through an interrupt subroutine or by polling.

An 8255 could also have been used to perform these functions. With the 8255, the A port functions as the keyboard input, with the four high-order pins of the C port used for handshaking. The B port outputs data to the printer, with the four low-order pins of the C port for handshaking. The 8255 would be configured for mode 1 operation.

Dual PIA Interface for Apple II

Figure 2 shows the essential elements of a PIA interface connected to the Apple II microcomputer bus. (See photo 1.) The chip-select decoding can be done various ways.

Each Apple II peripheral slot has 16 exclusive I/O addresses assigned to it. Pin 41 on any given slot is low when any of the slot's 16 addresses is referenced. In the interface depicted in figure 3a, one PIA occupies the lowest four addresses in the 16-byte range, and the other PIA is addressed at the next higher four addresses.

The pin 41 DEVICE SELECT microprocessor bus signal partially enables both PIAs when it goes low, driving the single active-low chip-select input on each PIA. Microprocessor bus address line A2 drives an active-high enable of IC3 through 74HCT00 NAND gate IC2a, wired as an inverter. A2 is tied directly to an active-high enable of the second PIA, IC4.

When pin 41 is low, the active interface adapter will be selected by A2. A2 will be low when the lowest four I/O addresses for the slot are referenced, high for the next four higher addresses, then low again for four, and finally high for the highest four. Each PIA occupies eight addresses out of the sixteen total. However, the chip still has only six internal registers accessed through four addresses.

The two PIAs occupy the eight lower of the slot's sixteen I/O addresses and, without further decoding, the upper eight addresses, also. If you had a large enough prototyping card, you could have four PIAs on a card, using half of a 74LS139 decoder to divide the 16-byte address range into four 4-byte ranges, with a PIA assigned to each block.

Figure 3b shows this approach. The 74LS245 transceiver (IC1 in figure 3a) that buffers the data lines is enabled directly by pin 41 on the microprocessor bus and is always active whenever any of the slot's addresses is referenced.

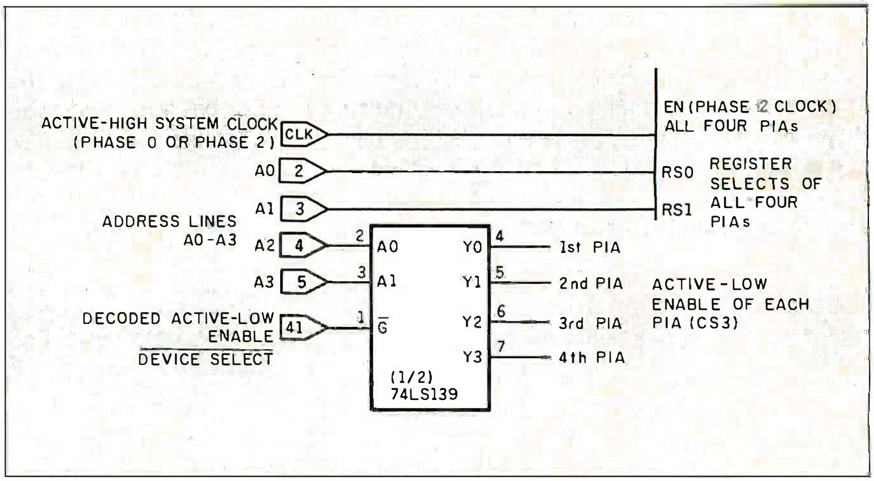


Figure 3b: *Using a 74LS139 decoder to put four PIAs in a single Apple II slot.*

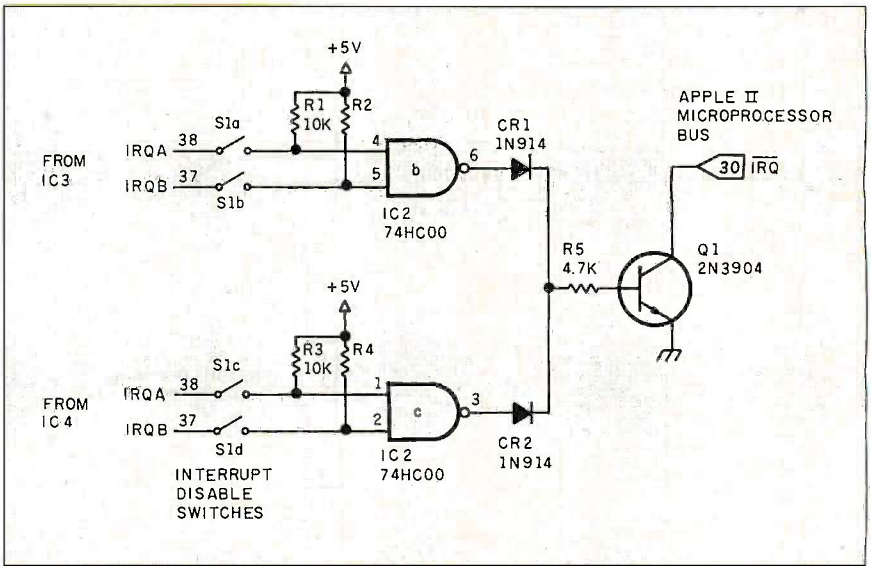


Figure 3c: *An interrupt circuit for the Apple II. The DIP switches (S1a through S1d) allow any of the four PIA-generated interrupts (IRQ-A and IRQ-B from IC3 and IC4) to be disabled.*

For interrupt generation, two of the gates in the 74HC00 NAND gate package (IC2b and IC2c in figure 3c) are used to source base current to a 2N3904 transistor through 1N914 or similar switching diodes (CR1 and CR2). The 2N3904 transistor, in turn, drives the IRQ pin on the bus, pulling it low when active. Each interface adapter has two interrupt outputs, IRQ-A and IRQ-B, both open-drain, active-low. Each is held high with a 10-kilohm pull-up resistor (R1 through R4) and drives an input of a NAND gate (IC2b and IC2c).

DIP switches S1a through S1d enable the user to disconnect the interrupt outputs on the PIAs from the NAND gates. Any of the four interrupts can be enabled/disabled through these switches. The choice of the NPN transistor is not critical. Any general-purpose NPN transistor will do. The 2N3904 was selected because it is easy to find. The collector of the transistor is tied to the IRQ line on the microprocessor bus, and the emitter is connected to ground.

(continued)

Both interrupt outputs of a PIA are normally high. This causes the outputs of the NAND gates IC2b and IC2c to be low and keeps transistor Q1 turned off. If a PIA interrupt output goes low, the output of the NAND gate driven by it will go high, sourcing base current to transistor Q1, which turns on, pulling the IRQ line nearly to ground. This interrupts the 6502 microprocessor (assuming the interrupt has not been masked). DIP switches S1a through S1d are provided so that each interrupt output can be disconnected, allowing the corresponding port to be used for polled I/O with a control-register bit for a flag.

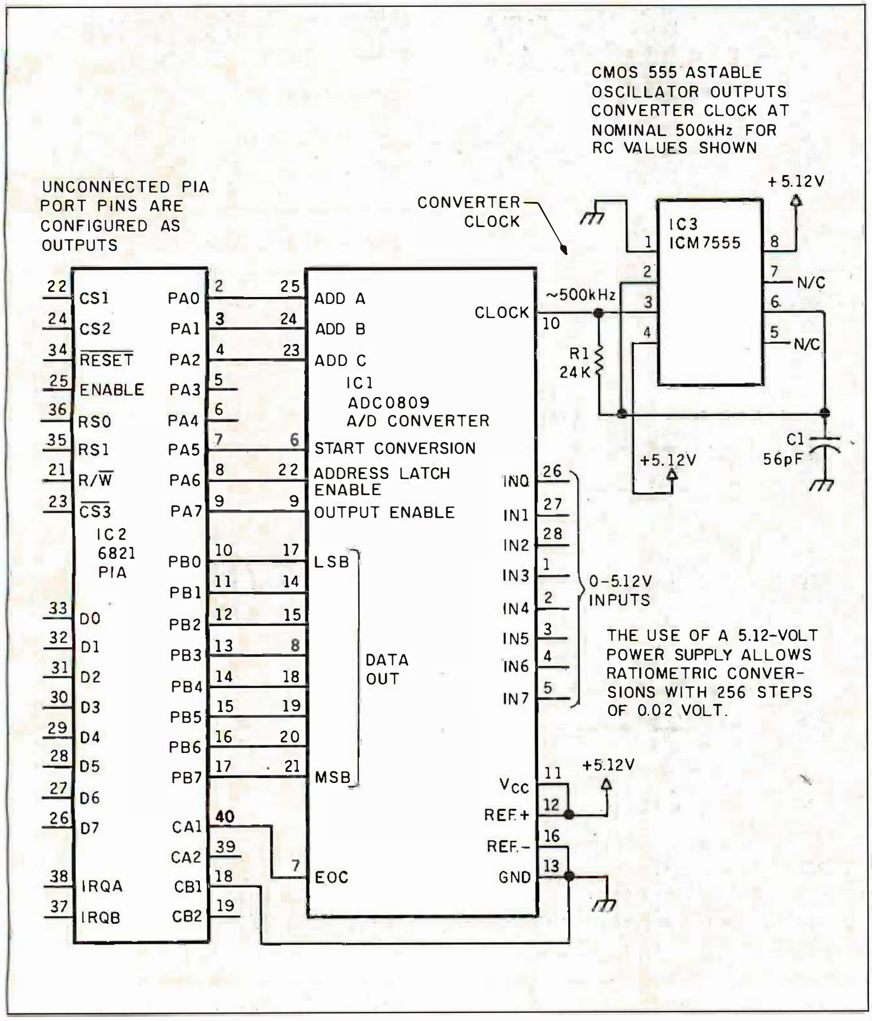


Figure 4: *An ADC0809 A/D converter with dual PIA interface.*

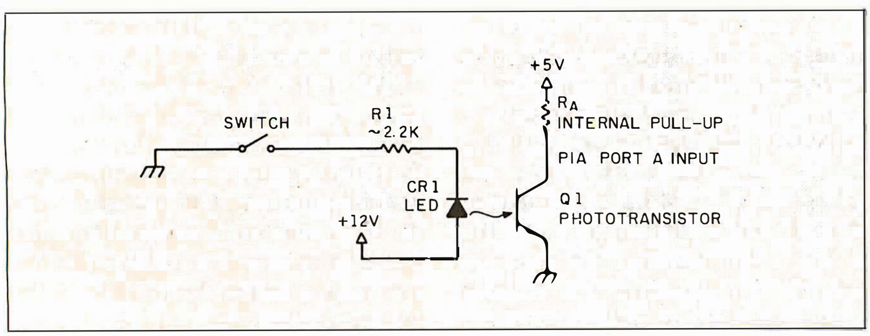


Figure 5: *Using an optoisolator to interface to the A port of a PIA.*

INTERFACES FOR THE PIA CARD

Figure 4 shows an ADC0809 8-channel, 8-bit A/D converter (IC1) interfaced to the PIA card. Connection between the boards is through 40-conductor ribbon cable with an appropriate connector at each end. Typically, a 40-pin edge-card or header-socket connector would be used.

The PIA card and the external card are connected so that the control pins of the converter, ALE (address latch enable), START CONVERSION, and the address inputs (ADD A, ADD B, and ADD C) are driven by the A port of one of the PIAs. The guaranteed input threshold for a high for the ADC0809 is 1½ V below the positive supply. With the converter operating at 5 V or somewhat higher (e.g., 5.12 V, for ratiometric conversions), the B port pins aren't guaranteed to reach that minimum, 3.5–3.62 V, without pull-ups.

The eight data outputs of the converter are therefore connected with the 6821 port B. The PIA's A port, with its built-in pull-ups, easily meets the threshold minimums of the converter. Figure 5 shows how the A port of a PIA, with its built-in pull-ups (RA shown in figure), can be used with optical couplers as an isolated input port with up to ten 1-bit inputs (PA0–PA7, CA1, and CA2).

The diagram shows an unbiased phototransistor (Q1) and an LED (CR1). They can be separate components, as pictured, or combined into one of the commercially available isolator packages like the 4N26 or 4N28. This arrangement can be used to sense switch openings or closings and to monitor low-speed events in circuits with incompatible voltage levels.

The "switch" could be window foil in a security system, or it could be another phototransistor, illuminated by its own LED, that is part of an intrusion alarm system.

You'll find a number of additional uses for this type of interface. The current-sourcing capability of the B port could be used to drive NPN transistors, which in turn could drive relays or solenoids. Specialized relay drivers, like the NE5090, could be driven by either port, although the built-in pull-ups of the A port could guarantee that no relays would be active on start-up.

Conclusions

Knowing the difference between a PIA and an IIA might not be earthshaking news, but there will be that trivia question someday that only you can answer. Discussing basic electronics might seem redundant to many of you, considering the usual Circuit Cellar fare, but I do get a lot of interfacing questions. Perhaps this article will help answer some of them.

I haven't spent the summer needlessly proving E=IR, however, and it will be back to the snowy blizzards of the past this fall.

Circuit Cellar Feedback

This month's feedback begins on page 54.

Next Month

Build the Circuit Cellar data encryptor. ■

Special thanks to Frank Kuechmann for his contributions to this article. JDR Microdevices provides the chips mentioned in this and many previous Circuit Cellar projects.

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 Co., P.O. Box 400, Hightstown, NJ 08250.

Ciarcia's Circuit Cellar, Volume I, covers articles in BYTE from September 1977 through November 1978. *Volume II* covers December 1978 through June 1980. *Volume III* covers July 1980 through December 1981. *Volume IV* covers January 1982 through June 1983. *Volume V* covers July 1983 through December 1984.

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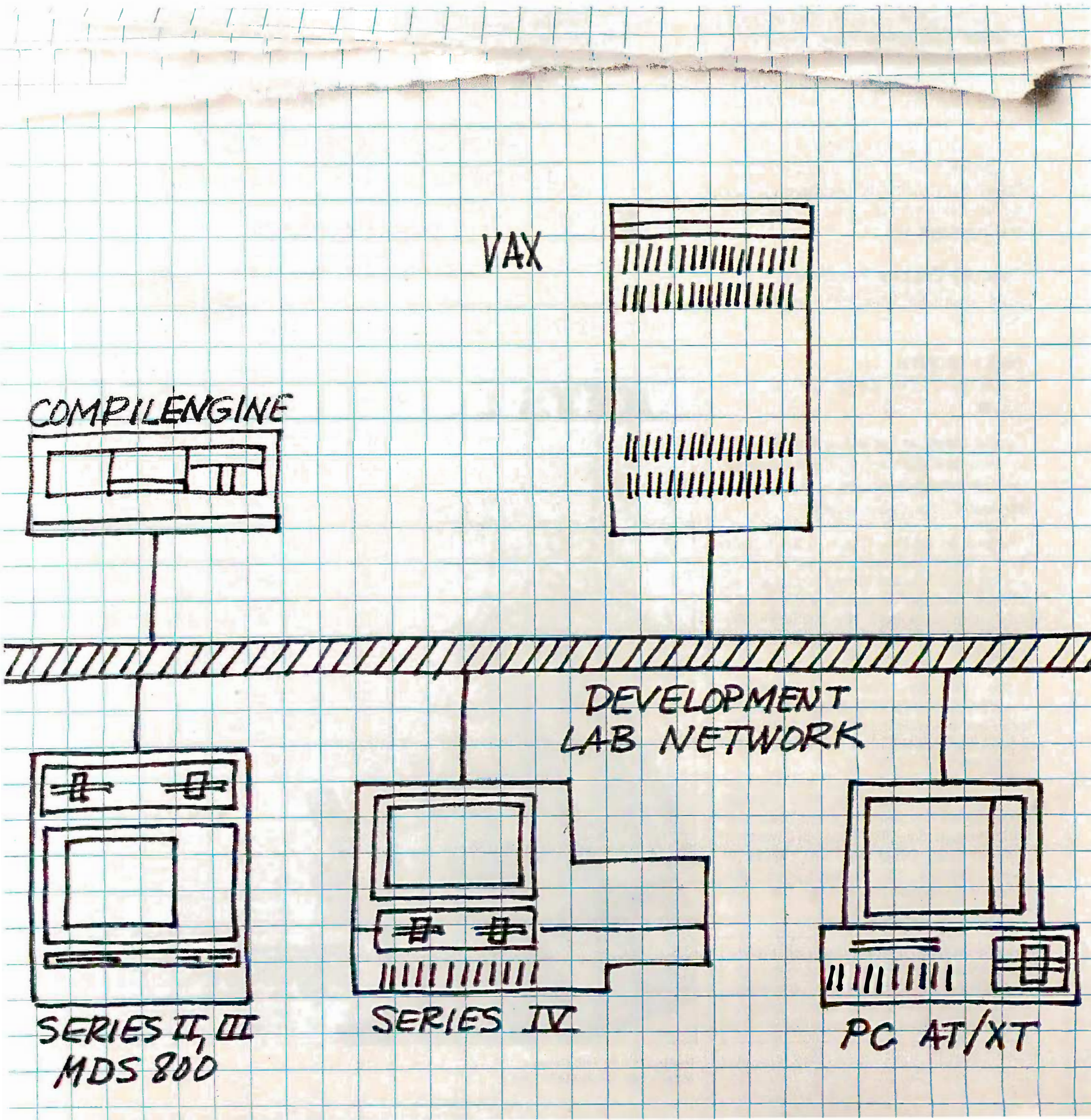

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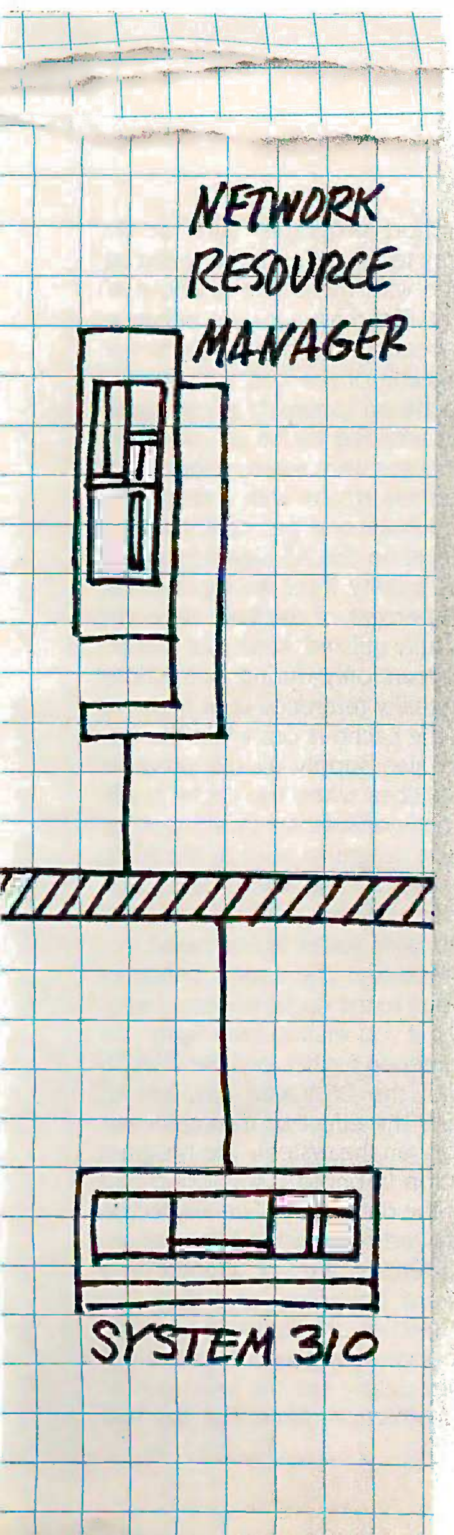

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Inquiry 139

THE DEFINICON 68020 COPROCESSOR

Software to give you 32-bit capabilities in a 16-bit machine

Editor's note: This is part 2 of a two-part article describing Definicon Systems Inc.'s DSI-020 coprocessor board for IBM XTs, ATs, and work-alikes. Part 1 (July BYTE) described the hardware and operating system kernel. Part 2 will focus on the software available for the board. For full information on the Motorola 68020 CPU chip, see "The MC68020 32-bit Microprocessor" by Paul F. Groepler and James Kennedy (November 1984 BYTE).

Last month we presented the schematics and hardware theory of operation for the DSI-020 coprocessor. Hardware, however, doesn't function too well without software tools; so this month, after looking at the remaining hardware topics, we'll discuss the available software support.

EFFECTIVENESS OF THE 68020'S INSTRUCTION CACHE

A jumper has been provided so that the internal instruction cache memory of the 68020 can be manually disabled. Running a program with and without this jumper quickly demonstrates how effective an instruction cache can be.

On short programs, such as the memory test in listing 1, the speed advantage with the cache is about 40 percent. The reason for this enhancement becomes evident if the scope photograph of the bus activity with the cache on (photo 1) is compared to that with the cache off (photo 2). Both photos were taken of the 68020 $\overline{AS}$ address strobe with a time base of 1 microsecond per centimeter. A high level on the $\overline{AS}$ signal indicates no bus activity. If the $\overline{AS}$ signal is low for 75 percent of the total time, the bus is fully utilized. Note that bus access occurs only during instructions that actually reference data memory when the cache is on, while the bus has to also supply all the program code fetches when the cache is off.

By comparison, on floating-point-intensive programs, such as the Whetstone benchmark, the difference is only a few percent. When the number of CPU wait states is increased (for slow memory) the speed enhancement due to the cache becomes even greater. If you wish to investigate this phenomenon further, pull the $\overline{2WAITS}$ input of the DSACK20 PAL low to simulate the effect of having slower memory on the system. The program execution in photo 1 was optimized in that the data fetches are aligned on a long-word boundary, while in photo 3 data fetches are not aligned on a long-word boundary, and thus two 16-bit fetches are required for each 32-bit access. In photo 2 (cache off) you can clearly see the execution of each instruction. Note that the two

Listing 1: *Memory test program.*

```
         ORG      $00004000
;
;set to 4030 if test on longword boundary
;
TSTORG   EQU      $00004032
;
START:   MOVE.L   #RWADDR,A0
         MOVE.L   #$5555AAAA,D0
BEGIN:   CLR.L    D1
LOOP:    MOVE.L   D0,(A0)   ;data memory access
         CMP.L    (A0),D0   ;data memory access
         BNE.L    ERROR
         SUBQ     #1,D1
         BNE.L    LOOP
         BRA.L    BEGIN
;
ERROR:   STOP     #0
;
         ORG      TSTORG
;
RWADDR:  DC.L     0
         END
```

BY TREVOR MARSHALL, CHRISTOPHER JONES, AND SIGI KLUGER

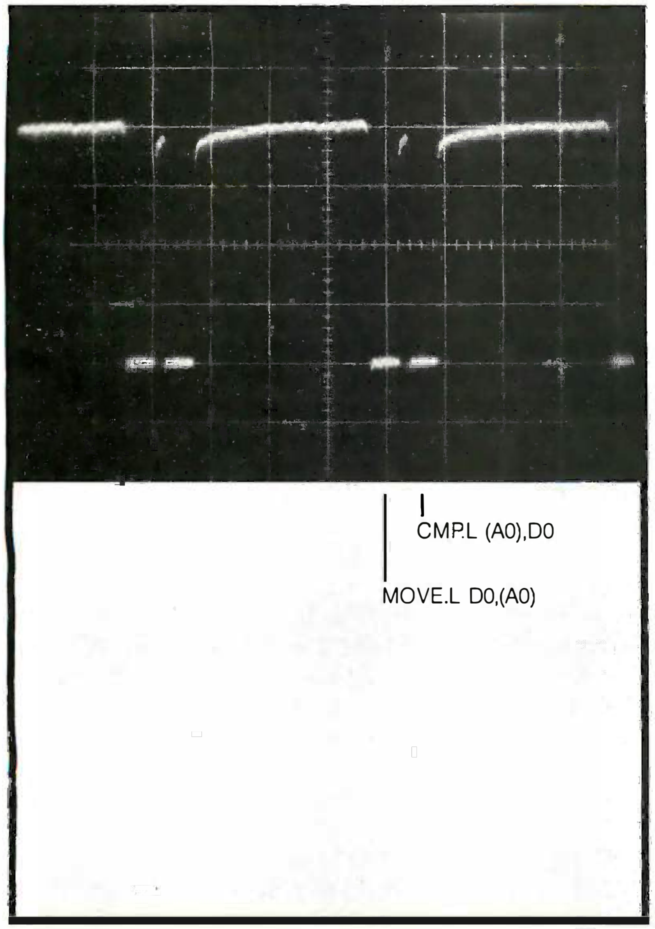


Photo 1: *The two fetches referencing data locations are displayed. All op-code fetching is from the cache.*

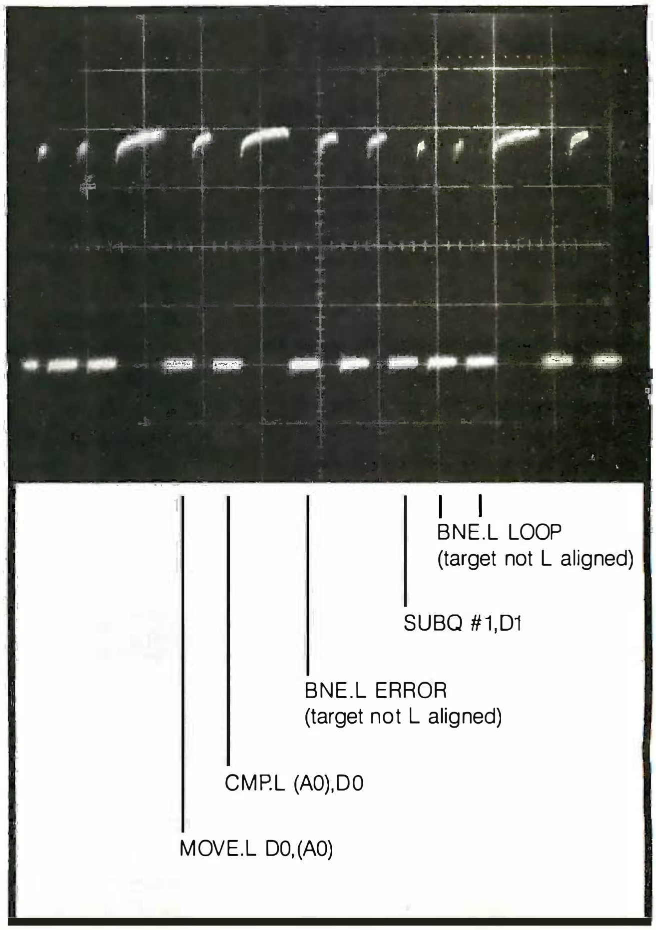


Photo 2: *With the cache disabled, all data fetches are seen on the scope. Note that two fetches occur for each of the conditional branches to non-long-word-aligned addresses.*

conditional branches reference non-long-word-aligned targets and require two cycles.

THE EEPROM CONTAINING THE DSI-020 SERIAL NUMBER

To get some of the larger software houses to port their products to the DSI-020, we had to provide a means to ensure that the software was indeed running on the board for which it was sold. The on-board 9306 COPS EEPROM can be interrogated by the kernel using function 33. It will return the serial number as a 32-bit integer. The most significant byte of the serial

(continued)

Trevor Marshall, Christopher Jones, and Sigi Kluger are engineers with Definicon Systems Inc. They can be contacted at 31324 Via Colinas #108/9, Westlake Village, CA 91362.

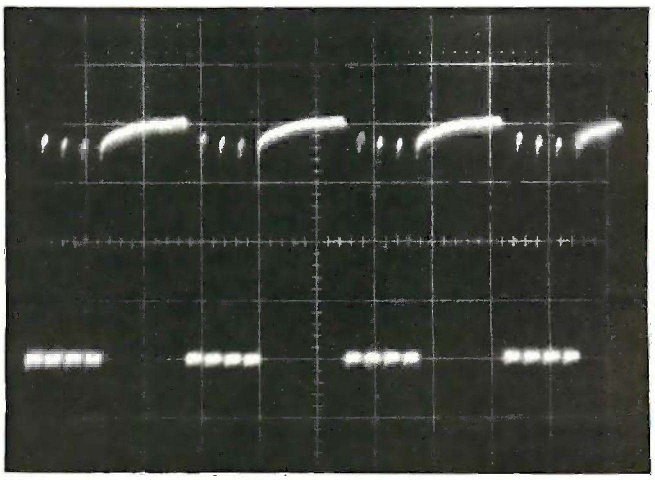


Photo 3: *This photo shows two memory fetches for each of the data locations due to the data not being aligned on a long-word boundary. Instead of fetching 32 bits of data, two 16-bit transfers are executed.*

The kernel software, a simple assembler, a linker, and a debugger are bundled with the DSI-020 *hardware.*

number carries information about the hardware revision level.

Some bytes of this EEPROM are available for storing software parameters (such as passwords).

OPERATING SYSTEM

The basic operating system for programming or operating the DSI-020 is MS-DOS, and all communication between the user program and the MS-DOS host occurs via the 68020 TRAP #14 instruction. Parameters are transferred in registers. Data registers are used for values, address registers for pointers. All functions save only the registers they use, but data registers used to pass values may return with their contents altered. Abnormal conditions, such as trying to execute an invalid instruction, division by zero, attempts to use privileged instructions, or undefined function calls, will cause an error message on the host's console and immediate termination to MS-DOS or the debugger.

On entry to a program the kernel sets up the stack at the top of RAM and preloads the following registers:

A0.L	program entry point (4000 hexadecimal)
A1.L	start of heap
A2.L	top of heap/bottom of stack
4(A7)	ARGV pointer
8(A7)	ARGC

ARGC is the count of command-line arguments that were used when the program was invoked. ARGV points to a list of ARGC pointers that address the command-line arguments, saved as ASCIIZ strings (zero-terminated ASCII strings).

For HEX or IMAGE programs the entry point must be 4000 (hexadecimal). The remainder of your program can be located anywhere in the user program space. Files in DSI-LINK format (.E20) may be located at any address above 3FFF.

You can stop the program either by executing a TERMINATE service request (function 15) or by returning to the kernel using the RTS instruction. The TERMINATE service request always returns 00, while RTS supplies a value in D0.B to MS-DOS as return code. Since the return code may be tested in a conditional MS-DOS batch stream, the RTS method is preferred, provided you can maintain the stack integrity.

Your program may set up its own stack pointer, which can be located anywhere within the user program space. Alternately, you can use the system-provided default stack space allocated to start at the end of RAM and grow downward.

The interface kernel uses only 16K bytes of the 68020's address space, allowing your application to use almost the full megabyte of available RAM. Table 1 shows the memory map utilization. Note that the 68020 uses the first 400 hexadecimal bytes for its trap vector locations, and the rest of the address space to 4000 hexadecimal is used for disk buffers and the kernel code itself. After a programmed or power-on reset, the 68020 picks up its initial stack pointer from address 0 and its initial program counter value from address 4. This value points to the 2010 kernel code, which loads your program from the disk, relocates it to 4000, places the stack at the top of RAM, points HEAPLOW at the top of the program code, and begins execution.

The kernel software, a simplified assembler, a linker, and an assembly-level debugger are bundled with the DSI-020 coprocessor hardware. The simple assembler supports all the 68000 op codes, plus the 68881 floating-point instructions. However, many of the newer 68020 addressing modes are not supported. In addition, the syntax of those newer addressing modes that are supported follow the 68000, rather than the 68020, conventions. The debugger provides facilities similar to those of DOS's Debug or CP/M's DDT within the 68020 environment.

The kernel can load and execute disk files that have been created using Motorola S record format, absolute image format, or the DSI-020 linker. Programs created in S record or image format must load and begin execution at 04000 hexadecimal.

PROGRAMMING THE 68020 KERNEL IN ASSEMBLY LANGUAGE

Listing 2 contains a short program (in simplified 68020 assembly language) that takes an MS-DOS ASCII file of any length and types it on the console. Note that the program uses the (preferred) UNIX-like I/O functions 5, 8, and 9 to access the DOS file system. On entry from the kernel the stack is already initialized and pointers to the command-line parameters have been placed on it. The filename you give is opened for reading using function 5. The kernel returns a "handle" used to identify this file on subsequent accesses. A multibyte read command (80000 hexadecimal bytes) is executed. The return code, which is zero (if nothing has been read) or the actual number of bytes read, is examined. If it is zero, the program terminates. Otherwise, the number of bytes actually read are written to the

(continued)

Table 1: *Memory map of the* DSI-020. *The* DSI-020 *decodes* 16 *megabytes of* 68020 *address space.*

00000000-000003FF	reserved for 68020 reset and trap vectors
00000400-00003FFF	used by the kernel
00004000-000FFFFF	user program RAM space
	user default stack grows down from top of RAM
00F7FE03	2681 DUART base address
00F00000	addresses the VEC20 PAL
	reads EEPROM and RS-232C channel B signals

Listing 2: *Program to type an MS-DOS file on the console. Note the calls to the DSI-020 kernel for file I/O and the alternate console I/O method for the error message.*

```
;THIS PROGRAM TYPES A FILE ON THE CONSOLE USING THE DSI-020 CARD
;USE: LOAD TYPE FILENAME
;
        ORG     $00004000
;
ENTRY:  MOVE.L  8(A7),D0        ; GET ARGC PASSED BY KERNEL INIT
        MOVE.L  4(A7),A1        ; GET *ARGV
        MOVE.L  4(A1),A0        ; GET POINTER TO ARGV[1]
        CMPI.W  #2,D0           ; DO WE HAVE AN ARG?
        BEQ.B   OKAY            ; YES, GO ON
        MOVEQ   #1,D0           ; ELSE SET BDOS REQUEST
        MOVEQ   #9,D1           ; FUNCTION 9
        MOVE.L  #MESS1,A0       ; ERROR MESSAGE TO PRINT
        TRAP    #14             ; DO IT
        CLR.B   D0              ; CLEAR ERROR RETURN CODE
        RTS                     ; RETURN TO MSDOS
;
OKAY:   MOVEQ   #0,D1           ; 0 IN D1 MEANS OPEN FOR READ
        MOVEQ   #5,D0           ; FUNCTION 5 = OPEN FILE
        TRAP    #14             ; GET MSDOS TO DO IT
        CMPI.W  #$FFFF,D0       ; ERROR RETURN CODE?
        BEQ.W   NOTOPN          ; YES, GO FUSS ABOUT IT
        MOVE.W  D0,(HANDLE)     ; ELSE SAVE THE FILE'S HANDLE
LOOP:   MOVE.L  #BUFFER,A0      ; STORE BUFFER POINTER
        MOVE.W  (HANDLE),D1     ; GET FILE HANDLE AGAIN
        MOVEQ   #8,D0           ; READ FILE REQUEST
        MOVE.L  #$80000,D2      ; READ UP TO 524288 bytes
        TRAP    #14             ; DO IT
        CMPI.L  #0,D0           ; END OF FILE ENCOUNTERED?
        BNE.B   RDOK            ; IF NOT GO DISPLAY WHAT WE HAVE
        RTS                     ; ELSE JUST RETURN TO MSDOS
;
RDOK:   MOVE.L  D0,(BYTES)      ; STORE # OF BYTES READ
        MOVE.L  #BUFFER,A0      ; SET UP BUFFER PTR
        MOVEQ   #1,D1           ; WILL WRITE TO STDOUT
        MOVE.L  (BYTES),D2      ; # OF BYTES
        MOVEQ   #9,D0           ; WRITE FILE REQUEST
        TRAP    #14             ; SEND BYTES AND IGNORE RET CODE
        BRA.B   LOOP            ; SINCE STDOUT SHOULD EXIST
;
NOTOPN: MOVEQ   #1,D0           ; TELL THE OPERATOR HE
        MOVEQ   #9,D1           ; BLEW IT
        MOVE.L  #MESS2,A0       ; AND HAD BETTER LEARN TO SPELL
        TRAP    #14
        RTS                     ; THEN LET DOS MAKE HIM TRY AGAIN
;
MESS1:  DC.W    $0D0A           ; CARRIAGE RETURN AND LINE FEED
        DC.W    'USE: LOAD TYPE FILENAME'
        DC.W    $0D0A
        DC.W    '$'             ; TERMINATES THE DOS OUTPUT STRING
;
MESS2:  DC.W    $0D0A
        DC.W    'CANNOT OPEN FILE',$0D0A,'$'
;
HANDLE: DC.W    0               ; USED TO HOLD THE FILE HANDLE RETURNED BY DOS
BYTES:  DC.L    0               ; THE NUMBER OF BYTES WE ACTUALLY READ
;
BUFFER: DC.B    0       ; BUFFER START, ENDS AT THE TOP OF RAM
        END
```

It is possible to code specialized multitasking software using the 2681 DUART timer.

console by addressing it as stdout, and the read operation is repeated. The second read attempt after reading the whole file will, of course, cause the program to terminate. Thus, you can display a file of any size up to the disk or operating system limits.

The error message handler, however, uses the alternate console I/O method. Function 1 (BDOS call) is used to send an MS-DOS interrupt 21H to the host with AH = 9. Reference to a DOS manual will show that this causes MS-DOS to output the indicated string until a $ character is reached. Although this technique is often simpler for an experienced programmer, you should not attempt it if you are unfamiliar with MS-DOS assembly language programming. One of the pitfalls of this method is that some DOS functions require a buffer to be placed in 8086 memory to receive the data (this is the function of system calls 23 and 24).

MULTITASKING

The structure of the DSI-020 kernel makes it possible, but difficult, to write specialized multitasking software using the interrupt-driven timer in the 2681 DUART. Most programming applications typically require tasks such as target program execution, editing, and printing to be concurrent. This allows you to set up an execution task, the source code, and a link map in windows on the display. Because the host MS-DOS kernel is not reentrant and the editor and typing functions are usually performed in the host environment, a multitasking host DOS will be necessary. We have found that Concurrent DOS (Digital Research, Pacific Grove, CA), which offers four concurrent tasks windowed onto the display, comes closest to the ideal environment. Unfortunately, it is not MS-DOS and so is not 100 percent compatible. It also requires significant user familiarization before all its features become usable.

Other multitasking systems that work fine with the DSI-020 include DoubleDOS (SoftLogic Solutions, Manchester, NH), Microsoft Windows, and TopView (IBM). Note that early versions of Windows did not allow a background task to remain active. DoubleDOS is by far the least expensive solution, and although it offers only two tasks plus a print spooler, this is often as many activities as you can concentrate on anyway!

With such a multitasking environment you can operate the DSI-020 as an array processor. An application can be set up in the DSI-020 to, for example, invert some large matrices. You can switch the DSI-020 to a background task and pass parameters to it from a foreground program running on the host computer. It is our experience, however, that this approach is seldom worthwhile. This multiprocessor approach rarely gives equivalent performance to having the entire software package running on the 32-bit processor itself. If it is necessary for you to examine the results using a package such as dBASE, the results can be easily passed to the 8086 in a disk file.

SOFTWARE DEVELOPMENT TOOLS

Two sets of commercial compilers are available for the DSI-020. In addition, Definicon has ported Gordon Brandley's 68000 version of the public domain Palo Alto Tiny BASIC interpreter and a minimal 8080 emulator that can run CP/M-80 software. Tiny BASIC provides the minimal environment to experiment with the 68020, and its performance in no way compares with that of the other DSI-020 software.

All of the specialized compilers are fully optimizing compilers that produce compact and efficient code. Assembly language modules, written using the bundled simple assembler, can be interlinked with the code from any of these compilers.

It should be noted that all of these compilers produce object code directly. In order to see the efficiency of the code being generated you must use a disassembler or Definicon's assembly-level debugger.

Silicon Valley Software (Cupertino, CA) has ported its FORTRAN, Pascal, C, and BASIC to the DSI-020. SVS compilers are currently sold (at much higher prices) by most major workstation manufacturers. The linker and assembler were written by SVS. In addition, Lattice Logic Ltd. (Edinburgh, Scotland) has provided ports of its optimizing Pascal and C compilers for the DSI-020.

The SVS FORTRAN is a 68020 version of the company's fully validated ANSI-77 FORTRAN. It also includes a number of the more common extensions.

The SVS Pascal is an ANSI Level 0 Pascal enhanced with a number of extensions predominantly derived from the UCSD system, including string handling and the ability to compile code modules separately. Thirty-two-bit integers and both single- and double-precision floating-point data types are supported.

LLL Pascal is a 68020 version of Lattice's fully BSI (British Standards Institute) certified compilers, which comply with the standard for ANSI Level I Pascal with conformant arrays. The BSI uses the identical standards required by the FSTC (Federal Software Test Center). ANSI Pascal does not support the string data type directly. Strings may, however, be programmed using conformant arrays.

The SVS BASIC interpreter follows the DEC BASIC Plus language definition. SVS will support this interpreter only by paying prompt attention to any bugs that may be reported. It will not be enhanced from its current capabilities.

Both SVS C and LLL C are full Kernighan and Ritchie definitions as extended by the UNIX environment. The compatibility of the SVS compiler is sufficient to allow the entire UNIX System V source kernel to be compiled without error.

Definicon has ported the BASIC-to-C converter from Living Software (Milton Keynes, Great Britain) to the DSI-020. This converter takes Microsoft (IBM) BASIC and converts it to a form that can be compiled using either C compiler. The BASIC run-time functions are implemented for the 68020. This converter provides programmers with the fastest possible environment to execute BASIC code. It is not, however, an interpreter. Microsoft BASIC (on the host PC) should be used to debug the program before attempting to convert and run it using the 68020.

Assembly language software devel-

(continued)

Table 2: *Comparison of the* LINPAK *results with two versions of the* DSI-020, *an* IBM RT PC *Model* 20, *and a* VAX-11/780. *All machines have floating-point hardware or math coprocessors.* VAX-11/780 LINPAK *values courtesy* Argonne National Laboratories.

Double-Precision LINPAK

Performance is quoted in terms of total time taken, in seconds.

DSI-020 (12.0 MHz)	DSI-020 (16.7 MHz)	IBM RT PC	VAX-11/780
10.0	7.38	19.1	4.96

opment has been supported by Quelo Inc. (Seattle, WA). Quelo has written a complete software development package that enables you to directly bootstrap a 68020 product. The DSI-020 itself is testimony to the effectiveness of Quelo software. Quelo is offering a specially priced subset of its complete package to BYTE readers, consisting of an assembler, macro preprocessor, and symbol report generator. In addition it is providing LTXCON, a converter to allow modules compiled using Quelo tools to link and run on the DSI-020.

Quelo's assembler package is identical in capability to Motorola's Macro Assembler. It implements completely all the 68020 instructions and addressing modes. The assembler creates standard S record output files in addition to the relocatable output format. This package allows programmers to develop and test other (dedicated) 68020 systems using the DSI-020. Although the program's starting point must be 4000 hexadecimal, all of the memory can be used by a stand-alone program. If the kernel is overwritten, however, no MS-DOS support functions will be available to the user's program.

Editor's note: For prices of the software mentioned in the section above, see part 1 of this article (July BYTE*) or contact Definicon Systems.*

CONCLUSION

Since the publication of the first part of this article, we have obtained the LINPAK benchmark results for the DSI-020 board. The LINPAK test suite, from the Argonne National Laboratories, tests the ability of a computer system to perform linear arithmetic, that is, matrix algebra, addition, subtraction, multiplication, and division. Specifically, it uses Gauss-Jordan elimination to solve a series of large matrices. It is written in FORTRAN. Table 2 gives the double-precision results obtained with the DSI-020 at 12.0 MHz, the DSI-020 at 16.7 MHz, the IBM RT PC, and a VAX-11/780. Note: the CPU frequency for the production model DSI-020 is 12.5 MHz, while the benchmark times are for a prototype board (12.0 MHz) and a peak performance version (16.7 MHz).

The DSI-020 is the second 32-bit coprocessor to come from a Definicon design team. As technology marches on, it is often hard to stop and look at where we are and where we are going. The DSI-020, we believe, represents the achievement of a goal we set two years ago: to put VAX-11/780 power on every scientist's desktop.

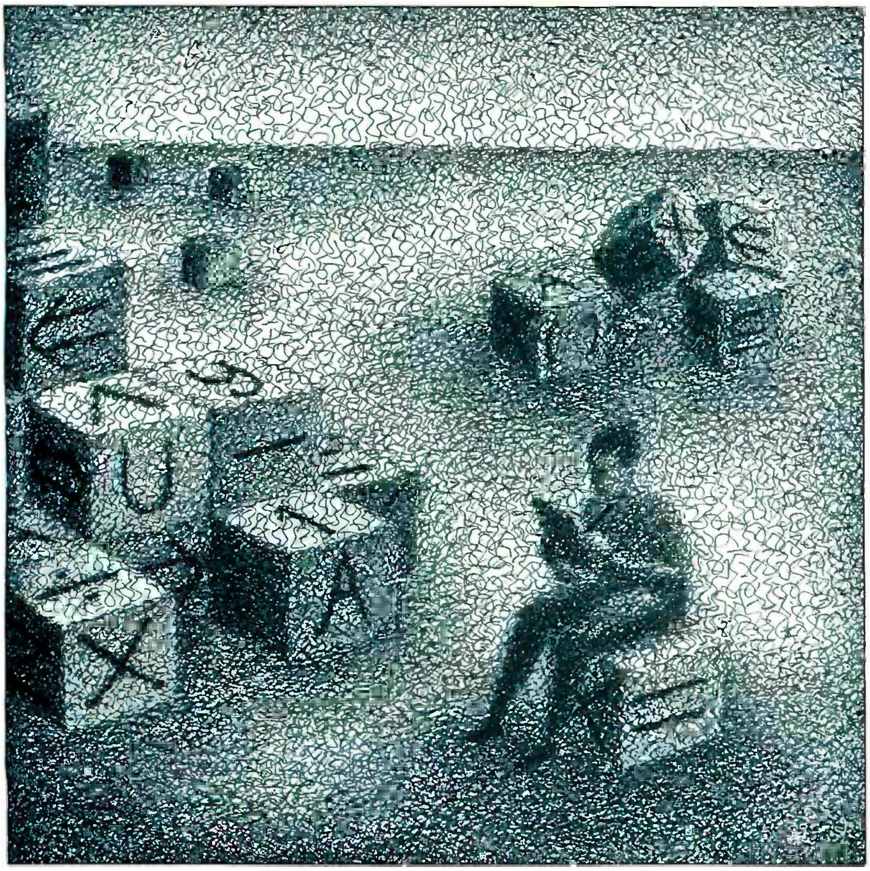
Reaching that goal, however, is like shooting at a moving target. Already Motorola is talking about 25-MHz 68020s, bringing further memory and peripheral interface problems. It often seems that engineers are good at creating more work for themselves. Let's hope that while we press on with faster and faster technologies, the tools we leave behind get into the hands of the applications programmers who can put them to good use. ■

BY C. A. R. HOARE

MATHEMATICS OF PROGRAMMING

Mathematical laws help programmers control the complexity of tasks

Editor's note: This article contains the text of the speech given by Tony Hoare at the Boston Computer Museum on the occasion of BYTE's 10th Anniversary celebration. For practical reasons, some of the author's original notation has been modified slightly.



I hold the opinion that the construction of computer programs is a mathematical activity like the solution of differential equations, that programs can be derived from their specifications through mathematical insight, calculation, and proof, using algebraic laws as simple and elegant as those of elementary arithmetic. Such methods of program construction promise benefits in specifications, systems software, safety-critical programs, silicon design, and standards.

PRINCIPLES

To substantiate this opinion, I begin with four basic principles:

1. Computers are mathematical machines. Every aspect of their behavior can be defined with mathematical precision, and every detail can be deduced from this definition with mathematical certainty by the laws of pure logic.
2. Computer programs are mathematical expressions. They describe, with unprecedented precision and in the most minute detail, the behavior, intended or unintended, of the computer on which they are executed.
3. A programming language is a mathematical theory that includes concepts, notations, definitions, axioms, and theorems. These help a program-

(continued)

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ILLUSTRATED BY DAVE RIDLEY

mer develop a program that meets its specification and prove that it does.
4. Programming is a mathematical activity. Like other branches of applied mathematics and engineering, its successful practice requires the determined and meticulous application of traditional methods of mathematical understanding, calculation, and proof.

HOWEVER . . .

These are general philosophical and moral principles, but all the actual evidence is against them. Nothing is as I have described it, neither computers nor programs nor programming languages nor even programmers.

I find digital computers of the present day to be very complicated and rather poorly defined. As a result, it is usually impractical to reason logically about their behavior. Sometimes, the only way of finding out what they will do is by experiment. Such experiments are certainly not mathematics. Unfortunately, they are not even science, because it is impossible to generalize from their results or to publish them for the benefit of other scientists.

Many computer programs of the present day are of inordinate size—many thousands of pages of closely printed text. Mathematics has no tradition of dealing with expressions on this scale. Normal methods of calculation and proof seem wholly impractical to conduct by hand, and 15 years of experience suggest that computer assistance can only make matters worse.

Programming languages of the present day are even more complicated than the programs you write with them and the computers on which they are intended to run. Valiant research has attempted to formulate mathematical definitions of these standard languages. But the size and complexity of those definitions make them impractical in deriving useful theorems or proving relevant properties of programs.

Finally, many programmers of the present day have been educated in ignorance and fear of mathematics. Of course, many programmers are mathematical graduates who have acquired a good grasp of topology, calculus, and group theory. But it never seems to occur to them to take advantage of their mathematical skills to define a programming problem and search for its solution.

Our present failure to recognize and use mathematics as the basis for a programming discipline has a number of notorious consequences. They are the same as you would get from a similar neglect of mathematics in drawing maps, marine navigation, bridge building, air-traffic control, and exploring space. In the older branches of science and engineering, the relevant physical and mathematical knowledge is embodied in a number of equations, formulas, and laws, many of which are simple enough to be taught to schoolchildren. The practicing scientist or engineer will be intimately familiar with these laws and will use them explicitly, or even instinctively, to find solutions to otherwise intractable problems.

What then are the laws of programming that would help programmers control the complexity of their tasks? Many programmers would be hard-pressed to name a single one.

ARITHMETIC

But the laws of programming are as simple, as obvious, and as useful as the laws in any other branch of mathematics, for example, elementary arithmetic. Consider the multiplication of numbers. Figure 1 shows some of the relevant algebraic laws: Multiplication is associative; its identity (or unit) is the number 1; it has the number 0 as its zero (or fixed point); and, finally, it distributes through addition. Figure 2 gives the defining properties of an ordering relation ($\leq$) like comparison of the magnitude of numbers. Such an order is reflexive, antisymmetric, and transitive. These laws hold also for a partial ordering like the inclusion relation between sets.

Figure 3 describes the properties of the least upper bound, or LUB, of an ordering, denoted by the cup notation ($\cup$). These laws are equally valid, whether the LUB is the union of two sets or the greater of two numbers. The first law states the fundamental property that the LUB is an upper bound on both its operands, and it is the least of all such bounds. The remaining laws are derived from the fundamental law by the properties of ordering. They state that the LUB operator is idempotent (i.e., $x \cup x = x$), symmetric, and associative. Finally, the partial ordering can itself be defined in terms of LUB.

Figure 4 shows some additional laws that hold for natural numbers or nonnegative integers. Here, the LUB of two numbers is simply the greater of them. If you multiply the greater of x or y by z, you get the same result as multiplying both x and y by z and choosing the greater of the products. This fact is clearly and conveniently stated in the laws of distribution of multiplication through the LUB. An immediate consequence of these laws is that multiplication is a monotonic operator, in the sense that it preserves the ordering of its operands. If you decrease either factor, the product can only decrease, too, as stated in

$$x \times (y \times z) = (x \times y) \times z$$
$$x \times 1 = 1 \times x = x$$
$$x \times 0 = 0 \times x = 0$$
$$(x + y) \times z = (x \times z) + (y \times z)$$

Figure 1: *Some algebraic laws relevant to the multiplication of numbers.*

$$x \leq x$$
$$x \leq y \;\&\; y \leq x \rightarrow x = y$$
$$x \leq y \;\&\; y \leq z \rightarrow x \leq z$$

Note: $\leq$ can be interpreted as "is a subset of"; $\rightarrow$ denotes "implies"; & denotes "and."

Figure 2: *Defining properties of an ordering relation or a partial ordering.*

$$(x \cup y) \leq z \leftrightarrow x \leq z \;\&\; y \leq z$$
$$x \cup x = x$$
$$x \cup y = y \cup x$$
$$x \cup (y \cup z) = (x \cup y) \cup z$$
$$x \leq y \leftrightarrow x \cup y = y$$

Note: $\leftrightarrow$ denotes "is equivalent to."

Figure 3: *Properties of the least upper bound of an ordering.*

the last law of figure 4.

In the arithmetic of natural numbers, multiplication does not in general have an exact inverse. Instead, we commonly use a quotient operator—which approximates the true result from below. It is obtained from normal integer division by just ignoring the remainder. Thus, the result of dividing y by nonzero z is the largest number such that when you multiply it back by z, the result still does not exceed y. This fact is clearly stated in the first law of figure 5. The same fact is stated more simply in the second law, which I will call the fundamental law of division.

Other properties of division can be easily proved from the fundamental law. For example, the third law of figure 5 is proved by substituting y divided by z for x in the first law. The last law states that division by a product is the same as successive division by its two factors. A proof is given in figure 6. The proof shows that any w that is bounded by the left-hand side of the equation is bounded also by the right-hand side, and vice versa; it follows by the properties of partial ordering that the two sides are equal. The only laws used in the main part of the proof are the associativity of multiplication and the fundamental law of division, which is used three times to move a divisor from one side of the inequality to the other.

PROGRAMS

I have selected these laws to ensure that computer programs satisfy the same laws as elementary arithmetic. I will write programs in a mathematical notation first introduced by Edsger W. Dijkstra. Some of the commands are summarized as follows:

- The SKIP command terminates but does nothing else. In particular, it leaves the values of all variables unchanged.
- The ABORT command is at the other extreme. It may do anything whatsoever, or it may fail to do anything whatsoever. In particular, it may fail to terminate. A computer that has "gone wrong" or a program that has run wild, perhaps by corrupting its own code, can behave this way. You would not want to write an ABORT command; in fact, you should take pains to prove that you have not created such a situation by accident. In such proofs, and in the general mathematics of programming, ABORT plays a valuable role. However much we dislike it, there is ample empirical evidence for its existence.
- The sequential composition of two commands x and y is written $(x \oplus y)$. This starts behaving like x. If and when x terminates, y starts in an initial state equal to the final state left by x. The composition $(x \oplus y)$ terminates when y terminates but fails to terminate if either x or y fails to do so.

The basic algebraic laws for sequential composition are given in figure 7. The first law of associativity states that if three commands are combined sequentially, it does not matter in which way they are bracketed. The second law gives SKIP as the unit of composition. It states that a command x remains unchanged when it is either followed or preceded by SKIP. The third law gives ABORT as a zero for composition. You cannot recover from abortion by preceding it or following it by any other command. These three algebraic laws for composition are the same as those for multiplication of numbers.

The next important feature of programming is the conditional. Let b be a logical expression that in all circumstances evaluates to a logical value, true or false. If x and y are commands, the notation

$x \not< b \not> y$ (x if b else y)

denotes the conditional command. If the logical expression b is true, the command x is obeyed and y is omitted. If the result is false, y is obeyed and x is omitted. This informal description you will find summarized in the first law of figure 8.

Interpreting the if symbol $\not<$ and the else symbol $\not>$ to be brackets surrounding the logical expression b, the notation $\not< b \not>$ appears as an infix operator between two commands x and y. The reason for this novel notation is that it simplifies the expression and use of the relevant algebraic laws. For example, the conditional $\not< b \not>$ is idempotent (i.e., $x \not< b \not> x = x$) and associative, and it distributes through $\not< c \not>$ for any logical expression c. Finally, sequential composition distributes leftward (but not rightward) through a conditional.

Figure 9 shows a picture of the conditional as a structured flowchart. Such pictures are useful in first presenting a new idea and in committing it to memory. But pictures are quite unsuitable for expressing algebraic laws or for mathematical reasoning. Unfortunately, some problems are so widespread and so severe that flowcharts must be recommended and actually welcomed as their solutions.

Listing 1 shows the expression of the structure of a conditional in BASIC. Programming in BASIC is like doing arithmetic with roman numerals. For simple tasks like addition and subtraction, roman numerals are easier than arabic because you do not first have to learn 100 facts about the

(continued)

$x \cup y$ = the greater of x and y
$(x \cup y) \times z = (x \times z) \cup (y \times z)$
$z \times (x \cup y) = (z \times x) \cup (z \times y)$
$w \leq y \;\&\; x \leq z \rightarrow w \times x \leq y \times z$

Figure 4: *Some additional laws for natural numbers or nonnegative integers.*

if $z \neq 0$
$y \div z = \max \{x \mid x \times z \leq y\}$
$x \leq (y \div z) \leftrightarrow (x \times z) \leq y$
$(y \div z) \times z \leq y$
$x \div (y \times z) = (x \div z) \div y$

Figure 5: *Properties of division of natural numbers.*

Given $y \neq 0$ and $z \neq 0$
$w \leq x \div (y \times z)$
$\leftrightarrow w \times (y \times z) \leq x$
$\leftrightarrow (w \times y) \times z \leq x$
$\leftrightarrow w \times y \leq x \div z$
$\leftrightarrow w \leq (x \div z) \div y$

Figure 6: *A proof of the last law of division given in figure 5.*

addition and subtraction of the 10 digits, and you avoid most of the complications of carry and borrow.

The disadvantages of roman numerals become apparent only in more complex tasks like multiplication, or worse, division for which the only known technique is trial and error. You have to guess the solution, test it by multiplying it by the divisor and comparing the dividend, and make a new guess if you are wrong. This is the way we teach beginners in BASIC, but division of roman numerals is much easier because the fundamental law of division tells you whether the new guess should be smaller or greater than the last.

Thankfully, arabic numerals have displaced roman ones in our schools, and the effective algorithm for long division has replaced the roman method of trial and error with an orderly process of calculation; when carefully executed, it leads invariably to the correct solution. In cases of doubt, the answer can still be checked by multiplication; but if this discovers an error, you do not try to debug the digits of your answer by trial and error. You go back over the steps of the calculation and correct them—or else you start again.

ABSTRACTION

An abstract command is one that specifies the general properties of a computer's desired behavior without prescribing exactly how that behavior is to be achieved. A simple example of an abstract command is the union, or LUB ($x \cup y$), of two commands x and y, which may themselves be either abstract or concrete. The union command can be obeyed by obeying either of its operands. The choice between them is left open and can be made later by the programmer, the compiler, or even by some device in the computer during program execution. For this reason, abstract programs are sometimes called nondeterministic.

The properties of the union operator (figure 10) are exactly what you would expect. A command to do x or x leaves you no choice but to do x. To do x or y gives you the same choice as y or x. And in a choice between three alternatives, it does not matter in what order you choose between them. Finally, ABORT (as defined above) is the abstract program that allows any behavior whatsoever.

Introducing abstraction permits you to define a useful ordering relation between concrete and abstract commands. If y is an abstract command specifying some desired effect, and x is a concrete command that achieves this effect, you can say that x satisfies y and use the notation used here for a partial order: $x \leq y$.

The command x can also be abstract. If it is, the ordering relation means that x is the same as y or that x is more specific, concrete, or deterministic than y. In either case, x meets the specification y because every possible execution of x is described and therefore allowed by y. As stated in figure 11, the satisfaction relation is a partial order, and the abstraction operator is its LUB.

Abstract commands can be combined by all the same operators as concrete commands. Figure 12 shows that sequential composition distributes through abstract choice in both directions. It follows that composition is monotonic in both its arguments. In fact, all the operators of a programming language are monotonic in this sense. There are good theoretical reasons for this, and there are also

(continued)

Listing 1: *The expression of the structure of a conditional in BASIC.*

```
410 IF b THEN GO TO 554
411
      .
      .
      .
550 GO TO 593
554
      .
      .
      .
593 REM
```

$x \oplus (y.z) = (x \oplus y) \oplus z$
SKIP $\oplus\, x = x = x \,\oplus$ SKIP
ABORT $\oplus\, x$ = ABORT = $x \,\oplus$ ABORT

Note: $\oplus$ denotes "composition."

Figure 7: *The basic algebraic laws for sequential composition of commands.*

$(x \not< \text{true} \not> y) = x = (y \not< \text{false} \not> x)$
$(x \not< b \not> x) = x$
$x \not< b \not> (y \not< b \not> z) = (x \not< b \not> y) \not< b \not> z$
$\quad = x \not< b \not> z$
$x \not< b \not> (y \not< c \not> z) = (x \not< b \not> y) \not< c \not> (x \not< b \not> z)$
$(x \not< b \not> y) \oplus z = (x \oplus z) \not< b \not> (y \oplus z)$

Note: $\not<$ denotes "if"; $\not>$ denotes "else."

Figure 8: *The conditional operator.*

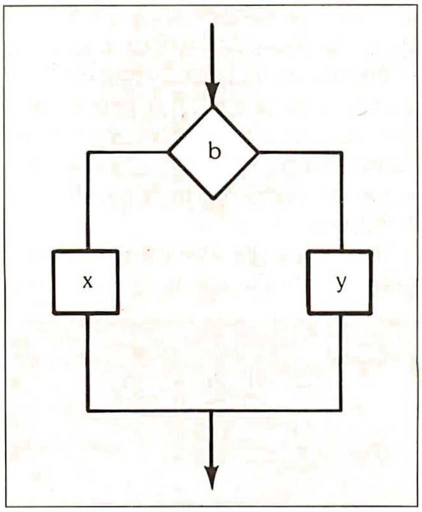


Figure 9: A *picture of the conditional as a structured flowchart.*

$x \cup y$ behaves like x or y
$x \cup x = x$
$x \cup y = y \cup x$
$x \cup (y \cup z) = (x \cup y) \cup z$
$x \cup$ ABORT = ABORT

Figure 10: *Properties of the union, or abstraction, operator.*

$x \leq y \leftrightarrow x \cup y = y$
$\leftrightarrow x$ satisfies specification y
$x \leq x$
$x \leq y \,\&\, y \leq x \rightarrow x = y$
$x \leq y \,\&\, y \leq z \rightarrow x \leq z$
$(x \cup y) \leq z \rightarrow x \leq z \,\&\, y \leq z$

Figure 11: *The satisfaction relation* ($\leq$), *a partial order, with the abstraction operator* ($\cup$) *as its LUB.*

very beneficial consequences for the practical solution of programming problems.

REFINEMENT

The task of a programmer can be described as a problem in mathematics. You start with an abstract description of what you want the computer to do, carefully checking that it is an accurate description of the right problem. This is often the most difficult part of the task and requires the most powerful tools. So in the specification y, you should take advantage of the full range of concepts and notations of mathematics, including concepts that cannot be represented on a computer and operations that could not be implemented in a programming language.

You must then find some program x that solves the inequality $x \leq y$, where y is the specification of the program. Mathematics provides many formulas and methods for solving equations (and inequalities), from linear and quadratic to differential and integral. In all cases, the derivation of a solution can use the full power of mathematics, but the solution itself must be expressed as a formula in some more restricted notation. The same is true in programming, where the eventual solution must be expressed in the restricted notations of an implemented concrete programming language.

The most powerful general method of solving a complicated problem is to split it into simpler subproblems, which can then be solved independently. The same method can be applied again to the subproblems until they are simple enough to solve directly by some other more direct method. In the case of computer programming, this is often called *top-down development* or *stepwise refinement* (see figure 13). You start with the problem of finding some command x (expressed in a concrete programming language) that meets the specification y (expressed in the abstract language of mathematics). The first step requires the insight to split this task into two subproblems and the skill to specify them as abstract programs v and w. Before proceeding further, you prove the correctness of your design so far by showing that the sequential composition of v and w meets the original specification y, or more formally, $v \oplus w \leq y$.

Now these two subproblems v and w can be solved sequentially or concurrently by a single programmer or by two teams of programmers, according to the size of the task. When both subproblems are solved, you will have two commands, t and u, expressed in the restricted notations of your chosen programming language, each meeting their respective specifications: $t \leq v$ and $u \leq w$. All that remains is to deliver their sequential composition ($t \oplus u$) as a solution to the original problem y. Correctness of the solution has been established not by the traditional laborious and ultimately unsound method of integration testing and debugging after the components have been constructed, but rather by a mathematical proof, which was completed on the very first step, even before the construction of components began.

The validity of the general method of top-down development depends on monotonicity of the composition operator and transitivity of the abstraction ordering. The method can therefore be applied to any other operator of a concrete programming language. It has been treated at length in many learned articles and books. A characteristic of the simplifying power of mathematics is that the whole method can be described, together with a proof of its validity, within the seven lines of figure 13.

I have drawn an analogy between the multiplication of natural numbers and the sequential composition of commands in programming. This analogy extends even to division. As with division of natural numbers, the quotient of two commands is not an exact inverse. However, it is uniquely defined by the same fundamental law, as shown in figure 14. The quotient of y divided by z is the most abstract specification of a program x, which, when followed by z, is sure to meet the specification y. As a consequence, the quotient itself, when followed by z, meets the original specification. And, finally, when the divisor is the composition of two commands, you can calculate the quotient by successively dividing by these two commands in the reverse order. Since the composition of commands is not symmetric, the reversal of order is important here.

In factoring large numbers, division saves a lot of effort: You only have to guess one of the factors and obtain the other one by calculation. The division of commands offers the same advantages in the factorization of pro-

(continued)

$$(x \cup y) \oplus z = (x \oplus z) \cup (y \oplus z)$$
$$z \oplus (x \cup y) = (z \oplus x) \cup (z \oplus y)$$
$$w \leq y \;\&\; x \leq z \rightarrow w \oplus x \leq y \oplus z$$

Figure 12: *Sequential composition of commands distributes through abstract choice in both directions.*

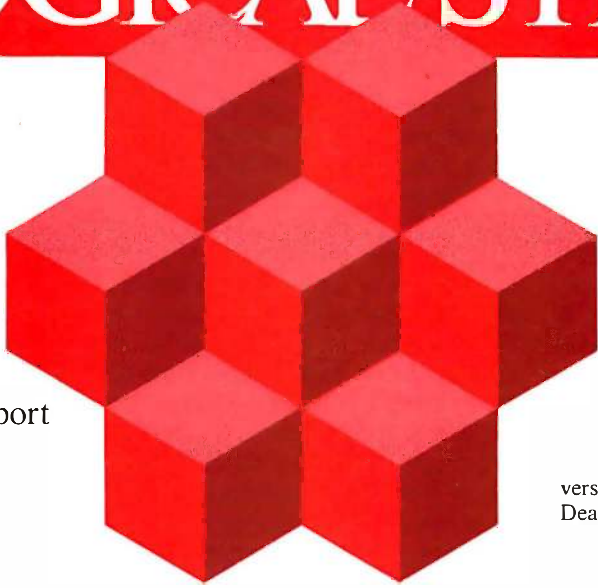
Problem: find x such that $x \leq y$
Step 1: find v,w such that $v \oplus w \leq y$
Step 2a: find t such that $t \leq v$
Step 2b: find u such that $u \leq w$
Step 3: deliver $t \oplus u$
Proof: $t \oplus u \leq v \oplus w$ $\oplus$ is monotonic
$\therefore\ t \oplus u \leq y$ $\leq$ is transitive

Figure 13: *Top-down development or stepwise refinement.*

$$(x \oplus z) \leq y \leftrightarrow x \leq (y \div z)$$
$$(y \div z) \oplus z \leq y$$
$$x \div (y \oplus z) = (x \div z) \div y$$

Figure 14: *The fundamental law of the quotient of commands. Like the division of natural numbers, the quotient of two commands is not an exact inverse of their multiplication.*

TAKE THE NEXT LOGICAL STEP



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gramming problems. In refinement, it replaces the guesswork required in discovering two simpler subtasks by the discovery of only the second of them, as shown in figure 15. Furthermore, the proof obligation in step 1 of figure 15 has been eliminated. It is replaced by a formal calculation of the weakest specification that must be met by the first operand of the composition. Reducing guesswork and proof to calculation is how mathematicians simplify their own tasks, as well as those of users of mathematics—the scientist, the engineer, and now the programmer.

The quotient operator for commands was discovered in a slightly restricted form by Dijkstra, who called it the weakest precondition (see reference 1). It is one of the most effective known methods for the design and development of correct algorithms, as shown in numerous examples by David Gries in reference 2.

PROGRAM MAINTENANCE

In my description of the task of a programmer, I have concentrated on the more glamorous part of that task: specifying, designing, and writing new programs. But a significant portion of a programmer's professional life is spent making changes to old programs. Some of these changes are necessitated by the discovery of errors, some by changes in the specification of the program's desired behavior. The program and the specification may be so large that it is not practical to write a new program from scratch; when only a small part of the specification is changed, you hope that only a small part of the program will need changing to meet it.

Of course, such a hope is not always justified. Consider again the analogy of the division of numbers. A small change in the least significant digits of the dividend results in a small change in the least significant digits of the quotient and can be achieved by a small amount of recalculation. But a small change in the most significant digit of either operand requires that you start the calculation again, leading to a completely different result. In the case of programs, it is often difficult to know which small changes in a large specification will require major changes to the program.

It is, therefore, most important for the original programmer to decide which parts of a specification are most likely to be changed and to structure the program design so that a change to one part of the specification requires a change to only one part of the program. The programmer should then document the program with instructions on how to carry out the change. This too can be done in a rigorous mathematical fashion (see figure 16). Let y be that part of a complete specification $g(y)$ that is liable to change. Let x be that command in a big program $f(x)$ that is designed to change when y changes. The problem now is to change x to x' so that $f(x')$ meets the changed specification $g(y')$.

The problem of program maintenance is most easily solved when the structure of the program f is the same as the structure of the specification g; in this case, it will be sufficient to ensure that the modified component meets the modified specification.

However, it is not always possible to preserve the structure of a specification in the design of a program. A specification is often most clearly structured with the aid of logical operators like negation and conjunction, which are not generally available in an implemented programming language. Nevertheless, mathematics can often help. Sometimes, the program f has an approximate inverse (f^{-1}), defined in the same way as for the quotient; it is then possible to calculate the proof obligation of the modified program as $x \leq f^{-1}(g(y'))$.

IN REALITY

I must inject a note of realism into my mathematical speculations. Many operators of a programming language do not have suitable approximate inverses, and even if they do, their calculation is impossibly cumbersome. Would you like to calculate the inverse of f, when f is a million lines of FORTRAN code? The problem of the size of mathematical formulas is exactly the same problem that limits the use of mathematics in other branches of science and engineering. Many scientists believe as fervently as I do in the principle that the whole of nature is governed by mathematical laws of great simplicity and elegance, and brilliant scientists have discovered many laws that accurately predict the results of experiments conducted in a rigorously controlled laboratory environment. But when the engineer tries to apply the same laws in practice, the number of uncontrollable variables is so much greater than in the laboratory that a full calculation of the consequences of each design decision is hopelessly impractical. As a result, the engineer uses experience and understanding to formulate and apply various rules of thumb, and uses flair and judgment to supplement (though never to replace) the relevant mathematical calculations.

Experienced programmers have developed a similar intuitive understanding of the behavior of computer programs, many of which are now remarkably sophisticated and reliable. Nevertheless, I would suggest that the skills of our best programmers will be even more productive and effective when exercised within the framework of understanding and applying the relevant mathematics. The mathematics has been demonstrated on

(continued)

Problem: find x such that $x \leq y$
Step 1: choose suitable z
Step 2a: find t such that $t \leq y \div z$
Step 2b: find u such that $u \leq z$
Step 3: deliver $t \oplus u$
Proof: $t \oplus u \leq (y \div z) \oplus z$ — $\oplus$ is monotonic
$(y \div z) \oplus z \leq y$ — property of $\div$
$\therefore\ t \oplus u \leq y$ — $\leq$ is transitive

Figure 15: *A simplification of figure 13, using division of commands.*

Given: $f(x) \leq g(y)$
Problem: find x' such that $f(x') \leq g(y')$
Case 1: $f = g$
solve $x' \leq y'$
Case 2: f has approximate inverse f^{-1}
solve $x' \leq f^{-1}(g(y'))$

Figure 16: *Mathematical treatment of program maintenance.*

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small examples, as it were, in the laboratory. The time has come to *start* the process of scaling up to an industrial environment. At Oxford University, we have a number of collaborative projects with industry to attempt this technology transfer. Preliminary indications are quite promising, both for advances in theory and for benefits in practice.

But it will be no easier to change the working habits of programmers than those of any other profession. I quote from Lord Hailsham, the British minister in charge of our judicial system (see reference 3). He is conducting a review on the improvement of judicial practices in the legal profession. He first lists the faults of our current system, including delay, complexity, and obscurity. He continues: "A change in working methods is of course immensely difficult. Habit, interest, training all militate in favour of the status quo. People must be persuaded, taught, if necessary possibly even leaned on—or at least assisted."

Pilot schemes may be necessary to test new methods. They may be unpopular, "but if the alternative is to let all cases to continue subject to the anomalies of a malfunctioning system, we may have to contemplate unprecedented arrangements to allow new methods to be tested."

Changes in professional practice will be just as difficult for programmers as they are for lawyers and judges. They will occur first in the areas of greatest necessity, where the lack of mathematical precision leads to the heaviest costs. In particular, I suggest five such areas: specifications, systems software, standards, silicon structures, and safety.

SPECIFICATIONS

In the initial specification and design of a large-scale software product, the use of mathematics has been found to clarify design concepts and enable you to explore a wide variety of options at a time when less successful alternatives can be cheaply discarded. As a result, the final agreed-upon specification may enjoy that simplicity and conceptual integrity that characterizes the highest quality in design.

(continued)

Furthermore, user's manuals, tutorials, and guides that are based on mathematical specifications can be better structured, more complete, and more comprehensible, even to users who have no knowledge of the underlying mathematics. This promises to mitigate the greatest single cause of error, inconvenience, and customer frustration in the use of sophisticated software products, that is, failure to read and understand the user's manual.

SYSTEMS SOFTWARE

A computer's basic systems software includes items like an operating system, language compilers, utilities, transaction-processing packages, and database management systems. These programs are written by large teams of programmers and are delivered to thousands or millions of customers, who use them daily, hourly, or even continuously. In the years after delivery of such software, many thousands of errors are discovered by the customers themselves; each error must be laboriously analyzed, corrected, and retested; and the corrections must be delivered to and installed by the customer in the next release of the software. A reduction in the number of corrections needed would be cost-effective for the supplier and convenient for the customer. A reduction in the number of errors discovered before delivery of the software could also save a lot of money. No method by itself can guarantee absolute reliability. However, in combination with management control, a mathematical approach looks promising. Even when mistakes are made, they can be traced to their source, and steps can be taken to ensure they do not happen again.

STANDARDS

The standardization of languages and interfaces in hardware and software is a vital precondition for free competition and for the propagation of technical advances. The construction of a mathematical specification for these standards offers the same promise of improved quality in design that I have just described; it also offers a hope of reducing the ambiguities and misunderstandings which lead to errors and incompatibility in various implementations of the standard, and which have prevented us from obtaining full benefit from the existing standards.

SILICON STRUCTURES

The advance of technology in very-large-scale integration now makes it possible to build hardware as complex as software. As a result, we are beginning to detect as many design errors during the manufacture and testing of complex devices as we have been finding with software. But now each error costs many thousands of dollars to remove; what is worse, by delaying the introduction of a new device onto the market, these errors can prevent an innovative company from assuming market leadership or even prejudice its survival. As a result, many products are delivered with known design errors, for which the customer will never obtain a correction or restitution. Fortunately, mathematical methods similar to those for sequential programs can be adapted to check logic designs. These methods are especially valuable when the design involves concurrency or parallelism.

SAFETY

Computer programs are increasingly used in systems that are critical to the safety of the general public—control of railway signaling, airplane engines, and chemical and nuclear processes. The engineering techniques used in these systems are subject to the most rigorous analysis and control, often enforced by law. Mathematical methods offer the best hope of extending such control to computer software, and when this happens, a program could gain a reputation as the most reliable component of any system in which it resides.

CONCLUSION

These are the five areas in which I believe the introduction of mathematical methods gives the greatest promise of rapid economic return. But their implementation will require a significant change in working habits and working attitudes, not only of individual programmers but of whole teams and departments. It requires the enthusiastic participation of coders, systems analysts, project leaders, and managers at all levels. It involves reforming the curricula in training departments, colleges, and universities. It even requires educating the general public to demand and expect as much—or more—quality and design integrity from computer programs as they do from other products critical to their economic and physical well-being.

That is why I am pleased and grateful for this opportunity to address you on the 10th anniversary of the foundation of BYTE magazine. This is a magazine that has a deservedly wide readership in our profession, ranging from theoretical computer scientists through lecturers, teachers, managers, engineers, and students to home computer enthusiasts. But it is also a magazine that takes seriously its responsibility to propagate improved methods and higher standards in the programming profession. I salute its ideals and achievement and wish it continued prosperity and progress.■

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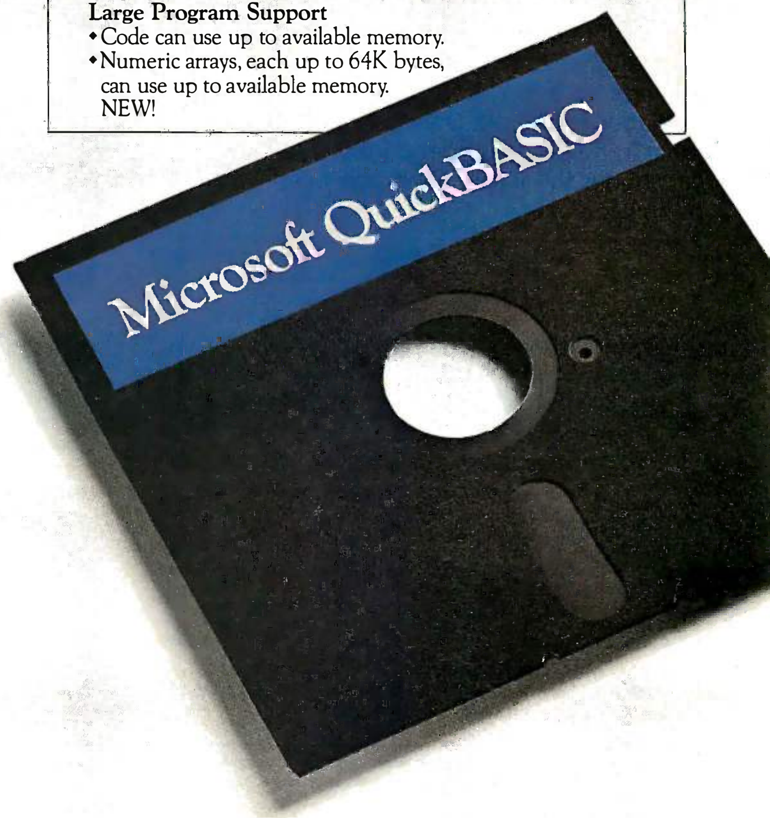

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POLAR NORMAL DISTRIBUTION

BY ALAIN LATOUR

Generate normal deviates and evaluate the cumulative probability of a normally distributed random variable

IN THE OCTOBER 1985 BYTE, Arthur G. Hansen suggested a way to generate normal deviates (Programming Insight: "Simulating the Normal Distribution"). Basically, a normal deviate is obtained by considering the value

$$X = (U_1 + U_2 + \ldots + U_n - n/2)/\sqrt{(n/12)}$$

where $U_1, U_2, \ldots, U_n$ are independent uniform numbers between 0 and 1. The value of X can be considered as a normal deviate with mean $\mu = 0$ and standard deviation $\sigma = 1$, if n is sufficiently large. As reported by Abramowitz and Stegun (reference 1), "When $n = 12$, the maximum errors made in the normal deviate are 9×10^{-3} for $|X| < 2$, 9×10^{-1} for $2 < |X| < 3$." But if n is too small, we have only an "approximate normal distribution."

THE POLAR METHOD

I would like to suggest a relatively simple approach, known as the "polar method," proposed by G. E. P. Box, M. E. Muller, and G. Marsaglia, which is proven in reference 2. Here is the pseudocode of the algorithm:

Repeat
1) Get 2 independent random variables, V_1 and V_2, uniformly distributed between -1 and 1.
2) Evaluate $S := (V_1)^2 + (V_2)^2$
until $S < 1$.
Evaluate $S := \sqrt{-2\ ln(S)/S}$
Set $X_1 := V_1S$ and $X_2 := V_2S$.

The two random numbers X_1 and X_2 are independent normal variables. If the uniform generator used returns a number U between 0 and 1, you just have to set $V = 2U - 1$ to obtain a number between -1 and 1. The square root and the logarithm functions must be evaluated for each pair of normal deviates.

Although the algorithm is complex, its advantage is that you obtain numbers really distributed as normal deviates, and fewer uniform deviates are needed. The last point may be an important one. For example, the random-number generators available on some personal computers cannot produce a sequence of numbers longer than 65,536 without cycling.

CLASSIFYING THE OBSERVATIONS

Suppose you know that almost all the observations will fall between the limits *Y*Min and *Y*Max. That would mean that the data range is approximately *Y*Range = *Y*Max − *Y*Min. To classify the values in *Nb* classes where *Y* is an observed value, you can use

Trunc((*Y* − *Y*Min)/*Y*Range × *Nb*)

For example, if *Y* = *Y*Min, the above statement will produce 0. And you could use the extreme classes to collect extreme values.

I have written a short Pascal program called NORMAL.PAS that generates 10,000 normal deviates and sorts them into 30 classes as they are generated. The results could be used to plot the observed distribution of the numbers generated. [*Editor's note:* NORMAL.PAS *is available in a variety of formats; see page 405 for details.*]

THE CUMULATIVE PROBABILITY FUNCTION

If you're interested in comparing the simulated distribution with the theoretical distribution, you must

(continued)

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evaluate the probability of each class. One way to do it is by tedious calculations using a table of probability. Another, more interesting way is to write a function that, given a number x, will give you the probability that a normal deviate will be less than or equal to x. We will denote this probability by $P[z \leq x]$. There is a polynomial approximation of degree 5 to this probability that is quite good (see reference 1). It requires the evaluation of the density function of a normal variable, that is:

$$f(x) = c\, e^{-x^2/2}$$

To compare the simulated distribution with the theoretical distribution, you must evaluate the probability of each class.

where c is a constant equal to $1/\sqrt{(2\pi)} = 0.3989422804$. So, for $x \geq 0$, we have

$$P[z \leq x] = 1 - f(x)\, t\, (b_0 + b_1 t + b_2 t^2 + b_3 t^3 + b_4 t^4) + \text{error}$$

where $t = 1/(1 + px)$ with $p = 0.2316419$ and where $b_0 = +0.319381530$, $b_1 = -0.356563782$, $b_2 = +1.781477937$, $b_3 = -1.821255978$, and $b_4 = +1.330274429$. The error is less than 7.5×10^{-8}. If $x < 0$, you can use the well-known property of the normal curve, $P[z \leq x] = 1 - P[z \leq -x]$. [*Editor's note:* *Both functions are contained in* DENSITY.PAS, *which is available in several formats; see page* 405.]

Figure 1 shows the empirical distribution obtained by the polar method. As you can see, the adjustment seems to be quite good.

Figure 2 shows the empirical distribution obtained by using the sum of three uniforms. Both cases simulated 10,000 deviates. Obviously, the adjustment is not as good as that in figure 1. You can also compare the two methods by evaluating the chi-square measure of adjustment. With 47 degrees of freedom, in the first case we have a chi-square equal to 36; in the second case, the chi-square is equal to 147. In other words, the method using the sum of three uniforms doesn't pass the chi-square test. ■

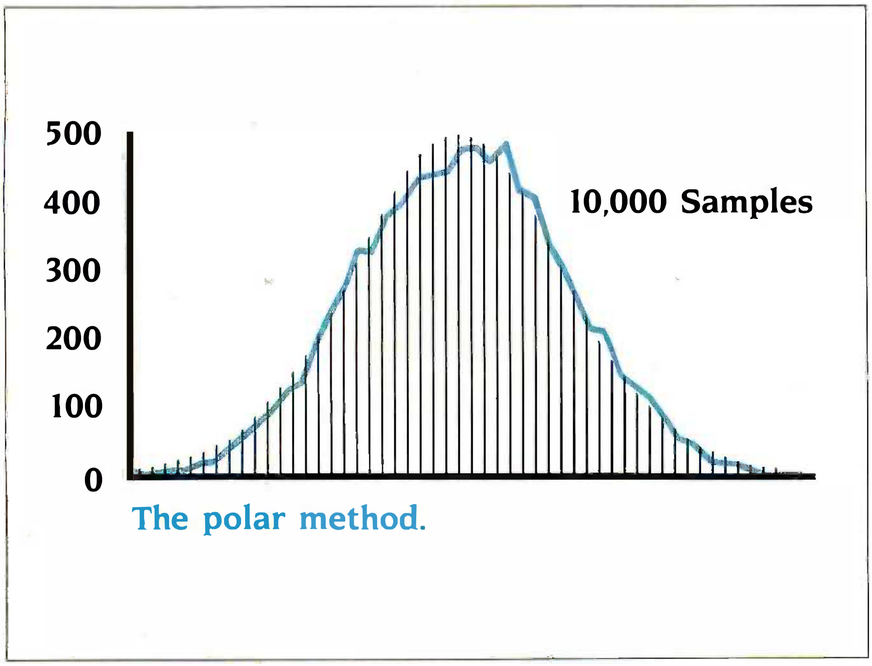

Figure 1: *The empirical distribution obtained by simulating* 10,000 *deviates by the polar method. The adjustment seems to be quite good.*

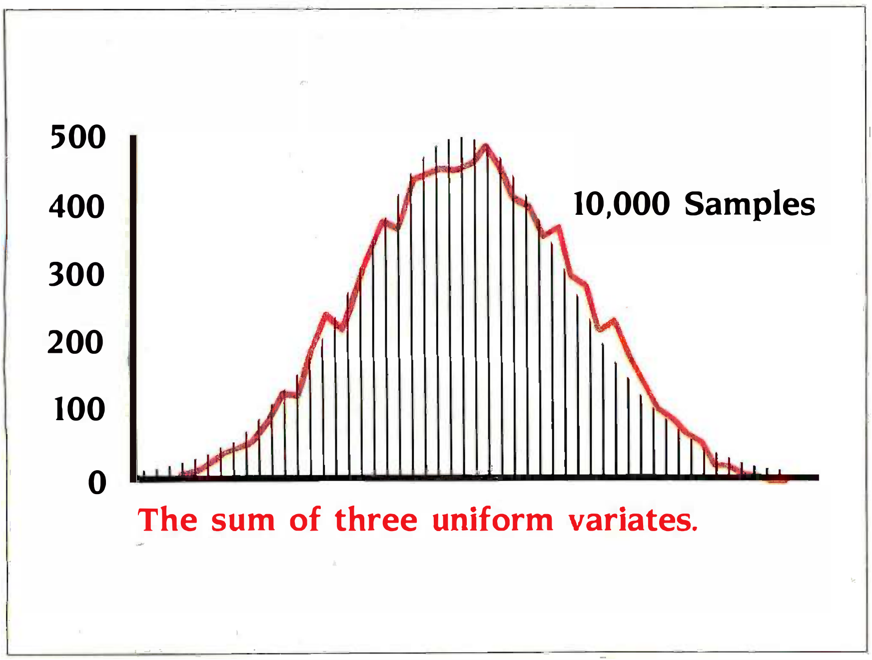

Figure 2: *The empirical distribution obtained by using the sum of three uniforms.*

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2. Knuth, D. *The Art of Computer Programming,* Volume 2. Reading, MA: Addison-Wesley, 1969.

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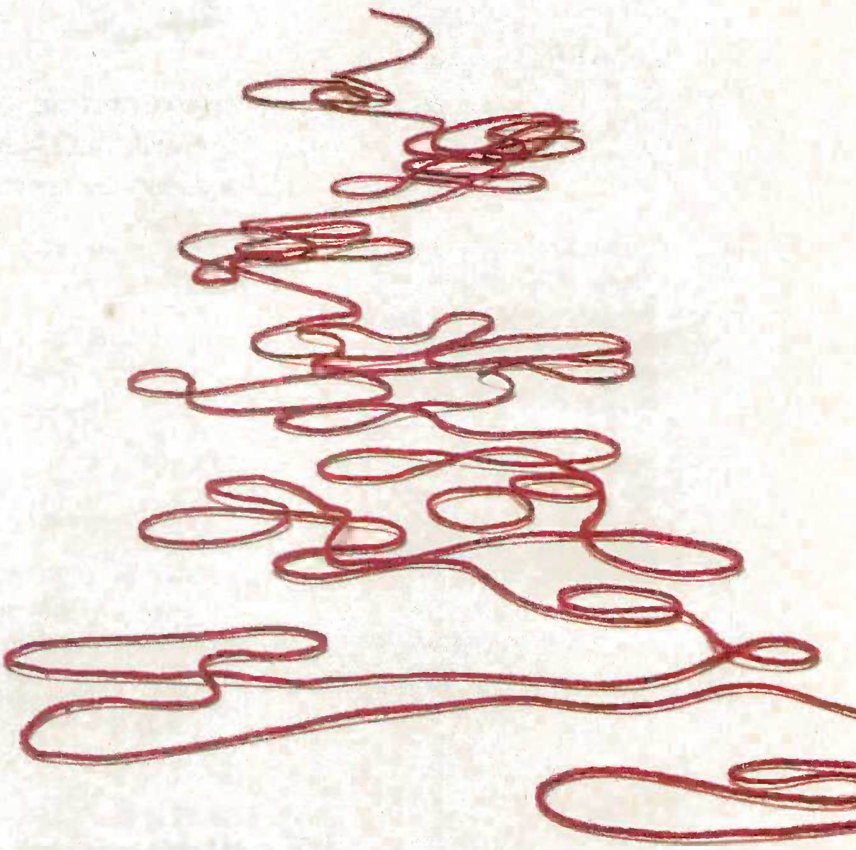

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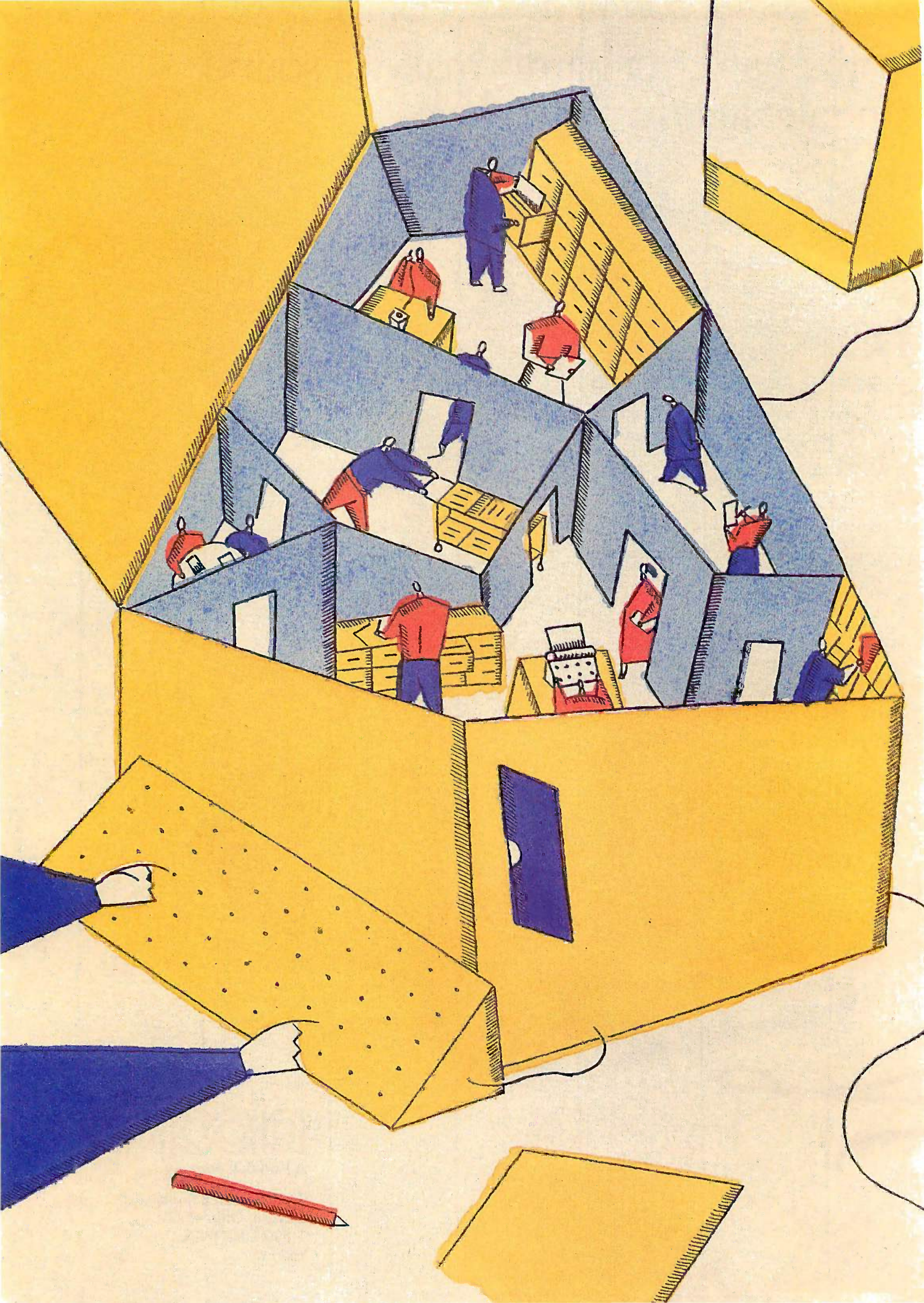

Object-oriented Programming

OBJECT-ORIENTED PROGRAMMING, with its claims of improved programmer productivity and easy program maintenance, is emerging as a vital force in the programming community. This is despite the fact that object-oriented languages were not generally available until fairly recently.

The prototypical object-oriented language is Smalltalk, and in August 1981, BYTE devoted an entire issue to it, even though at the time the language was not commercially available. Today, Smalltalk is available for microcomputers, and object-oriented concepts have been extended to many conventional languages.

In this issue, we present a group of articles examining the current state of object-oriented languages. To start things off, Geoffrey A. Pascoe outlines the basics of the subject in "Elements of Object-oriented Programming." Geoff does a good job of defining exactly what object-oriented programming is and, more important, what it is not.

For those who may have missed our Smalltalk issue, Ted Kaehler and Dave Patterson give the flavor of what it's really like to program in that language in "A Small Taste of Smalltalk," excerpted from their recent book, *A Taste of Smalltalk.*

The microcomputer that is most closely related to the original Smalltalk philosophy and object-oriented programming in general is the Apple Macintosh. And, not surprisingly, a number of object-oriented languages have evolved for that machine. Kurt J. Schmucker explores a number of them in his comprehensive article, "Object-oriented Languages for the Macintosh," comparing seven languages that are now or soon to be available for the Mac. We also convinced Kurt to write a few pages on MacApp, a powerful object-oriented application framework that Apple Computer will be releasing shortly.

Brad Cox, one of the developers of Objective-C, has helped promote the understanding of object-oriented programming by proposing the concept of the software-IC, a software module that can be easily added to a program. Brad, together with Bill Hunt, shows how object-oriented programming techniques make building iconic user interfaces easier in their article, "Objects, Icons, and Software-ICs."

Another early object-oriented language for micros is Neon for the Macintosh. The developer of that language, Charles B. Duff, discusses the inefficiencies of object-oriented languages and ways to improve them in "Designing an Efficient Language."

Finally, we bring back one of the authors from our 1981 Smalltalk issue. Larry Tesler, a former Xerox PARC researcher, presents interviews with people who are actually using object-oriented languages in their various fields of work in "Programming Experiences."

The article by our U.K. correspondent, Dick Pountain, is particularly fitting this month. Dick, a formidable FORTH programmer in his own right, has written his own object-oriented extension to FORTH. In "Object-oriented FORTH" he describes his program and how it works.

—Eva White and Rich Malloy, Technical Editors

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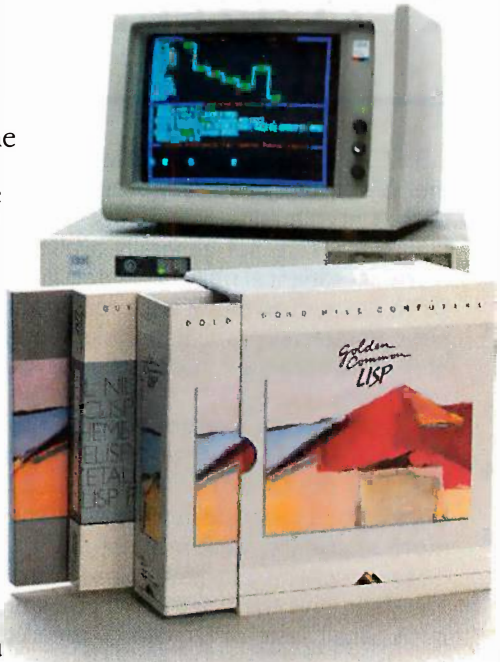

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ELEMENTS OF OBJECT-ORIENTED PROGRAMMING

BY GEOFFREY A. PASCOE

What features must a language have to be considered an object-oriented language?

THERE ARE AS many different views of what object-oriented programming is as there are computer scientists and programmers. Because the term was first used to describe the Smalltalk programming environment developed at Xerox PARC (see references 1–5), this article will present object-oriented programming concepts, terminology, and characteristics from that perspective. I will stress the differences between an object-oriented programming style and the more conventional procedure-oriented style. I hope to show that a language must have four elements to support object-oriented programming: information hiding, data abstraction, dynamic binding, and inheritance. (Some languages that have one or two of these elements have been improperly called object-oriented.) I will follow this with a discussion of the advantages and disadvantages of object-oriented programming languages.

DATA PROCEDURES VS. OBJECT MESSAGES

Most programming languages support the "data-procedure" paradigm. Active procedures act on the passive data that is passed to them. A typical example might be a square root function, sqrt(x), that takes a number and returns its square root.

In a strongly typed language such as Pascal, it would be typical to have a different version of sqrt(x) for each data type of x, usually returning a floating-point result. A late-binding language such as LISP detects x's data type at run time and performs the appropriate operations for that data type. Such generic operations are generally primitives restricted to a small class of data types such as numbers, or they are functions defined in terms of such primitives.

Object-oriented languages employ a data or object-centered approach to programming. Instead of passing data to procedures, you ask objects (data) to perform operations on themselves. To emphasize this difference I will use an object-oriented expression syntax of my own invention. The object name is followed by :operation, followed by any further arguments, and terminated by a period (in some ways the syntax is similar to that of Smalltalk-80, though simpler). For example, an expression to take the square root of x will look like this:

```
x :sqrt.
```

The implication is that x is asked to perform the :sqrt operation on itself. You say that x is the *receiver* of the *message* :sqrt.

A more complicated example would be the dot-product operation. The dot-product of two one-dimensional vectors, x and y, is computed, producing a scalar result:

```
x :dot y.
```

Here, x is told to perform a dot-product operation with itself and the argument y. You could take the square root of the dot product of x and y and assign the result to the variable z in the following manner

```
z ← (x :dot y) :sqrt.
```

(continued)

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using parentheses to indicate the order of evaluation, although the parentheses are really not needed here, assuming left-to-right evaluation.

SOME TERMINOLOGY

The basic terminology of object-oriented programming is illustrated in the text box "Data Structures" on page 142. The object that I have been referring to (i.e., x, in the sqrt example) is an *instance* of a *class*. The class provides all the information necessary to construct and use objects of a particular kind, its instances. (For this reason, a class is sometimes called a *factory*.) Each instance has one class; a class may have multiple instances.

The class also provides storage for *methods*. Methods are simply procedures that are invoked by sending *selectors* to a class's instances (also called sending messages). The methods reside in the class to save storage, since all instances of a class have an identical set of methods. Methods may allocate temporary variables for use during the execution of the method. These temporary variables are much like local variables in Pascal procedures in that their value is lost when you leave the method.

Each instance has storage allocated for maintaining its individual state. The state is referenced by *instance variables*. Instance variables may be primitive data types such as integers, other objects, or both, depending on the language. Each object has its own set of instance variables. Both temporary and instance variables may be freely referenced within the scope of an object's method, but unlike temporary variables the value of instance variables is not lost when you leave the object's method.

Computation is performed by sending messages to objects, which invokes a method in the object's class. Typically, a method sends messages to other objects, which invokes other methods, etc., until you reach the point where a *primitive method* is invoked. Here ends the chain of message-sends. Each message-send eventually returns a result to the sender (e.g., x :sqrt returning the square root of x). The end result of all these message-sends is usually the changing of the state of one or more objects. Sometimes, however, a message is sent simply to invoke some primitive having a side effect external to the world of objects, for example, accessing an external file system or controlling hardware.

To fully support object-oriented programming a language must exhibit four characteristics: information hiding, data abstraction, dynamic binding, and inheritance. I will examine two languages, Ada and Modula-2, that have been mistakenly called object-oriented in order to illustrate why all four characteristics are necessary and why conventional procedure-oriented languages cannot adequately support object-oriented programming.

INFORMATION HIDING

Information hiding is important for ensuring reliability and modifiability of software systems by reducing interdependencies between software components. The state of a software module is contained in private variables, visible only from within the scope of the module. Only a localized set of procedures directly manipulates the data. In addition, since the internal state variables of a module are not directly accessed from without, a carefully designed module interface may permit the internal data structures and procedures to be changed without affecting the implementation of other software modules.

Most modern languages, even FORTRAN, to some degree, support information hiding. ISO (standard) Pascal is one notable exception, since it provides no way to declare static variables within the scope of a procedure.

DATA ABSTRACTION

Data abstraction could be considered a way of using information hiding. A programmer defines an abstract data type consisting of an internal representation plus a set of procedures used to access and manipulate the data. Modula-2 provides excellent data abstraction mechanisms. Listing 1 is a fragment of Modula-2 module that implements a stack as an abstract data type (called an *opaque type* in Modula-2 terminology. See reference 6). Variables of type Stack may be declared and manipulated in other program units.

Modula-2's data abstraction mechanism provides a certain degree of protection since no direct access to the internal state of a stack is provided. The stack is manipulated through the module's processing and query procedures. But there are a couple of problems with the Modula-2 solution. One is that the procedures used by a module must have either unique or qualified names. For example, if a module uses (imports) two different abstract data types, Stack and Queue, and variables of these types must be initialized, then the initialization procedures defined for these types must have different names, such as InitializeStack and InitializeQueue, or their usage must be qualified, as in Stack.Initialize and Queue.Initialize. This makes the resulting program less versatile. But more important than the need for unique identifiers is the drawback that Modula-2 abstract data types can operate on only one type of data. Stack, therefore, can store only integers.

Ada partially solves both these problems through two language features: operator overloading and generic program units (see reference 7). Operator overloading permits a program to use multiple operators with the same name. The distinction between operators can be determined at compile time by examining the types and number of parameters, just as + can be used to add either integer or real numbers in most modern languages. Generic program units permit the definition of a module to be used with different data types. The generic program unit is a procedural template that can be parameterized with actual types during compilation of programs using its capabilities.

A problem still exists if you wish to use the stack to store heterogeneous elements. Neither compile-time solution, operator overloading or generic program units, is sufficient. The solution is dynamic binding.

DYNAMIC BINDING

Dynamic binding is needed to make full use of this code for stacking other types of data. Consider the addition of a procedure, Print, to the StackHandler module that prints the contents of a stack. If you use the stack for storing integers, floating-point numbers, character strings, etc., a traditional procedure-oriented approach dictates that you include a case statement to check at run time that the correct printing procedure for an element's type is used. Trying to print an integer with a procedure designed to print character strings is potentially disastrous. The resulting problem is that every time you add

(continued)

Listing 1: *Definition and implementation modules for the abstract data type* Stack.

```
DEFINITION MODULE StackHandler;

TYPE
  Stack; (* Opaque type *)

  StackType = INTEGER;

PROCEDURE Initialize(VAR s: Stack): BOOLEAN;

PROCEDURE Push(s: Stack;
               value: StackType): BOOLEAN;

PROCEDURE Pop(s: Stack;
              VAR value: StackType): BOOLEAN;

PROCEDURE IsEmpty(s: Stack): BOOLEAN;

PROCEDURE IsEmpty(s: Stack): BOOLEAN;

PROCEDURE IsFull(s: Stack):BOOLEAN;

END StackHandler.
-------------------------------------

IMPLEMENTATION MODULE StackHandler;

  FROM SYSTEM IMPORT TSIZE;

  FROM storage IMPORT Allocate, Available;

  CONST

    BufferSize = 1000;

TYPE

  IndexRange = [0..BufferSize];

  StackRecord =
    RECORD
      index: IndexRange;
      buffer: ARRAY [1..BufferSize] of StackType
    END;

  Stack = POINTER TO StackRecord;

(* code for implementation part of Initialize,
Push, Pop, IsEmpty, and IsFull goes here *)
              .
              .
              .

BEGIN (* StackHandler *)
  (* No Initialization Required *)
END StackHandler.
```

a new type of data to the software system, you must modify all such case statements and recompile—a time-consuming and error-prone procedure. Ideally, additions should require only additions, not modifications.

The object-oriented approach pushes the responsibility for printing elements onto the objects themselves. Each object is sent the exact same message selector, Print, so that it will print itself in the proper way. This is known as *polymorphism*, since the same message can elicit a different response depending on the receiver. Operator overloading in Ada does not exhibit this form of dynamic polymorphism since the address of the procedure invoked is fixed at compile time.

This model of object-oriented programming can be improved. As presented thus far, the addition of a new type of object requires writing entirely new procedures for common operations such as Print. What's worse is that there will be a great deal of similarity between different Print methods, requiring continual rewrites of methods that differ slightly or not at all. This burden is likely to be so great that programmers would avoid the creation of new object types, significantly reducing the practical usefulness of object-oriented programming systems. Inheritance is a mechanism that largely relieves programmers of this burden.

INHERITANCE

Inheritance enables programmers to create classes and, therefore, objects that are specializations of other objects. For example, you might create an object, Trumpet, that is a specialization of a BrassInstrument, which is a specialization of a WindInstrument, which is a specialization of MusicalInstrument, etc. A Trumpet inherits behavior that is appropriate for BrassInstruments, WindInstruments, and MusicalInstruments.

Creating a specialization of an existing class is called *subclassing*. The new class is a *subclass* of the existing class, and the existing class is the *superclass* of the new class. The subclass inherits instance variables, class variables, and methods from its superclass. The subclass may add instance variables, class variables, and methods that are appropriate to more specialized objects. In addition, a subclass may override or provide additional behavior to methods of a superclass. Methods are overridden when you provide a new method for an old method's selector.

The mechanism to add new behavior to an existing method tends to be language-dependent. In those languages most closely modeled after Smalltalk, this is accomplished by embedding a message-send to the *pseudovariable* super in the new definition of a method (see the text box "Pseudovariables" on page 144). For example, suppose you have an initialization method, initialize, defined in a superclass. If a subclass adds some instance variables, x and y, that must also be initialized to zero, then both initialization behaviors will be exhibited by the following method:

```
initialize
    super initialize.
    x ← y ← 0.
```

The initialization in the superclass is performed, followed by the added initialization behavior. Depending on the placement of the message-send to super, the new behavior may precede, follow, or surround the existing behavior.

Inheritance enables programmers to create new classes of objects by specifying the differences between a new class and an existing class instead of starting from scratch each time. A large amount of code can be reused this way.

ADVANTAGES

Object-oriented languages have many advantages over more traditional procedure-oriented languages. Information hiding and data abstraction increase reliability and help decouple procedural and representational specification from implementation. Dynamic binding increases flexibility by permitting the addition of new classes of objects (data types) without having to modify existing code. Inheritance coupled with dynamic binding permits code to be reused. This

(continued)

DATA STRUCTURES

The class data structure in figure A contains information needed to construct and use object instances. The first and second fields indicate the number of instance variables and their names, respectively. The names are needed so that when methods are compiled, the instance variable names can be identified as referring to instance variables.

The third field of the class data structure is a flag that indicates whether an instance contains a variable number of indexable instance variables. Arrays are examples of objects that may have a variable number of instance variables. The instance variables of an array are accessed by indexing instead of by names. Since arrays of different sizes will respond to the same protocol (the set of messages to which an object responds), it does not make sense to have different classes for each array size.

The class variable field contains storage for variables shared by all instances. Class variable names are also stored here. Class variables can be convenient for storing information that should be common to all instances of the class. Not only does this save storage, but it greatly simplifies changing shared information. Otherwise, all instances of a class would have to be located to change an instance variable.

The method dictionary contains pairs of selectors and methods. When a message is sent to an object, the class's method dictionary is searched for a method to execute.

The superclass field points to the superclass of this class. The superclass is another class data structure that has all the same fields as this class. Other instance variables, class variables, and methods may be defined in the superclass.

If during a message-send a method is not found in the instance's immediate class, the superclass method dictionary is searched. If it is not found there, the superclass's superclass method dictionary is searched, and so on, until the class at the root of the hierarchy (most often called Object) is searched and found not to have a matching selector. In this case an error is returned.

Note that each instance contains a

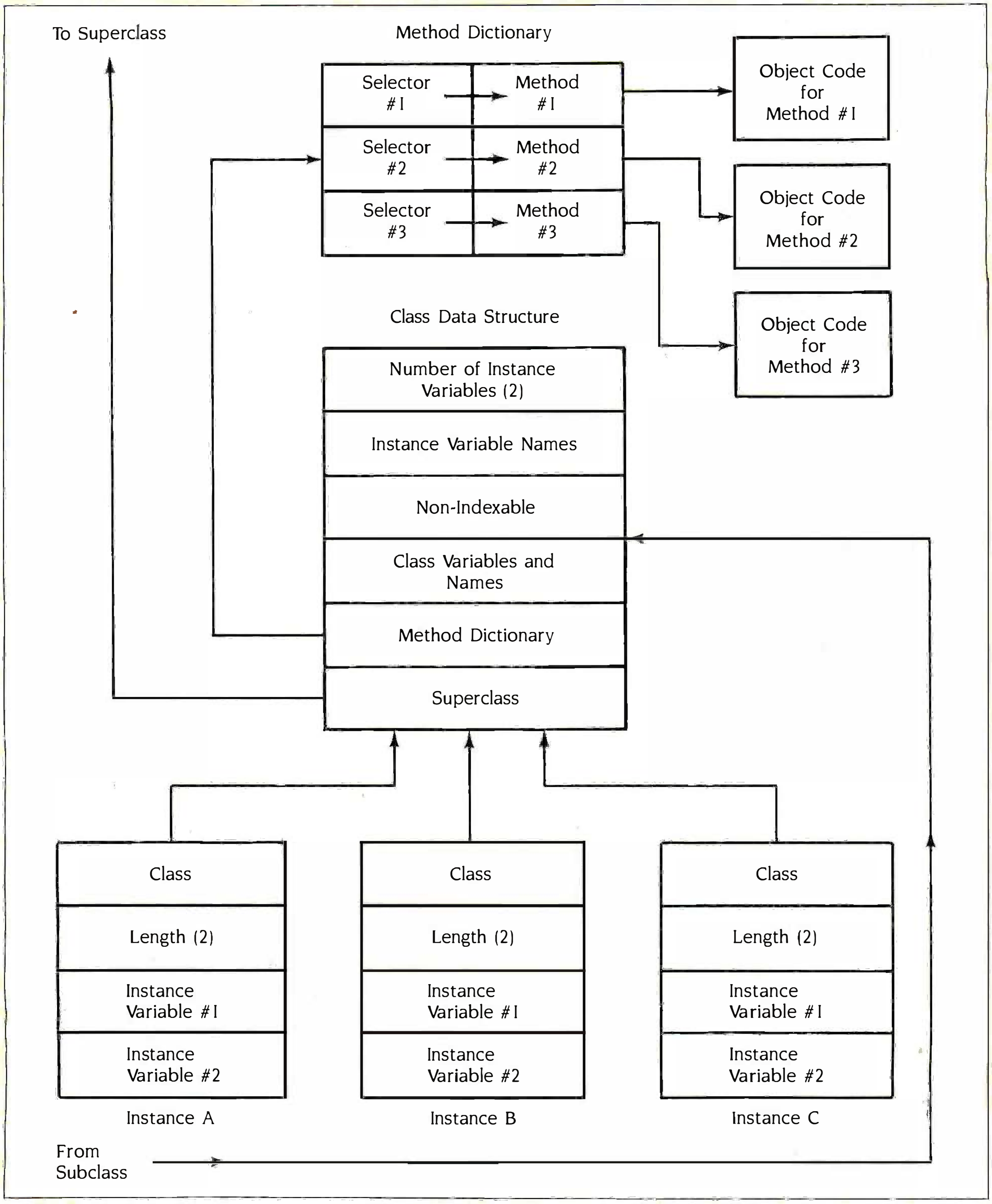

Figure A: *Data structures illustrating concepts related to object-oriented programming. Arrows indicate pointers.*

pointer to its class and a field indicating the length of the instance. The pointer to the class is needed so that the class, and therefore an object's methods, may be easily located when the instance is sent a message. Storing length information in the instance aids the storage manager and is useful when dealing with indexable instances.

has the attendant advantage of reducing overall code bulk and increasing programmer productivity, since you have to write less original code. Inheritance enhances code "factoring" (see references 1 and 2). Code factoring means that code to perform a particular task is found in only one place, and this eases the task of software maintenance.

DISADVANTAGES

Object-oriented languages have a few characteristics that are considered disadvantages by some. The one most often debated is the run-time cost of the dynamic binding mechanism. A message-send takes more time than a straight function call. Some studies have shown that with a well-implemented messager this overhead is approximately 1.75 times a standard function call (see references 8 and 9). Actual differences in execution speed between traditional languages and their object-oriented counterparts, however, do not prove to be very significant. This is most likely due to the fact that the overhead applies only to message-sends and that message-sends accomplish more than a function call. Often, some of the work done automatically by a message-send must be done by the programmer anyway using code surrounding function calls or even multiple function calls. In fact, a case can be made that in large applications the ability to standardize and fine-tune the functionality supplied with the message-sends can make the application run faster than a traditional counterpart. The primary reason is that messaging obviates much of the variability in function setup code that results from different programming styles and skill levels. Messaging also eliminates the complex code often needed when traditional programs have to simulate dynamic binding.

Another disadvantage often cited is that implementation of object-oriented languages is more complex than comparable procedure-oriented languages, since the semantic gap between these languages and typical hardware machines is greater. Therefore more software simulation is required. Fortunately, you pay the cost of implementation only once for a given machine.

Another potential problem is that a programmer must learn an often extensive class library before becoming proficient in an object-oriented language. As a result, object-oriented languages are more dependent on good documentation and development tools such as Smalltalk-80 browsers (see references 2 and 4).

CONCLUSION

There are other important concepts in object-oriented programming that I haven't covered because they either do not fit well into the Smalltalk model or are not central to object-oriented programming. Two that require at least abbreviated mention are multiple inheritance and automatic storage management.

Multiple inheritance allows a class to have more than one superclass. The potential for code sharing is greater, but the possibility of conflicts between multiple superclasses increases the complexity of such systems. Certain flavors of LISP get a great deal of power by using multiple inheritance.

Automatic storage management, though not necessary, is so useful that it almost qualifies as a fifth major element. Automatic storage management techniques such as reference counting and garbage collection permit programmers to ignore details concerning the release of an object's storage. Application code becomes cleaner, and the overall system becomes more reliable.

Object-oriented programming provides major advantages in the production and maintenance of software: shorter development times, a high degree of code sharing (good factoring), and malleability. These advantages make object-oriented programming an important technology for building complex software systems now and in the future. ■

PSEUDOVARIABLES

Syntactically, pseudovariables are treated the same as normal variables. Their semantics, however, are different since they cannot be assigned a new value during any particular invocation of a method.

Two important pseudovariables in Smalltalk are self and super. Both self and super refer to the object that received the message currently being processed. For example, if there happen to be 22 different rectangle objects currently existing and one of them is sent the center message, then the system will set both the pseudovariables self and super to refer to that rectangle. The difference between these two pseudovariables lies in the way that the message lookup is performed.

When self is sent a message, the message lookup algorithm is identical to the way a lookup is performed when the message is sent externally, starting in the object's direct class.

When super is sent a message, the lookup is performed starting in the superclass of the class in which the method that is currently executing is found. Note that this is not necessarily the superclass of the object's class. This pseudovariable mechanism gives objects a controlled way of accessing superclass methods.

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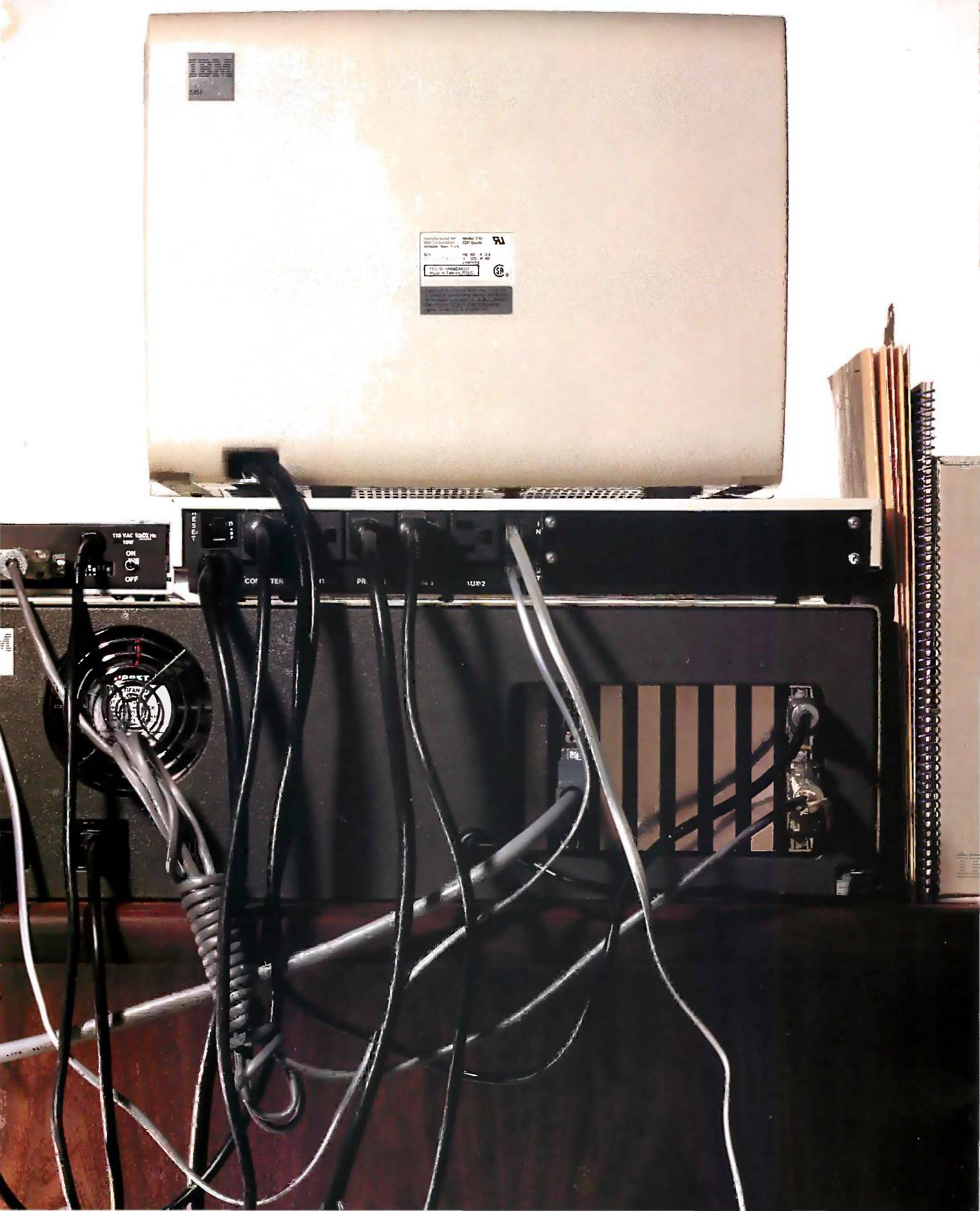

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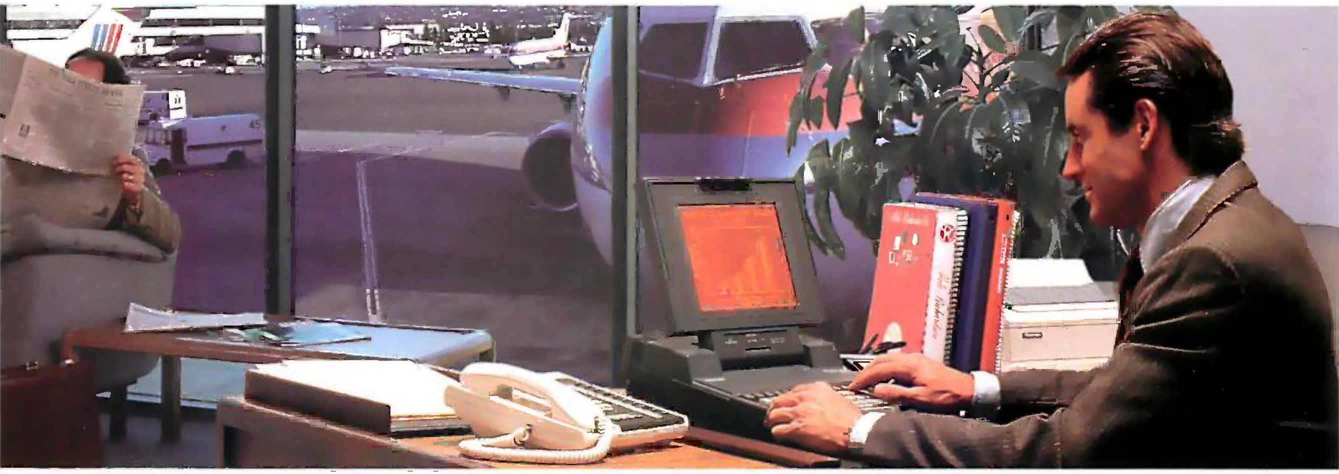

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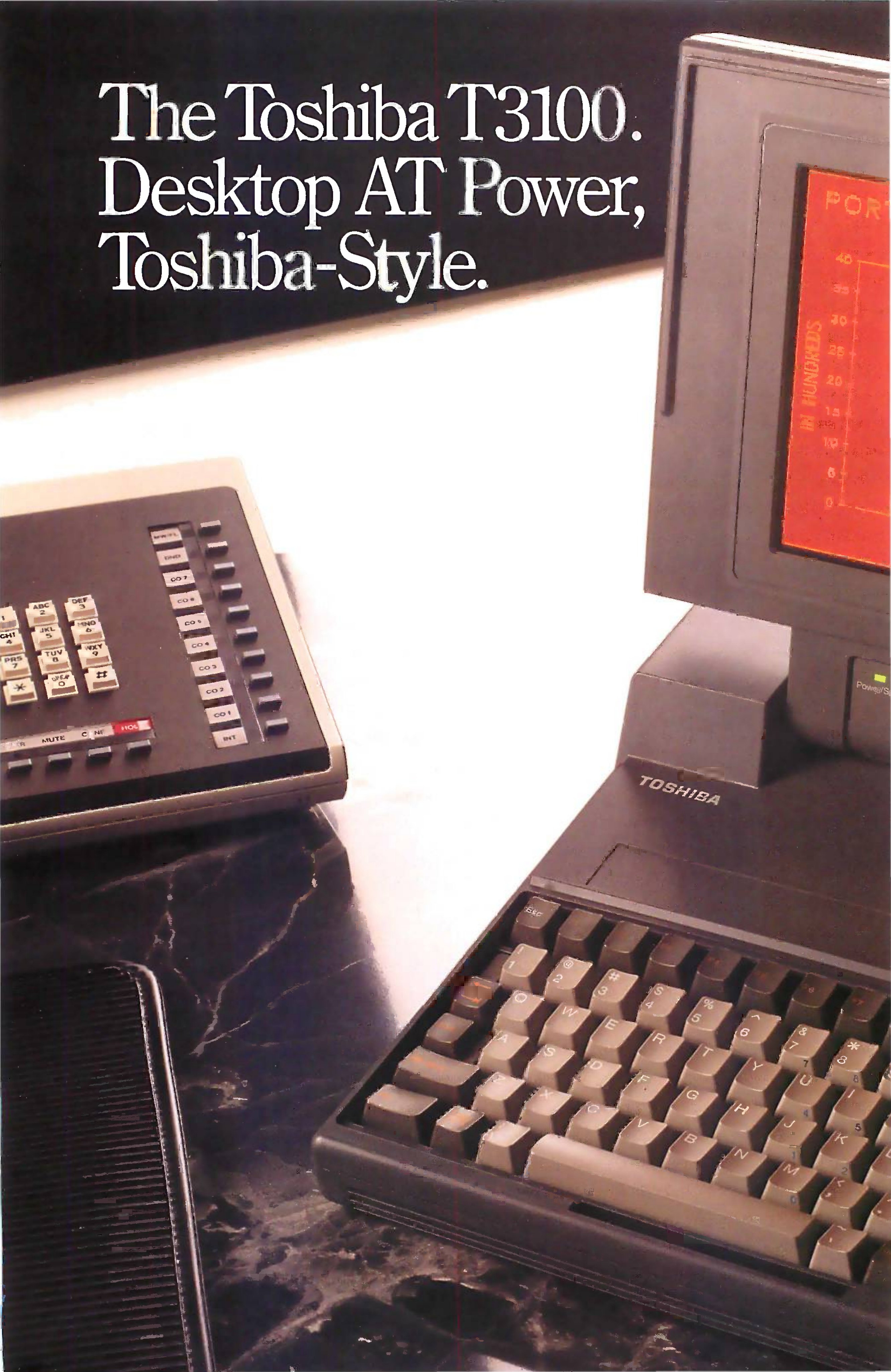
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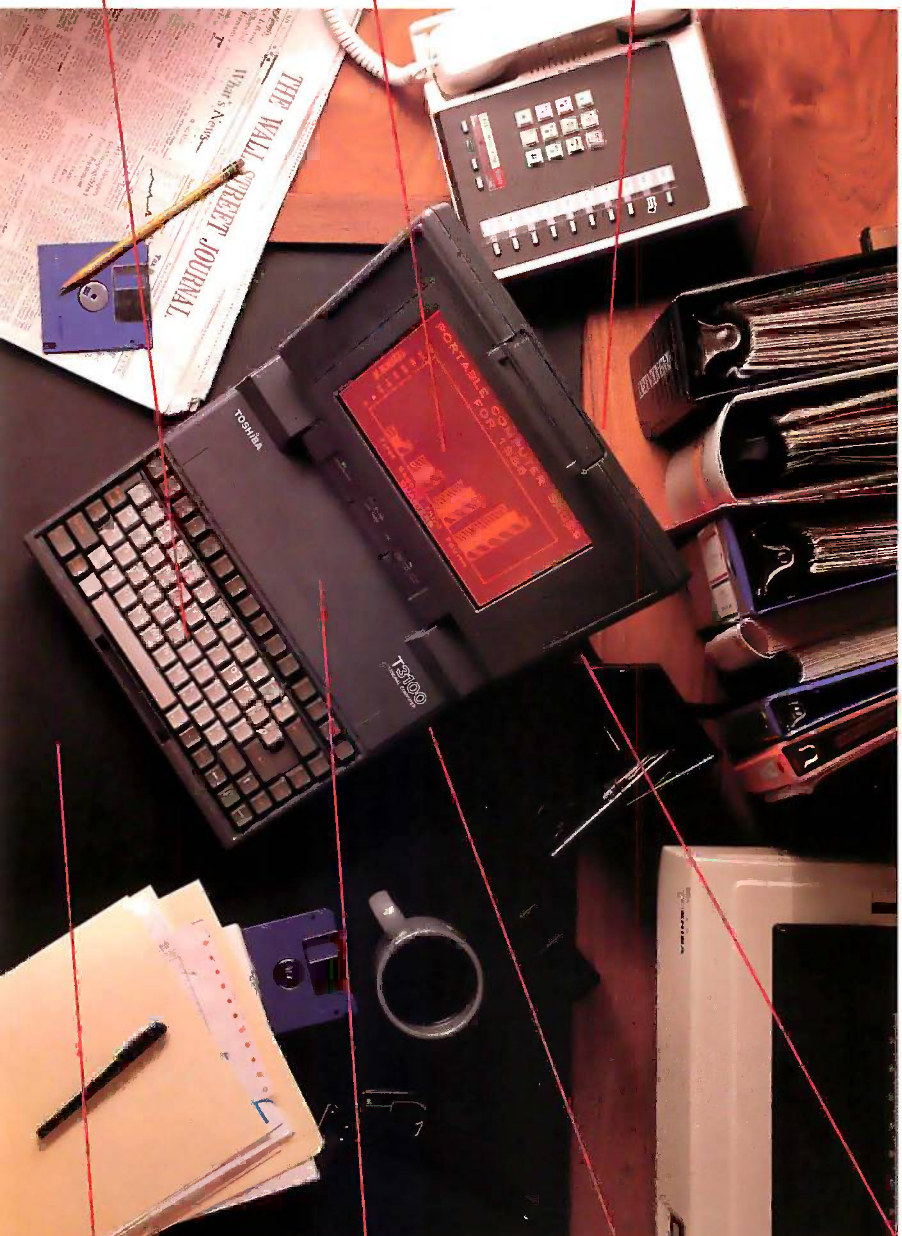

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A SMALL TASTE OF SMALLTALK

BY TED KAEHLER AND DAVE PATTERSON

Two classic programming problems illustrate Smalltalk syntax and design philosophy

This article is adapted by kind permission of the publisher from A Taste of Smalltalk *by Ted Kaehler and Dave Patterson (New York: W. W. Norton & Co., 1986).* *"The Animal Game" section is new material provided by the authors for use in this article.*

NEWCOMERS TO OBJECT-ORIENTED languages often have difficulty phrasing their programming problem in terms of objects. They struggle with how to divide a new programming problem into objects. A good starting place is to imagine that every fragment of program and every piece of data are floating together in space. Now imagine pieces of string between code and the data it uses, and between segments of code that are used together or that perform a similar function. Then imagine moving everything around until the total length of string is the shortest. Clustered around each data structure would be the routines that use it, and natural divisions in the code become apparent. Dividing a problem into objects is just a process of putting things where they belong.

Dividing a problem into objects and defining actions that are "natural" for those objects actually simplifies programs. When the actions of an object are divided into the right kinds of "chunks," we can think and write code at a higher level. We know that the procedures we call from the high-level code are correct because they match the way we think about the problem. When that assurance exists, we make fewer mistakes. We have less anxiety about whether the subordinate procedures are doing the right thing.

The overhead of calling a Smalltalk procedure is small for both the system and the programmer. The system has optimized Smalltalk procedure calls because they happen so frequently, typically 10 to 50 times per procedure. The overhead for a programmer to create a new Smalltalk procedure is small as well. Declarations and preambles are very short in the Smalltalk-80 system, and you can edit, run, and debug without changing environments. In Smalltalk, compiling a method and linking it into the system takes only a few seconds, as opposed to several minutes in a "batch-processed" system, where many modules may have to be recompiled. Writing a new procedure and calling it in the original program is easier in Smalltalk than in Pascal. Thus, Smalltalk encourages programmers to modularize code.

We will now stop philosophizing and start explaining with the aid of some sample programs just how object-oriented programming makes the programmer's job easier. In the next section we will write a program in Smalltalk that looks just like a program in a traditional language. (We will also include a Pascal version of the program so you can see how close it is.) The program is not written in an object-oriented style, but it does serve as a Rosetta stone for learning Smalltalk. Later in the article we will write a program to solve the Animal Game in a truly object-oriented style. Along the way we will provide a step-

(continued)

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by-step description of how to use the Smalltalk user interface.

A Towering Tutorial

The Tower of Hanoi program represents one of the few examples of agreement in computer science. Practically every programming text introduces recursion using this program, and our book is no exception (reference 1). The Tower of Hanoi is based on a game (popular in the 1960s) that has its own mythology (also popular in the 1960s):

> An ancient myth has it that in some temple in the Far East, time is marked off by monks engaged in the transfer of 64 disks from one of three pins to another. The universe as we know it will end when they are done. The reason we do not have to concern ourselves about the cosmological implications of this is that their progress is kept in check by some clever rules: the monks can only move one disk at a time; the disks all have different diameters; and no disk can ever be placed on top of a smaller one (reference 2).

The rules seem easy enough, but with 64 disks you might get confused and never be sure if you were making forward progress. Luckily, there is a way to simplify things and find an algorithm.

To move *n* disks from peg A to peg C:

1. Move *n* − 1 disks from A to B.
2. Move 1 disk from A to C. (This is easy.)
3. Move *n* − 1 disks from B to C.

Since we know how to handle the case when *n* equals one (move the single disk from A to C), we can easily do *n* equals two. From there we can do the cases of three or more disks. The only problem is keeping track of which step of which solution for which number of disks we are currently working on. This solution is more suited to a computer than to a person, and listing 1 shows a Pascal program to solve the Tower of Hanoi problem.

Listing 1: *Tower of Hanoi in Pascal. This program is derived from a program found in* Programming in Pascal *by Peter Grogono (reference 4).*

```
program hanoi(input, output);
  var total : integer;
  procedure movetower (Height, Frompin,
             Topin, Usingpin : integer);

    procedure movedisk ( Frompin,
                         Topin : integer);
    begin
      writeln( Frompin, '->', Topin)
    end; { movedisk }

  begin { movetower }
    if Height > 0 then
      begin
        movetower(Height-1,  Frompin,
                  Usingpin, Topin);
        movedisk( Frompin, Topin);
        movetower(Height-1, Usingpin,
                  Topin, Frompin)
      end
  end; { movetower }

begin { hanoi }
     read(total);
     movetower(total,1,3,2)
end.  { hanoi }
```

Listing 2a: A *recursive Smalltalk program to solve the Tower of Hanoi problem. Note that this method refers to the method* moveDisk:to: *in listing 2b.*

```
moveTower: height from: fromPin to: toPin
                         using: usingPin
"Recursive procedure to move the disk at a
 height from one pin to another using a
 third pin"
   (height > 0) ifTrue: [
     self moveTower: (height - 1) from:
        fromPin to: usingPin using: toPin.
     self moveDisk: fromPin to: toPin.
     self moveTower: (height - 1 ) from:
        usingPin to: toPin using: fromPin]

"This comment gives an example of how to
 run this program.  Select the following
 text and choose 'do it' from the
 middle-button menu.

(Object new) moveTower: 3 from: 1 to:
                       3 using: 2 "
```

Messages and Objects Everywhere

Smalltalk strives to use a small number of powerful concepts unconstrained by conventions or terms from other programming languages. For example, a Smalltalk procedure or subroutine is called a *method*. We will try to justify the Smalltalk names as soon as you learn enough to understand the excuse, but for now we will keep the unconventional names to a minimum in this tutorial. Variable names in Smalltalk are often highly descriptive and thus quite long. Following the Smalltalk tradition, we use capitals as visual separators (moveTower) instead of hyphens. The designers of the Smalltalk language chose a format for procedure names that encourages the programmer to describe each of the arguments. The idea is to provide more than just the order of the arguments to help the programmer remember which one is which. Each part of a procedure name ends with a colon and is followed by the argument it describes. [*Editor's note: In an effort to distinguish Smalltalk code from menu items of the Smalltalk pop-up menu, we have used the* Triumvirate Light *typeface for code words and* Triumvirate Oblique *type for menu items.*]

The four words ending in colons in the first line of listing 2a are the four parts of the name of the method that is being defined. When you want to talk about the method, squeeze all the parts of its name together; in this example, the actual name of the methods we have been working with is moveTower:from:to:using:, a method with four arguments. This method calls three methods (itself twice

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An object is a package of data and procedures that belong together. Specifically, all constants and the contents of all variables are objects.

and moveDisk:to: once). You may find it helpful to mentally translate calls on Smalltalk methods to the familiar format of procedure name followed by arguments, for example, moveTower:from:to:using: (height, fromPin, toPin, usingPin).

The moveTower:from:to:using: method in listing 2a has local names for its arguments: height, fromPin, toPin, usingPin. On the second line, the text between double quotes is a comment. Next is an expression, (height > 0), that evaluates to true or false. The Smalltalk if statement is like Pascal except that the Boolean expression precedes, instead of follows, the if. Next is a block, similar to Pascal blocks, except that Smalltalk surrounds blocks with square brackets instead of begin and end. There are three statements in the block, and they are executed sequentially. In Smalltalk, periods are used to separate statements. Pascal programmers will find this syntax familiar provided they remember to use a period instead of a semicolon. There is a comment at the end of the procedure.

You've probably heard that Smalltalk is an object-oriented system and may be curious to know what an *object* is. An object is a package of data and procedures that belong together. Specifically, all constants and the contents of all variables are objects. An object in Smalltalk is like a record in Pascal but much richer and more versatile. The only things that don't denote objects are the message selectors (operators or procedure names), the comments, and a few punctuation characters.

Most systems get work done in a variety of ways: by calling procedures, applying operators to operands, conditionally executing blocks, and so forth. Following the goal of using a small number of consistent abstractions, Smalltalk has exactly one way of getting work done: by "sending messages" to objects. A *message* is a message selector with its operands. The object that receives a message, the receiver, appears just to the left of the message. In listing 2a, everything that is not an object, a comment, a bracket, or a period is a message selector.

Smalltalk always returns a value as the result of each method, and, as you might expect from an object-oriented language, that result is also an object. For example, in listing 2a, height – 1 returns an integer object and height > 0 returns a Boolean object.

You now know enough that we can explain more Smalltalk lingo. The terms "method" and "message selector" were invented while asking the question, "How do we select the method an object will use to respond to this message?" The answer is, "Use the selector to find the right method to execute."

If you talk to yourself while you read code (don't be bashful, everyone does), then you need to know how to "talk" Smalltalk. The phrase height > 0 does exactly what you think it does, and you can pronounce it just the way you would in other languages ("height is greater than zero"), but it is really shorthand for "the object height receives the message greater-than with the argument zero."

When an object receives a message, it looks up the message name to see if it understands the message. If the message is found, it starts executing the method that tells how to respond to the message.

Just as a Pascal procedure may call other procedures, a method may need to call other methods. The way to start another method is to send a message to an object. Sometimes you want to send a message to the same object that received the current message. How is that object named locally? In other words, when a Smalltalk object talks to itself, what does it call itself? Why, self, naturally. Not surprisingly, messages to self are common. You can see them sprinkled throughout the program in listing 2a. When a piece of code happens to send a message to the same selector as the current method, the program is using recursion.

The method moveDisk:to: in listing 2b includes a couple of new things. The System Transcript is a window on the screen. It behaves like a traditional character-oriented terminal. The object that represents the transcript is held in the global variable, Transcript. The message cr tells the transcript to append a carriage return. The message show: takes a string as an argument and appends it to the transcript. It also redisplays the text in the transcript window, so you can see it.

Each comma in the expression (fromPin printString, ' –> ', toPin printString) is a selector meaning "concatenate two strings." In this case, fromPin printString returns a string, and the comma concatenates the literal string ' –> ' onto the end of it. The result of toPin printString is then concatenated to the end of that. An array also understands the message comma. It returns a new array consisting of itself concatenated with the argument.

Specifying an object, sending it a message, and getting back another object as the result are the only things that ever happen in Smalltalk code. Things that require new kinds of constructs in other languages, such as control

(continued)

Listing 2b: *The* moveDisk:to: *method referred to in listing 2a.*

```
moveDisk: fromPin to: toPin

"Move disk from a pin to another pin.
 Print results in the transcript window"
   Transcript cr.
   Transcript show: (fromPin
    printString, '->', toPin printString).
```

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structures and arithmetic operators, are simply messages sent to objects in Smalltalk. The result of one message can be used as the object that receives another message or as an argument in another message. For example, the object that is the result of the message −1 being sent to height is used as an argument in the method moveTower:from:to:using:. Except for the assignment operator, all Smalltalk code is a grand concoction of messages sent to objects.

ENTERING THE PROGRAM

The Smalltalk programming environment tries to provide every tool you want for finding, viewing, writing, and running Smalltalk methods. The system can tell that a particular piece of text is a method by the window in which it is typed. Thus, there is no need for special punctuation marking the beginning or end of a Smalltalk method. Every time you deal with a whole method, it is inside a window that expects a method.

With traditional programming systems you create a new program that is loosely linked to other programs via the operating system. In Smalltalk, on the other hand, every program is just a piece of the whole system, and the pieces are linked together. This Zen-like approach to programming means we must find a place for the Tower of Hanoi before we can write the program. Let's create a games section in one of the more generic parts of the system. [*Editor's note: The Smalltalk-80 system developed at Xerox PARC used a color-coded three-button mouse with red, yellow, and blue buttons. These buttons are often referred to as left, middle, and right buttons, and we will use this terminology. If you are using Smalltalk-80 on a Macintosh, you should refer to the documentation included with that system.*]

To place the games category in the Smalltalk hierarchy, we will perform a number of steps using a tool called the system browser (figure 1). We have labeled the parts of the browser with letters to ease references to them.

1. Move the cursor into area A of the system browser and select *Kernel-Objects*. (See figure 2.)
2. Move to area B and select *Object*.
3. In area F, make sure the word *instance* is selected.
4. Now let's add a category in which to put new procedures. Select *add protocol* from the middle-button menu in area C. When you select this item, a little window will appear, asking you to type a name. There will be an old name there in reverse video, so just type the word games word games and press the Return key.

If your menu does not have the item *add protocol* on it, you have a License 1 system from Apple and must do a little more work. Do not choose any items from the menu (move out of the menu and release the button). Move into area B and choose *protocols* from the middle-button menu. After a moment, a long list will appear in area E. Move the cursor there, and without clicking anywhere, type ('games') and press Return. Be sure the parentheses and single quotes are there. Keep the cursor in area E and choose *accept* from the middle-button menu.

5. The name of your new section, *games*, will appear and

(continued)

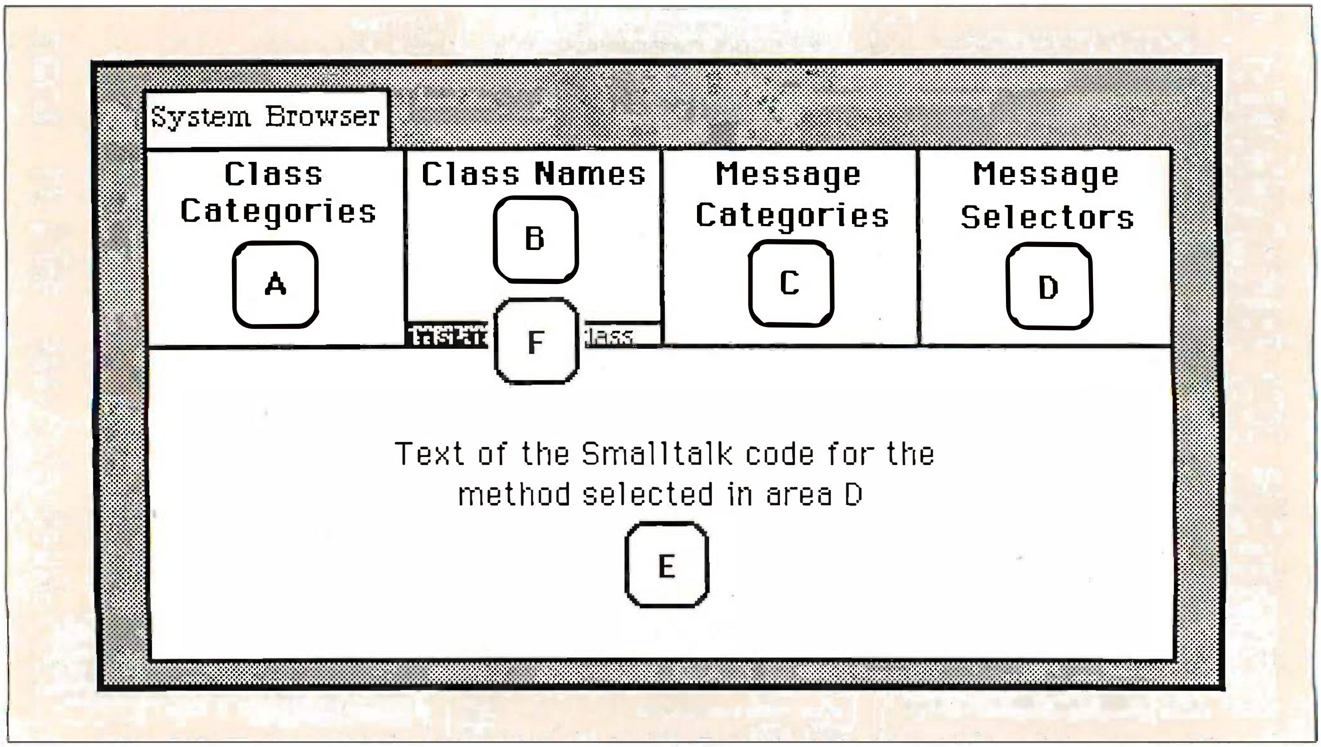

Figure 1: *The Smalltalk system browser. The four lists across the top are four levels of detail in the path to a method (a piece of code). The user moves from left to right, choosing an item in each list.*

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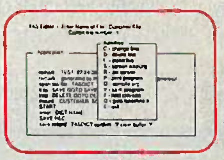

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be selected for you in area C. Move the cursor into area E at the bottom of the browser. The browser should appear as in figure 2.
6. Replace the text in area E with listing 2a.
7. Read over what you have typed. If you have typed it in correctly, select *accept* from the middle-button pop-up menu of area E. This attempts to compile, link, and load what we have just typed. You don't need to select any text because *accept* reads everything in area E.
8. The system will tell you that it doesn't understand moveDisk:to: and ask you if you made a typo or are just mentioning a new procedure. Reassure the system by clicking *proceed as is* (or, on a Macintosh, click the name of the method). When the system successfully accepts the new procedure, it will list the name of the procedure in area D and show the name in boldface in area E.
9. Now we will type in moveDisk:to:. Go to area D and click once on moveTower:from:to:using: to deselect it. Go to area E and replace all the text in area E with listing 2b and choose *accept* from the middle-button menu. The message selector moveDisk:to: should appear in area D of the browser.

RUNNING THE PROGRAM

Let's try the Tower of Hanoi using three disks. Move the cursor to the window labeled System Transcript (probably in the upper left corner of the display) and click the left button. When the window wakes up, point to the end of the text, click once, and type:

(Object new) moveTower: **3** from: 1 to: **3** using: **2**

Select the text and choose *doit* from the middle-button pop-up menu (see figure 3). *doit*, as you might expect, tells Smalltalk to execute what you have selected. The System Transcript shows program output, just as a traditional character-oriented terminal does in other programming systems. This sequence of moves should scroll by:

1 -> 3
1 -> 2
3 -> 2
1 -> 3
2 -> 1
2 -> 3
1 -> 3

Notice that we never declared the type of the arguments to our procedure, moveTower:from:to:using:. In this instance, Smalltalk is much more like LISP than Pascal because Smalltalk variables can be any type. As long as they understand the messages they are sent, variables can hold values of a different type than we originally intended. Without making changes to the procedures, we can ac-

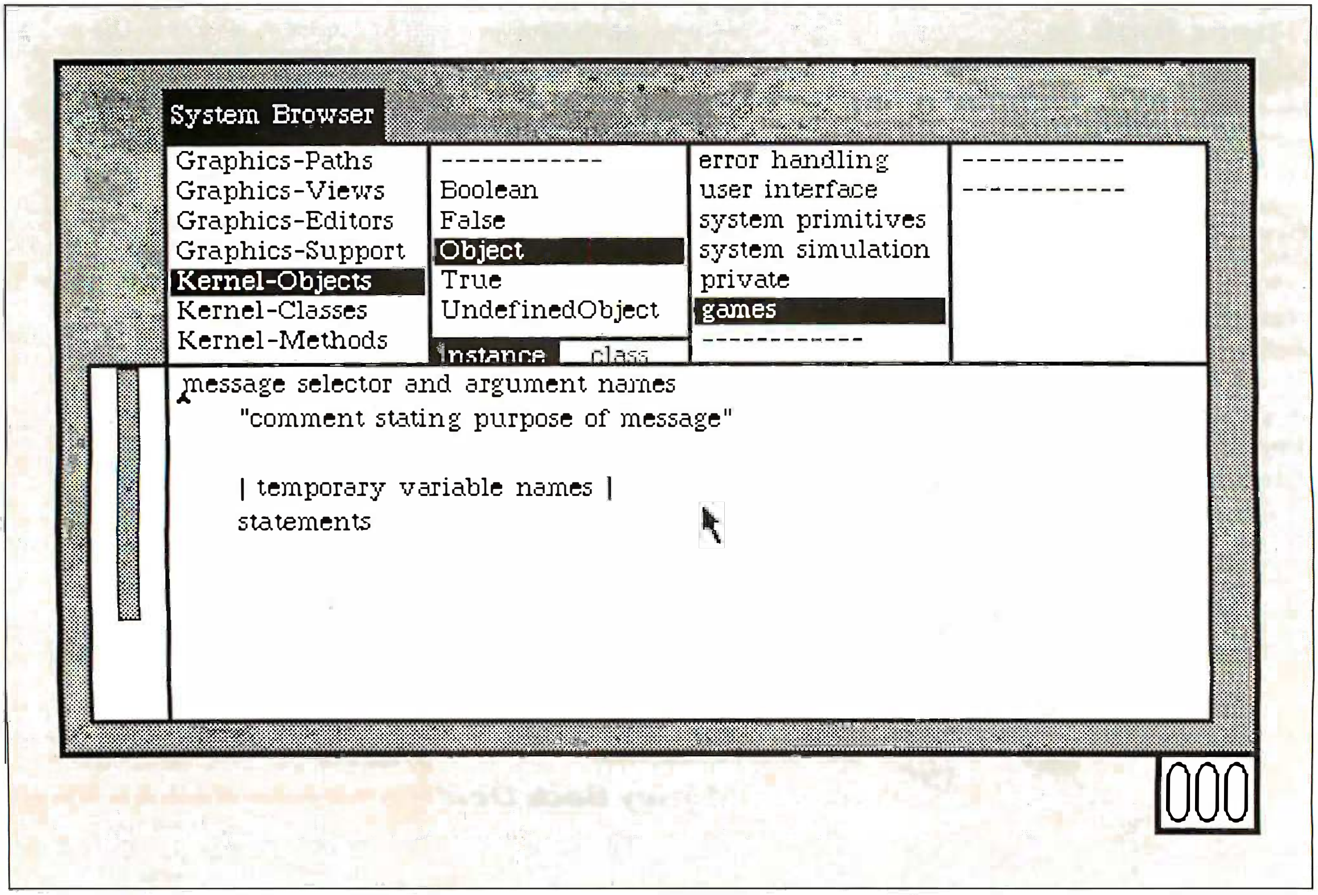

Figure 2: *The state of the browser just before adding the methods in listings 2a and 2b.*

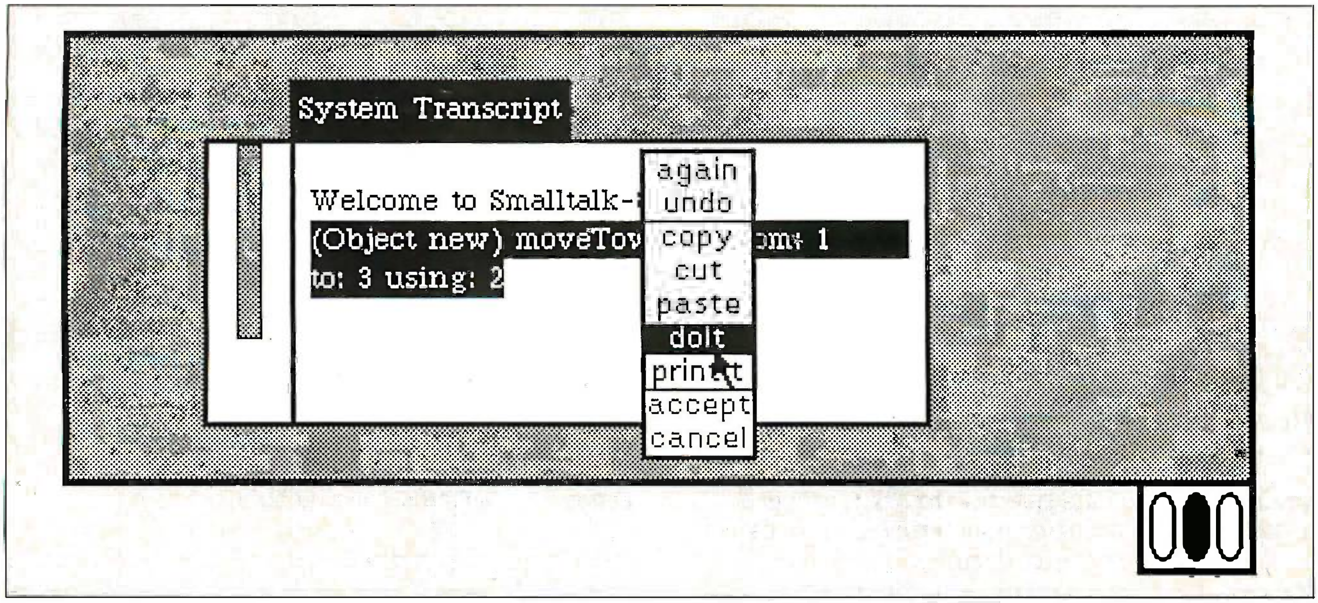

Figure 3: *The System Transcript with the text to run the Tower of Hanoi program highlighted. The* doit *command that will execute the highlighted text is about to be chosen.*

tually run the program with strings as the names of the poles instead of integers! Furthermore, the height can be a floating-point number. Try the example again with new pole names:

```
(Object new) moveTower: 3.0
from: 'North' to: 'South' using: 'Telephone'
```

When you select this and choose *doit*, the System Transcript will show

```
'North' –> 'South'
'North' –> 'Telephone'
'South' –> 'Telephone'
'North' –> 'South'
'Telephone' –> 'North'
'Telephone' –> 'South'
'North' –> 'South'
```

The recursive solution of the Tower of Hanoi problem presented here is not object-oriented. The program in Smalltalk looks very much like the equivalent program in the other languages. It contains objects, but they are not exhibiting the full power of object-oriented programming. [Author's note: A Taste of Smalltalk *contains versions of this program that are object-oriented and that take advantage of Smalltalk graphics to show an animation of disks moving between the poles.*]

THE ANIMAL GAME

Let's now consider a new game and write a program that uses objects as they are meant to be used. The Animal Game is used commonly as an example of binary trees (we found it in *Oh! Pascal!* by Doug Cooper and Michael Clancy [reference 3]). The user thinks of an animal, and the program tries to guess what it is.

```
Does it swim?
            <click yes>
Does it have gills?
            <click no>
Are you thinking of a Dolphin?
            <click no>
Gee, I don't know this one.
What animal were you thinking of?
(type it and press return)
            Penguin
Please type a question that distinguishes between
a Penguin and a Dolphin
            Does it have feathers?
Remind me about a Penguin. Does it have feathers?
            <click yes>
Would you like to think of another animal?
            <click yes>
Does it swim?
  . . .
```

The program begins by asking the user a series of yes-or-no questions and finally suggests a specific animal. If the program is wrong, it asks the user what animal he or she was actually thinking of and what question would distinguish it from the other animal. By installing this information at the right place in a binary tree, the program builds up a collection of questions and animals to ask about in the next round.

The tree is composed of "question objects" and "animal objects" (see figure 4). Each object has variables it owns, much like the variables in a Pascal record. A question object needs to store the following information:

fatherNode object above this one in the tree (a question, an animal, or nil)

(continued)

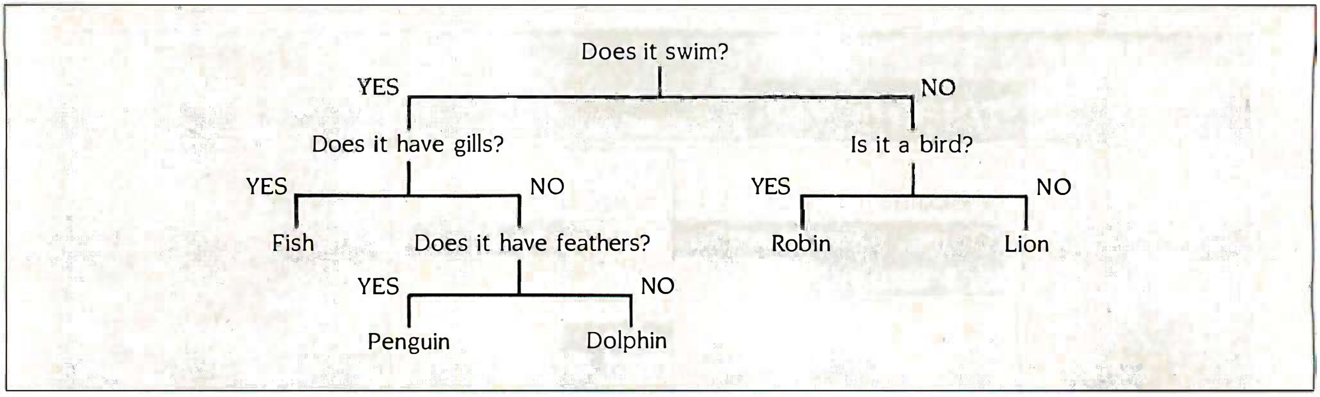

Figure 4: *An example of a binary tree that the Animal program might build.*

myQuestion	text of a question to ask (a string)
yesBranch	object to go to if the user says yes (an object in the tree)
noBranch	object to go to if the user says no (an object in the tree)

And an animal object needs to store:

fatherNode	node above this one in the tree (another object or nil)
name	animal's name (a string)

Before creating an object, we need to describe it. After we have described a single object, the description can serve as the definition of a whole class of objects. We call such an object description a *class*. A class is like a user-defined data type combined with a module that has a set of procedures as an external interface. Any object created from the description is called an *instance* of the class. We

(continued)

have already decided what information an individual question should hold (fatherNode, myQuestion, yesBranch, noBranch); these variables are called *instance variables*. Each instance has its own private values for its instance variables.

Since both class Question and class Animal have the variable fatherNode, let's separate it out into another description called TreeNode (see listing 3). We make the classes Question and Animal subclasses of TreeNode so they can inherit the common instance variable and the methods fatherNode: and playGame that are common to Animal and Question. (See class descriptions in listings 4 and 5.)

Let's consider how the program asks the user a question. We send the message ask to the top object in the tree. This object might be a question or it might be an animal, and we want different things to happen in each case. Since questions and animals are different kinds of objects, they can respond differently to the message ask.

In listing 4 under the message ask, we see how a question responds to ask. The third line declares a local variable, answer. (In Smalltalk you do not need to declare the types of variables.) Names enclosed in vertical bars at the beginning of a method are local to that method. The next statement puts the question on the screen in a confirmation window and stores the user's response in the variable answer. The confirm: message returns true for "yes" and false for "no." A left arrow is the assignment operator; you can pronounce it as "gets." In the last two lines of the method, we send the message ask to the yesBranch object if the answer was true, and we send ask to the noBranch object if the answer was false. The up arrow at the beginning of the last statement means return an object to the method that sent the message that caused this method to be run. The object is the result of the chosen branch of the conditional. Every Smalltalk method returns a single object as its result. If you don't specify what object to return (by using an up arrow), the object that received this message (which we know as self) is returned.

Sending the message ask to an animal object causes an entirely different piece of code to run (see the ask message in listing 5). We declare answer and newQuestion as local variables. The next line presents a confirmer window to the user, asking if the user was thinking of this animal and storing the response in the variable answer.

If this was not the correct animal guess, we need to build a new object and put it in the tree. We create a new question object (*Question new*), send it the message askForNewAnimalAndQuestion: with the current object (self) as an argument, and store the result in newQuestion. The expression (fatherNode == nil) tests if this animal is the top node in the tree (it could be if there is only one object in the tree). If not, fatherNode is an object above, and we tell that object to substitute the new question on one of its branches. The top of the tree is stored in a global variable called AnimalTree, so the program will remember its knowledge between games. If self is the top of the tree, store newQuestion into AnimalTree. (Normally, you can

Listing 3: *The variable* fatherNode *and the methods* fatherNode: *and* playGame *have been factored out of the classes* Animal *and* Question *and put into their own class description,* TreeNode.

```
Class Description for TreeNode:

Object subclass: #TreeNode
  instanceVariableNames: 'fatherNode '
  classVariableNames: ''
  poolDictionaries: ''
  category: 'Kernel-Objects'

Methods for class TreeNode:

fatherNode: aNode
"remember the parent decision node"
   fatherNode ← aNode

playGame
"To start new game, select the text
 within the double quotes in the line
 below and choose 'do it' from
 middle-button menu:"
   "(Animal new name: 'Robin') playGame."
"To restart an old game:"
   "AnimalTree playGame."

| exclamation |
Smalltalk at: #AnimalTree put: self.
[exclamation ←
       (Smalltalk at: #AnimalTree) ask.
nil confirm: exclamation,
'Would you like to
 think of another animal?'] whileTrue.
```

Listing 4: *The class description and methods for* Question. *This class is a subclass of* TreeNode.

```
Class Description for Question:

TreeNode subclass: #Question
  instanceVariableNames: 'myQuestion
                   yesBranch noBranch '
  classVariableNames: ''
  poolDictionaries: ''
  category: 'Kernel-Objects'

Methods for Class Question:

ask
"Ask the user a question"
 | answer |
 answer ← nil confirm: myQuestion.
"Ask a more detailed question"
 ↑ answer ifTrue: [yesBranch ask]
          ifFalse: [noBranch ask].
```

```
askForNewAnimalAndQuestion: oldAnimal
"Ask the user the name of the new animal
 and get a distinguishing question."

| newName newAnimal polarity |
newName ← FillInTheBlank request:
    'Gee, I don''t know this one.
What animal were you thinking of?
(type it and <return>)'.
newAnimal ← Animal new name: newName.
myQuestion ← FillInTheBlank request:
'Please type a question that distinguishes
between ', oldAnimal name, ' and ',
 newAnimal name.
polarity ← nil confirm:
' Remind me about ', newAnimal name, '.
',myQuestion.
polarity ifTrue: [yesBranch ← newAnimal.
                  noBranch ← oldAnimal]
         ifFalse: [yesBranch ← oldAnimal.
                  noBranch ← newAnimal].
  newAnimal fatherNode: self.


substitute: newQuestion for: oldAnimal
"replace an animal branch with a
decision branch"
  (yesBranch == oldAnimal) ifTrue:
               [yesBranch ← newQuestion].
  (noBranch == oldAnimal) ifTrue:
               [noBranch ← newQuestion].
  newQuestion fatherNode: self.
```

Listing 5: *The class description and methods for* Animal. *This class is a subclass of* TreeNode.

```
Class Description for Animal:


TreeNode subclass: #Animal
  instanceVariableNames: 'name '
  classVariableNames: ''
  poolDictionaries: ''
  category: 'Kernel-Objects'


Methods for Class Animal:


ask
"ask the user if this animal is the one"
  | answer newQuestion |
  answer ← nil confirm:
    'Are you thinking of ', name, '?'.
  answer
  ifTrue: [↑ 'Oh, boy!  I got it!
 ']
  ifFalse: ["ask what were you thinking of"
    newQuestion ← Question new
        askForNewAnimalAndQuestion: self.
    fatherNode == nil
    ifFalse: [ fatherNode substitute:
                newQuestion for: self]
    ifTrue: [Smalltalk at: #AnimalTree
```

(continued)

just say AnimalTree ← newQuestion, but here we explicitly look it up in Smalltalk, the global dictionary, so you won't have to declare AnimalTree before you type this program.) Finally, we set our own fatherNode to be the new question object, because we are now below it in the tree.

In the code for ask in class Animal we create the new instance of class Question and send it a message that gathers the data for a new question. Looking at the method askForNewAnimalAndQuestion: in class Question, the message request: to FillInTheBlank puts up a window that asks the user for input, using the string we supply as a herald. We store what the user typed in newName. We construct the string by using commas to concatenate several strings. The message name sent to oldAnimal asks the animal object for the string in its name field.

The line

newAnimal ← Animal new name: newName.

creates a new instance of class Animal and tells it that its name will be the name we just got from the user (newName).

The next line collects a question from the user to distinguish this animal from the wrong guess and stores it directly into the instance variable question. We need to know if a positive answer to our new question indicates the new animal or the old one. We ask the user and store the answer in polarity. We then test polarity and assign the animal objects to the yes and no branches accordingly. Finally, we inform the new animal that its father node is ourself.

We used the messages name and name: to retrieve and set the name string of an animal. Pairs of messages that have the same name except for a colon are common in Smalltalk. By informal convention, one sets a value and the other retrieves it. In class Animal (see listing 5) the name method simply returns the contents of the instance variable, name. The name: method not only sets the value of the instance variable, name, but also adds a little class to this program (as if there weren't enough classes already) by automatically putting "a" or "an" in front of the name. "Lion" becomes "a Lion," and "Elephant" becomes "an Elephant." To get the first letter of a string, we treat it as an array and index into it using the message at:. Thus, (newName at: 1) returns the first character of the string. We want to know if the vowels in the string 'aeiouAEIOU' contain this character. The message indexOf: returns the index of the first occurrence of its first argument (a character) in the string. If the index is zero, our character is not a vowel.

When you are exploring the Smalltalk system, you will often be doing what we just did: reading unfamiliar code. Reading code is easy if you can do two things: identify the objects and understand the order in which messages are sent. All words that begin with a letter and don't end with a colon are objects, except those that immediately follow another object. In the expression (oldAnimal name), oldAnimal is an object and name is a message. In a series of words without colons such as (oldAnimal name

(continued)

```
                        put: newQuestion ].
        fatherNode ← newQuestion.
        ↑ ' '].


name
"reply with my name"
  ↑ name

name: newName
"Save the name of this new animal.
 Add 'a' or 'an' before the name."
 ('aeiouAEIOU' indexOf:
            (newName at: 1)) = 0
   ifTrue: [name ← 'a ', newName]
   ifFalse: [name ← 'an ', newName]
```

asUppercase), the first word is an object and the rest are message names. In (height printString) size, the token size is still a message name, since the expression in parentheses evaluates to an object.

The order in which messages are sent in Smalltalk is a little more complicated than identifying which things are objects. As you might expect, parentheses are used to show what to do first. We were amazed to find that parentheses are not required in any of the methods we wrote until name:. In the expression

('aeiouAEIOU' indexOf: (newName at: 1)) = 0

(newName at: 1) is evaluated first. The message indexOf: uses the result as its argument, and the message = is sent last of all. When you write code you can include as many parentheses as you want, but you may have to read code that has a minimum of parentheses, so it helps to know the order of evaluation.

Smalltalk has just two rules that tell which messages are sent before others. Messages without arguments (name, printString, etc.) are executed first. They take precedence over adjacent messages that are operators (+, −, *, =, >, comma, etc.). Thus, aString size > 0 is the same as (aString size) > 0 and means send the message size to aString first. Operator messages are executed before adjacent messages whose names contain colons. Thus,

```
(yesBranch == oldAnimal) ifTrue:
      [yesBranch ← newQuestion ].
```

does not need parentheses to cause yesBranch and oldAnimal to be compared before the message ifTrue: is sent. Two messages without arguments are evaluated left to right, as are two operators in a row (3+4*5 evaluates to 35). The Smalltalk books (references 1 and 4) have the complete story. As you may have guessed, all spaces, tabs, and carriage returns in Smalltalk code are meaningless to the system. Packed methods compile just as well as beautiful, poetically indented ones. (You do need a space in oldAnimal name to show that it is not the single long name, oldAnimalname.)

Returning to our program, in the method ask we sent a message to fatherNode, the object above the current node, so it will use the new Question object next time. In class Question, look at the method substitute:for: (see listing 4). If the animal we are replacing is exactly the same object as the yesBranch (tested by the message ==), replace it with the new question. If the noBranch was the old animal, then it is the one to replace. In any case, set the fatherNode of the new question object to be the current object (self).

The methods substitute:for: and askForNewAnimalAndQuestion: in class Question each tell an object to set its fatherNode. Both Animals and Questions get their fatherNodes set in the same way, so we can put the code in class TreeNode where it will be shared by both kinds of nodes (see listing 3).

We are all done except for launching the game. The top node of the tree is stored in the global variable AnimalTree, and it can be a node of either kind. The comments that compose the first four lines of the method playGame (see listing 3) tell how to start the game, both normally and from scratch.

After exclamation is declared local and the current object is installed as the root of the tree (the same object is already there when this method is called from the expression AnimalTree playGame), the rest of the method is a single statement. The block of code enclosed in brackets is a while loop, and it is executed repeatedly until the last expression in the block returns false. All the work is done by the first statement in the block, which sends the message ask to AnimalTree, which is an animal or a question object.

ENTERING THE PROGRAM

Let's consider how to enter our program into a Smalltalk-80 system. In area B of figure 1, deselect any class that is currently selected. A class-definition template will appear in area E. Modify it to be the definition of class TreeNode and *accept* it. Our new class, TreeNode, will appear in area B. Deselect it and enter the class descriptions of Animal and Question in the same way. (You can create a second browser on the screen by holding down the left mouse button in the gray area outside all windows.) Now we will enter the methods for these classes.

If you are using an early version of the Level 0 Smalltalk system for the Macintosh 512K, you will have to add the method request: to the system. Do this by entering area A of the browser and selecting the category *Interface-Menus* (it is above *Kernel-Objects*). Select *FillInTheBlank* in area B and *class* in area F. Look in area D to see if the method *request:* is there. If not, enter the method request: shown in listing 6 and *accept* it. When you have finished, be sure you change the selection back to *instance* in area F.

In each of the three classes, create a category for messages, as we did in the Tower of Hanoi example, and enter and *accept* the methods. Be sure to put the right method in the right class. Note that you make a left arrow by typing an underscore and an up arrow by typing a caret. To run the program, select the appropriate part of the com-

Listing 6: *Missing method in the class portion of* FillInTheBlank. (*Only early versions of Apple's Level 0 system are missing this method.*)

```
request: messageString
"Create an instance of FillInTheBlank
 whose question is messageString.  Display
 it centered around the cursor. Return the
 string that the user types and accepts."

self
 request: messageString
 displayAt: Sensor cursorPoint
 centered: true
 action: [:response | response]
 initialAnswer: ''. "<- two single quotes"
↑ response
```

ment in playGame and choose *doit* from the middle-button menu. The system should ask you questions in the form of small windows that appear on the screen. You have now explored a truly object-oriented program.

Why Use Object-Oriented Languages Anyway?

The most important part of object-oriented programming is not any technical advantage it gives but the fact that it crosses a threshold of perception. When we put all the information associated with a question node into an instance of class Question, we didn't just clean up the Animal program. We allowed ourselves to think of that body of information and action as a single unit, namely, a question node. We perceive the world around us as made up of objects, and our brains arrange information into chunks. By using objects in a programming language, we can tap into an existing pattern of thought.

Thinking of an algorithm in terms of objects makes it easier to understand. This ease of understanding often comes not from the details of how a procedure is constructed but from not having to think about the rest of the program. When you are working inside one Smalltalk class, you are largely safe from the side effects and complexities of parts of your program outside that class.

Good design and clean code are not the sole province of Smalltalk. It is possible to write extremely beautiful code in other languages, as well as terrible code in Smalltalk. However, the designers of Smalltalk believe that you already know what makes a good design and clean code. Smalltalk encourages you to follow your best instincts.

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BY BRAD COX AND BILL HUNT

Object-oriented programming can make it easier to create iconic user interfaces

MAKING COMPUTERS EASIER TO USE has been an enduring dream since the dawn of computing. This is one of the reasons for the current interest in *iconic* or *object-oriented* user interfaces---interfaces that present information as pictures instead of text and numbers. However, iconic programs can be excruciatingly difficult to build. They must not only do all that conventional programs do, but they must also present their workings as pictures instead of the usual words and numbers, and they must determine the user's needs from a graphical input device like a mouse rather than the usual commands from a keyboard. Unless tools can reduce this complexity, iconic user interfaces will remain costly and comparatively rare.

This article will demonstrate why object-oriented programming is becoming so popular, not only for building iconic programs but for programs of any kind. This popularity is the result of two language features beyond those provided by non-object-oriented languages: encapsulation and inheritance. Encapsulation means that code suppliers can build, test, and document solutions to difficult user interface problems and store them in libraries as reusable software components that depend only loosely on the applications that use them. Encapsulation lets consumers assemble generic components directly into their applications, and inheritance lets them define new application-specific components by inheriting most of the work from generic components in the library.

Building programs by reusing generic components will seem strange if you think of programming as the act of assembling the raw statements and expressions of a programming language. The integrated circuit seemed just as strange to designers who built circuits from discrete electronic components. What is truly revolutionary about object-oriented programming is that it helps programmers reuse existing code, just as the silicon chip helps circuit builders reuse the work of chip designers. To emphasize this parallel we call reusable classes Software-ICs.

Even though the examples in this article are written in Objective-C, not Smalltalk-80, you will find the graphics primitives chapter in Adele Goldberg and David Robson's book *Smalltalk-80: The Language and Its Implementation* (Addison-Wesley, 1983) helpful in understanding the portable graphics substrate on which this work is based. More information on Objective-C and the Software-IC approach to system building is contained in Lamar Ledbetter and Brad Cox's article "Software-ICs" (June 1985 BYTE) and in Cox's book *Object-oriented Programming: An Evolutionary Approach* (Addison-Wesley, 1986).

WORKBENCH

To determine how much a Software-IC library can help in building iconic applications, we developed the program whose interface is shown in the top window in figure 1.

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This program is called Workbench because it lets a programmer describe the files on his workbench and how they should be transformed into other files by tools like compilers and linkers. Workbench shows each file as an icon, dependencies between files as lines, and the programs that transform files as small circles. For example, the file named testOutput depends on two other files, testInput and theProgram. The file named theProgram depends on the three binary files shown as Software-IC icons, and each of these depends on its own source file. By relying on the operating system to maintain time stamps showing when each file was last changed, Workbench could be made to automatically rebuild the target files to bring them up to date when the source files they depend on change.

Since Workbench is currently only a prototype that we built to test the Software-IC library, we have not yet implemented the logic for rebuilding target files when source files change. Except for this unimplemented (but crucial) feature, Workbench and the UNIX utility make provide radically different user interfaces for the same problem. Figure 2 shows the file a user would have to build to describe the same information described in figure 1 by Workbench.

BUILDING THE COMPONENTS

An iconic user interface is like an animated movie or cartoon. Once a cartoon has been designed through scriptwriting and storyboarding, an artist builds the components of the animation by painting gels on transparent acetate sheets, turning generic materials from an art supply store into the specialized components needed for the movie on hand. The user interface library is the programmer's art supply store. It provides generic components from which specialized ones are defined by using encapsulation and inheritance the way an artist uses paint, scissors, and glue. This section will show how a programmer builds

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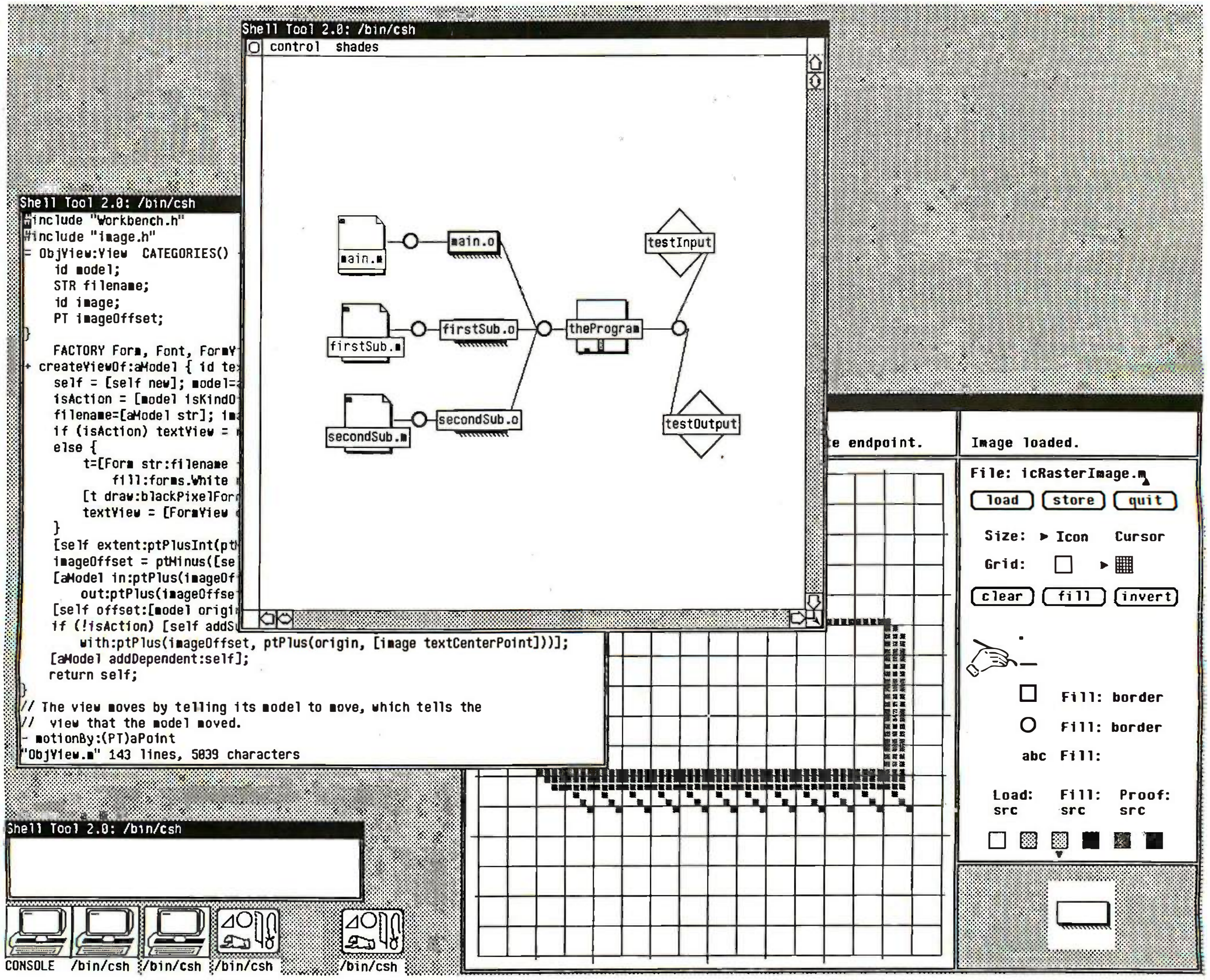

Figure 1: *Workbench as it might be seen by a programmer. The topmost window shows the iconic user interface, the window to the left shows a text editor, and the window to the right shows a bit-map editor.*

a stockpile of specialized components from generic components in the library. Later we will show how the components are assembled into an application and brought to life in the way that an artist assembles gels into layers and moves them with respect to each other to simulate motion.

The programmer's sheet of acetate is a generic class in the library named View. [*Editor's note: It is a naming convention to capitalize the first letter of class names and lowercase the first letter of the instances of these classes.*] Workbench's user interface in figure 1 was produced by many different instances of many specialized kinds of views, assembled like overlapping layers of acetate. No instances of the generic View class appear because instances of this class are transparent. But instances of specialized view classes can be seen because the programmer who defined them added "paint" to make them visible. For example, BorderedViews provide two colors of paint, one for a border of adjustable thickness and another for the region inside the border. One of these drew the white square in the upper left corner, two others drew similar squares in two other corners, and a fourth drew the tall vertical rectangle along the left edge. Several other BorderedView instances cannot be seen because they are obscured by other views lying on top of them. For example, the views in this figure are arranged on top of a large BorderedView that serves as an opaque backing to which all the others are attached.

Having seen how views work visually, let's turn to how they are implemented. The most generic abstraction, the View class, was defined by compiling a file that contains the following class definition statement, along with a large number of methods. In this section, no methods will be shown because they would introduce far too much detail for now.

```
= View : Rectangle {
      id clipList; // list of visible regions
      id superView; // or nil
      id subViews; // OrderedCol'n of subViews
      BITS flags; // flag bits
}
```

```
testOutput: testinput theProgram
      theProgram testinput >testOutput
theProgram: main.o firstSub.o secondSub.o
      objc main.o firstSub.o secondSub.o
                              -o theProgram
main.o: main.m
      objc -c main.m
firstSub.o: firstSub.m
      objc -c firstSub.m
secondSub.o: secondSub.m
      objc -c secondSub.m
```

Figure 2: *The file a user would have to build to convey the information in figure 1 to the* UNIX *utility* make.

This statement defines a new class, View, as a subclass of another generic class from the library, Rectangle. This declaration is all that is needed to ensure that every view will automatically inherit the ability to behave as a rectangular region. For example, each view instance will inherit two instance variables from Rectangle, namely a point (an *x,y* pair) named extent that describes the size of the view and a point named origin that specifies its position on the screen. Finally, the declaration adds four new variables that will be used to describe how each view is attached to other views. The superView variable identifies another view that provides the background against which this view will be displayed. A view's superview also establishes its coordinate system, and it clips any graphics drawn by the subview that extend beyond the superview's margins so that they don't appear on the screen. The variable subViews identifies those views for which the current view is background. These variables will be inherited by all other views. Thus every view will be linked into an important data structure, the view hierarchy, that describes how the views are stacked into layers.

BorderedViews are a specialized kind of view that is not transparent, and their declaration states as much explicitly:

```
= BorderedView:View {
      short borderWidth; // thickness of border
      id borderPattern; // color of border
      id insidePattern; // color of inside
      id outsideRectangle; // computed rectangle
}
```

In other words, a BorderedView instance is exactly like a view but has four additional variables to describe how thick its border should be and a pattern (a "color") to display for its border and central region.

This may seem like a lot of trouble just to draw a black line around a white box, but effort spent on generic classes is seldom wasted. BorderedView actually turns up repeatedly in this and other iconic applications, both as a component that is reused directly through encapsulation and as a generic class to be specialized through inheritance. We have shown several places where unmodified BorderedViews appear, but they are also inherited by specialized subclasses that can modify their appearance in surprising ways. For example, consider MacScrollBar, the class whose instances drew the horizontal and vertical scroll bars in the topmost window of figure 1:

```
= MacScrollBar : BorderedView {
      BOOL isVertical; // NO if horizontal
      id scrollMore; // ArrowFixture
      id scrollLess; // ArrowFixture
      id elevator; // ElevatorFixture
}
```

Even though the MacScrollBar instances look very different from ordinary BorderedViews, they were imple-

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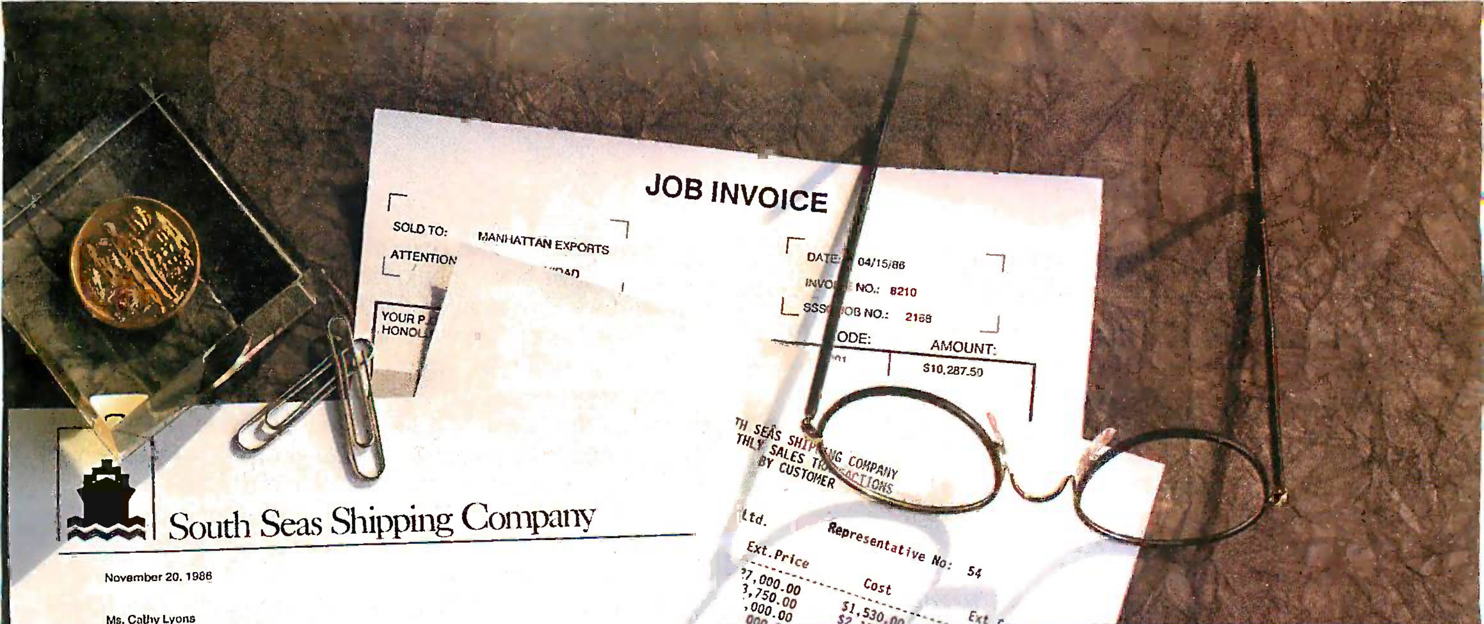


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Specializing from reusable generic code is what makes object-oriented programming so productive.

mented as a specialized BorderedView whose insidePattern variable is set to a uniform gray tone. Three instance variables are also added to refer to two instances of class ArrowFixture and one instance of class ElevatorFixture. These too are specialized BorderedViews that have overridden the method that draws their central region with one that displays a specific iconic image rather than a plain shade of gray. They also have additional methods that make them interpret cursor events as commands to control scrolling.

This ability to define specialized new facilities from generic facilities in the library is one of the key things that makes object-oriented programming so productive. When the new classes get so specialized that they are specific to the application on hand, they are no longer stored in the generic library. Nonetheless, they are still part of the inheritance hierarchy, and they are built exactly like the generic classes shown so far. For example, the large white region in the center of the Workbench user interface was drawn by an instance of class WbView that describes the files on the Workbench, a UNIX directory area.

```
= WbView : BorderedView {
      id model; // the Wb being viewed
}
```

This class defines an instance variable, model, that identifies the instance of class Wb to be interfaced to the user. Most applications involve several kinds of application-specific views, and these are produced in exactly the same way, by defining specialized subclasses of View.

MODELS AND VIEWS

Until now we've described only how the components of this application were defined. Now let's turn to how they work together when the Workbench program first runs in a particular UNIX directory. Like most other programs, Workbench must support two very different kinds of interfaces: one between itself and the file system, and the other between itself and the user. When Workbench starts executing, it must read information from the file system and represent it in some internal form. Then it must create whatever objects it needs for its user interface, draw these objects on the screen, and accept commands from the user that then modify the internal form. Finally, Workbench must save the modified information so that it will be available the next time the program is run in that directory.

This pattern is so typical that special terms are used to distinguish the two interface levels. The word *model* refers to the internal form, that is, whatever structure is used to represent the objects to be saved between sessions. The term *view* refers to the objects that implement the user interface. Views have been described in the previous section, and we turn now to the models.

The Workbench application uses only four kinds of model objects: Entity, Action, Obj, and Wb. Each file in the directory is represented by an instance of class Entity that holds the name of a file, its modification time, and two collections that describe those entities that depend on it and those that it depends on. When an entity's modification date is older than the date of a file that it depends on, it must be rebuilt by executing a program specified by the user. Another class, Action, holds the command string that describes how this program should be run. The Entity and Action classes have some features in common (such as where they are on the screen), and this is represented in a common superclass, Obj. A final class, Wb, represents the contents of the Workbench as a whole as a collection of entity and action instances.

When Workbench runs for the first time in a directory, it builds an instance of class Entity for each file and installs it in an empty instance of class Wb named workbenchModel. Next, the program creates a user interface so that the user can manipulate the models in the following ways: by moving them around on the screen, by describing which entities depend on which others, and by defining actions. (In the Workbench user interface, entities are presented to the user as file icons, actions are the circles, dependencies are the lines connecting the actions and entities.) The effect of this is to interconnect the models, forming a complicated web of linked objects that must somehow be saved at the end of the session so that it can be restored the next time the program runs in that directory. The code needed to do this is highly nontrivial to write, but object-oriented programming makes it seem simple. Since every class is a subclass of the most generic class in the system, Object, every object automatically inherits a method that can be used to save it in a file:

```
[workbenchModel storeOn:"workbench.io"];
```

When the application is executed again, it recreates workbenchModel by reading the file like this:

```
workbenchModel = [Wb readFrom:"workbench.io"];
if (workbenchModel == nil)
   workbenchModel = [Wb new];
[workbenchModel synchronizeWithDirectory];
```

The first statement requests the factory object for the Wb class to recreate workbenchModel from the file named workbench.io. The attempt will fail if the program has never been run in this directory, in which case the Wb factory object is requested to construct a new (empty) instance. In either event, the synchronizeWithDirectory message requests workbenchModel to examine the directory, adding or removing entities as needed to reflect files that have been created or removed since workbench.io was last written. Instance variables in the models are now updated to reflect the time at which each file was last changed.

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Object-oriented programming allows most of the work to be developed in advance, stored in the library, and reused off-the-shelf as generic Software-ICs.

Although workbenchModel is a complicated web of interconnected entity and action linked by dependency instances, the storeOn: method walks this web automatically, converting each object to a symbolic representation from which readFrom: can reconstruct the web during the next session. The developer of this application didn't have to design, code, test, document, or maintain this logic. Apart from the pair of triggering statements, this complicated data structure was saved and restored without writing any new code. The supplier of the most generic class in the system, Object, undertook this task once and for all, and every other class will inherit this work automatically.

The complete parts inventory for Workbench is shown in figure 3. Most of the classes are generic components taken directly from the user interface library. Only those in the bottom section are application-specific, and the total amount of application-specific code is 531 lines—269 lines specific to the internal representation of Workbench (model) and 262 lines used for the user interface (view). This was possible only because object-oriented programming allowed most of the work to be developed in advance, stored in the library, and reused off-the-shelf as generic Software-ICs, just as hardware designers use silicon chips to build specialized circuits.

ASSEMBLING THE USER INTERFACE COMPONENTS

We now have model objects to be interfaced to the user and a library full of components for building user interfaces. The next step is to assemble the components to to build a user interface for the model objects. First, we must build an opaque sheet of plain white acetate, on which all the others will be arranged, and attach to it another sheet painted with a standard frame of scroll bars:

```
[baseView = [BaseView new]
  addSubView:stdView = [StdSysView new]];
```

The baseView = [BaseView new] expression commands baseView, the factory object for class BaseView, to create a new instance named baseView, and baseView is immediately requested to add stdView, a newly created instance of class StdSysView, as its first subview. BaseView is a simple subclass of BorderedView that provides plain white backing on which any kind of animation can be assembled, and the StdSysView class defines a consistent overall appearance and behavior for all applications by arranging nine subviews in three rows and three columns to cover the available space completely:

```
= StdSysView:View {
      PT topLeftExtent;
      PT botRightExtent;
}
+ new {
      self = [super new];
      topLeftExtent = pt(16,16);
      botRightExtent = pt(16,16);
      // 0=topLeft 1=topCenter 2=topRight
      [self addSubView:[BorderedView new]];
      [self addSubView:[BorderedView new]];
      [self addSubView:[BorderedView new]];
      // 3=midLeft 4=midCenter 5=midRight
      [self addSubView:[BorderedView new]];
      [self addSubView:[BorderedView new]];
      [self addSubView:[MacScrollBar vert]];
      // 6=botLeft 7=botCenter 8=botRight
      [self addSubView:[BorderedView new]];
      [self addSubView:[MacScrollBar horz]];
      [self addSubView:[StretchFixture new]];
      return self;
}
```

This is the first example that shows how methods are defined in Objective-C. The plus sign in the fifth line assigns this method to the factory object for class StdSysView, while a minus sign in the same position signifies an instance method. Factory objects already inherit a method named new from the Object class, but it is being overridden here to create and initialize instances in a class-specific way. For example, the two instance variables (of type PT, short for Point) are given an initial value, and nine subviews are automatically installed, such as MacScrollBar instances in the center position of the bottom row and right column.

Newly created StdSysView instances contain only generic subviews initially, but they can be customized to the specific application by requesting them to replace one or more of them with application-specific views like this:

```
[stdView midCenterView:wbView =
  [WbView createViewOf:workbenchModel]];
```

WbView is an application-specific subclass of BorderedView that implements a user interface for an instance of class Wb.

```
= WbView . . .
+ createViewOf:aWorkbenchModel {
      id sequence, member;
      self = [super new];
      model = aWorkbenchModel;
      sequence = [[model entities] eachElement];
      while (member = [sequence next])
          [self addSubView:[ObjView
```

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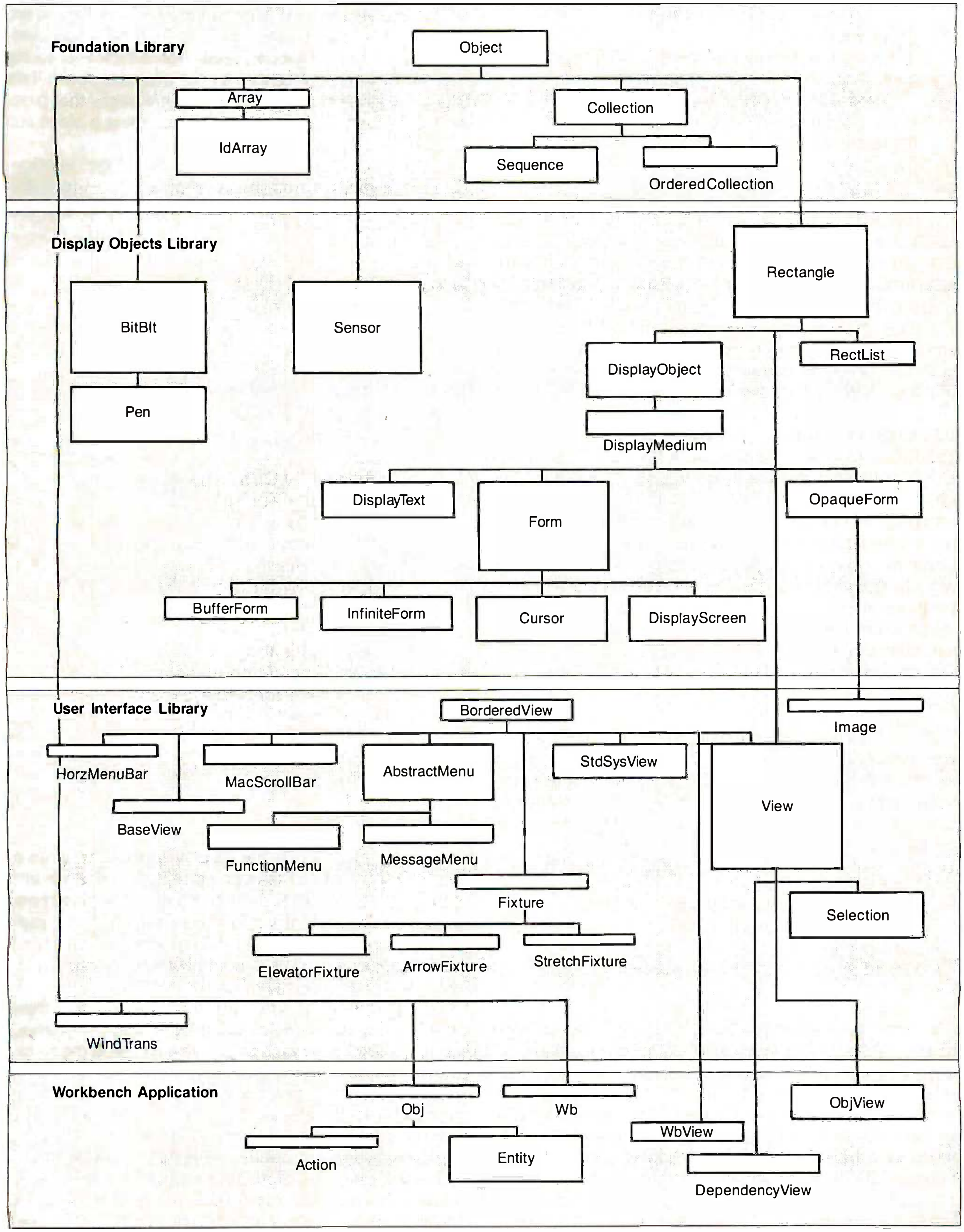

Figure 3: *The inheritance hierarchy for the Workbench classes. The source bulk in each class is represented as the height of each box.*

```
            createViewOf:member]];
    [sequence free];
    sequence = [[model actions] eachElement];
    while (member = [sequence next])
        [self addSubView:[ObjView
            createViewOf:member]];
    [sequence free];
    return self;
}
```

Application-specific views are exactly like the generic views discussed earlier, but they nearly always define an instance variable that points to the model that they are responsible for managing, plus factory methods for initializing this variable and installing any additional views that they need to implement the user interface. For example, this createViewOf: method loops over each of the entities and actions in the model and creates an instance of class ObjView for each one.

POSITIONING, SIZING, AND DISPLAYING

The application has created many different kinds of views and specified which ones lie on top of which others. But no attention has been given to how big each view should be and to where each view should be positioned on the screen. And of course, nothing has been displayed on the terminal. Since the sizing and positioning of each view may change each time the window size is changed, these functions are done separately in the course of responding to a windowChangedEvent. The event handler will automatically generate this event as soon as the application passes control to it:

```
[baseView controlStart];
```

One of BaseView's main functions is reading events from the event handler, determining which views lie under the location of the event, and sending those views messages that describe which event has occurred. Since the windowChangedEvent affects all views, the BaseView handles it specially:

```
= BaseView . . .
- (BOOL)windowChangedEvent {
  [self rect:currentDisplay];
  [self display];
  return YES;
}
```

The global variable currentDisplay identifies an instance of class Display that manages the window in which the application is running; the rect: message sets the BaseView's position and size to that of currentDisplay. This message is eventually implemented (in class Rectangle) via two separate messages, origin: and extent:, both of which are overridden (in class View) to give views the behavior of a sheet of acetate. For example, View defines a default implementation for the origin: method that automatically repositions a view's subviews when it is repositioned, and a default extent: method that changes only the receiver (stretching a background acetate does not stretch acetates that are attached to it). These defaults are sometimes inappropriate, so views like StdSysView override them to meet special needs, for instance, ensuring that subviews completely cover the available space. This triggers a wave of origin: and extent: messages that propagates through the view hierarchy, assigning a place and a size to every view.

Nothing appears on the screen until the windowChangedEvent method in BaseView executes [self display], which triggers the following generic display methods into operation:

```
= View . . .
- display {
    [currentDisplay lock:self];
    [[self topView] displayExcept:nil];
    [currentDisplay unlock];
    return self;
}
- displayExcept:aCollection {
    if (aCollection && [aCollection contains:self])
      return self;
    if (!TBIT(flags, ISLOCKED))
      [self computeClipList];
    if (lockedRegion == nil
      || [self intersects:lockedRegion]) {
      [self displayView];
      SBIT(flags, ISVISIBLE);
      if (TBIT(flags, ISSELECTED))
        [self emphasizeView];
      if (subViews) [subViews
        eachElementPerform:
            @selector(displayExcept:)
        with:aCollection];
    }
    return self;
}
- displayView
    { return self; }
```

The lock: message in the display method commands currentDisplay to set its clipping region to the margins of the receiver (the lock: and unlock messages) and commands the topmost view in the hierarchy to display itself and all of its subviews. The displayExcept: method is a multipurpose method used not only for redrawing the entire view hierarchy, as here, but also for erasing views and for highlighting views when they are selected, and these extra functions obscure the fact that this method basically sends a displayView message to each view in the hierarchy. As an efficiency optimization, it avoids considering views whose graphics would be clipped by the global clipping region, lockedRegion. The argument, aCollection, is a way of using the display methods to erase views, by redisplaying everything but the views that are to be erased.

All graphics are generated by displayView messages. A default implementation is defined in the View class that displays nothing, another way of saying that the View class implements transparent acetate. The views that do draw

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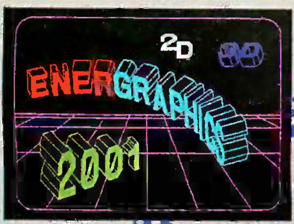

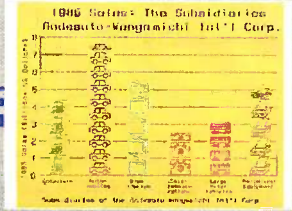
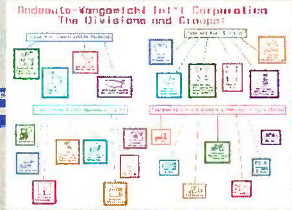


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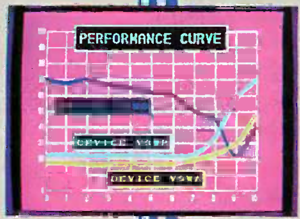

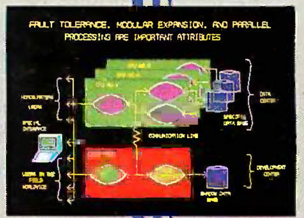

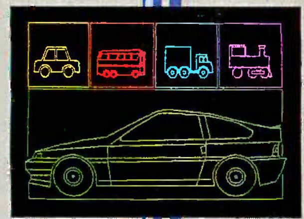


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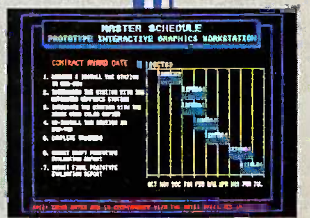

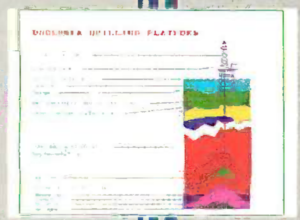
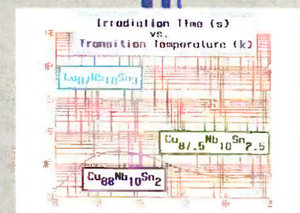

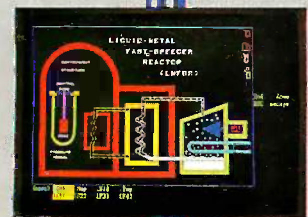

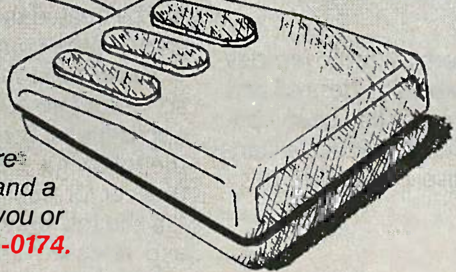
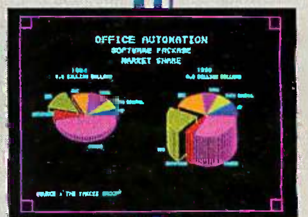

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Inquiry 105

Conceptually, events occur at the tip of the cursor and penetrate through the views at this location.

on the screen simply override this method, like this:

```
- Fixture : BorderedView {
    id form;
}
- displayView {
    [super displayView];
    [form displayOn:display at:origin
      clipBy:clipList rule:rules.Over];
    return self;
}
```

The Fixture class is the one that draws the small iconic fixtures in the scroll bars. Its instance variable, form, identifies the fixture's image, an instance of class Form that was hand-painted with a pixel editor.

Event Handling

Once the windowChangedEvent has caused each view to draw itself on the screen, control returns to the event handler to await interrupts from the graphics substrate signaling that something has happened; perhaps a key has been struck on the keyboard, one of the mouse buttons was pressed or released, or a time-out has expired. Conceptually, events occur at the tip of the cursor and penetrate through the views at this location like a needle through a stack of acetates. Each possible event is assigned a message, for example, leftButtonDown, keyboardEvent, timeoutEvent, and the View class defines a method for each one so that, by default, all views are transparent to all events.

```
 = View . . .
- (BOOL)rightButtonDown { return NO; }
- (BOOL)leftButtonDown { return NO; }
- (BOOL)middleButtonDown { return NO; }
- (BOOL)keyboardEvent { return NO; }
- (BOOL)windowChangedEvent { return NO; }
 . . .
```

When a view wants to receive an event, it just overrides the inherited method with one that works as desired and then returns YES to signify that the event has been consumed. For example, StdSysView instances attach a standard system menu to the right mouse button like this:

```
= StdSysView . . .
- (BOOL)rightButtonDown {
    static id menu = nil;
    if (menu == nil) { id tmp;
      menu = [MessageMenu str:"System Menu"];
      [menu add:[MessageMenu
          selector:@selector(exit)]];
      [menu add:[MessageMenu
          selector:@selector(refresh)]];
      [menu add:[MessageMenu
          selector:@selector(print)]];
      [menu add:tmp = [MessageMenu str:"debug"
          selector:@selector(dbgToggle)]];
          [tmp add:[MessageMenu str:"on"
              selector:@selector(dbgOn)]];
          [tmp add:[MessageMenu str:"off"
              selector:@selector(dbgOff)]];
    }
    [menu applyTo:self at:event.origin];
    return YES;
}
```

Notice that the single abstraction, views as layers of acetate, suffices to organize both directions of information transfer between the program and the user. This is a departure from the Model-View-Controller paradigm of Smalltalk-80 in which events are handled by a separate hierarchy of Controller classes.

Interaction

So far, we have shown how a programmer defines the components of an iconic application by defining specialized subclasses of the generic View class. When the application begins executing, instances of these classes are created and linked into a hierarchy that represents how they are arranged with respect to each other. Finally, control is passed to the event handler, at which time a position and a size are assigned to each view and they are displayed for the first time to the user. The initial frame of the animated movie has been projected onto the screen, and a data structure, the view hierarchy, has recorded where the parts of the image appear on the screen.

Very little new code is needed to get an application to this point because most has been provided by generic classes from the library. For example, the user interface for the Workbench application involved only three new classes (WbView, ObjView, and DependencyView) of two methods each, one to create a view of a specified model (createViewOf:) and another to draw a picture of the model on the screen (displayView). Now the harder part by far remains, giving life to the picture by making it respond to commands from the user. This is a huge topic that cannot be treated thoroughly here, other than to demonstrate some of the complexities and show how inheritance and encapsulation can control them by abstracting interaction scenarios into generic classes that can be reused in diverse applications. For example, in the Workbench application, the following scenario is used for selecting one or more objects for subsequent operations:

If the left button is pressed over one or more objects and released immediately, only the topmost object is selected. If it is held while the mouse is dragged, a box should outline a rectangular region. When the button is released, each of the objects inside the box should be selected. Selections are undone by selecting nothing, that is, by clicking the button over the empty background.

(continued)

Items are automatically highlighted once they are selected, and the highlighting is removed when the selection is undone.

This scenario is implemented by a generic class from the library, Selection. When the left mouse button is pressed over the Workbench, WbView creates an instance of class Selection and passes control to it:

```
= WbView . . .
- (BOOL)leftButtonDown {
        [Selection fromUserIn:self];
        return YES;
}
```

The Selection class implements the fromUserIn: method like this:

```
= Selection : View {
    id selectedArea; // Rectangle
    id selectedViews; // OrderedCollection(Views)
}
+ fromUserIn:aView {
    self = [self rect:aView];
    selectedArea = [Rectangle fromUser];
    selectedViews = [OrderedCollection new];
    [aView addSubViewsIn:selectedArea
        to:selectedViews];
    if ([selectedViews isEmpty]) {
        id singleView = [aView
            subViewAt:[selectedArea center]];
        [selectedViews add:singleView];
    }
    if ([selectedViews isEmpty)
        return [self free];
    [self adjustSelectedArea];
    [selectedViews eachElementPerform:
        @selector(emphasize)];
    [aView addSubView:self];
    return self;
}
```

Once a selection has been created, it must override the usual meanings of all mouse events, so it simply behaves like a large transparent sheet of acetate that covers all of its sibling views. Since it covers them, it will receive all events before they do, and it can override the usual event meanings with new ones. For example, whereas the leftButtonDown event previously created the new selection, the selection immediately assigns it a new meaning:

```
= Selection . . .
- (BOOL)leftButtonDown {
    if ([self eventOverASelectedView]) {
        PT old = event.origin;
        [superView erase:selectedViews
                    in:selectedArea];
        [selectedViews eachElementPerform:
            @selector(motionStart)];
        while([currentSensor leftButtonDown]) {
            PT delta = ptMinus(event.origin, old);
```

(continued)

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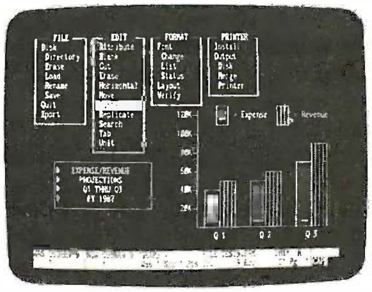

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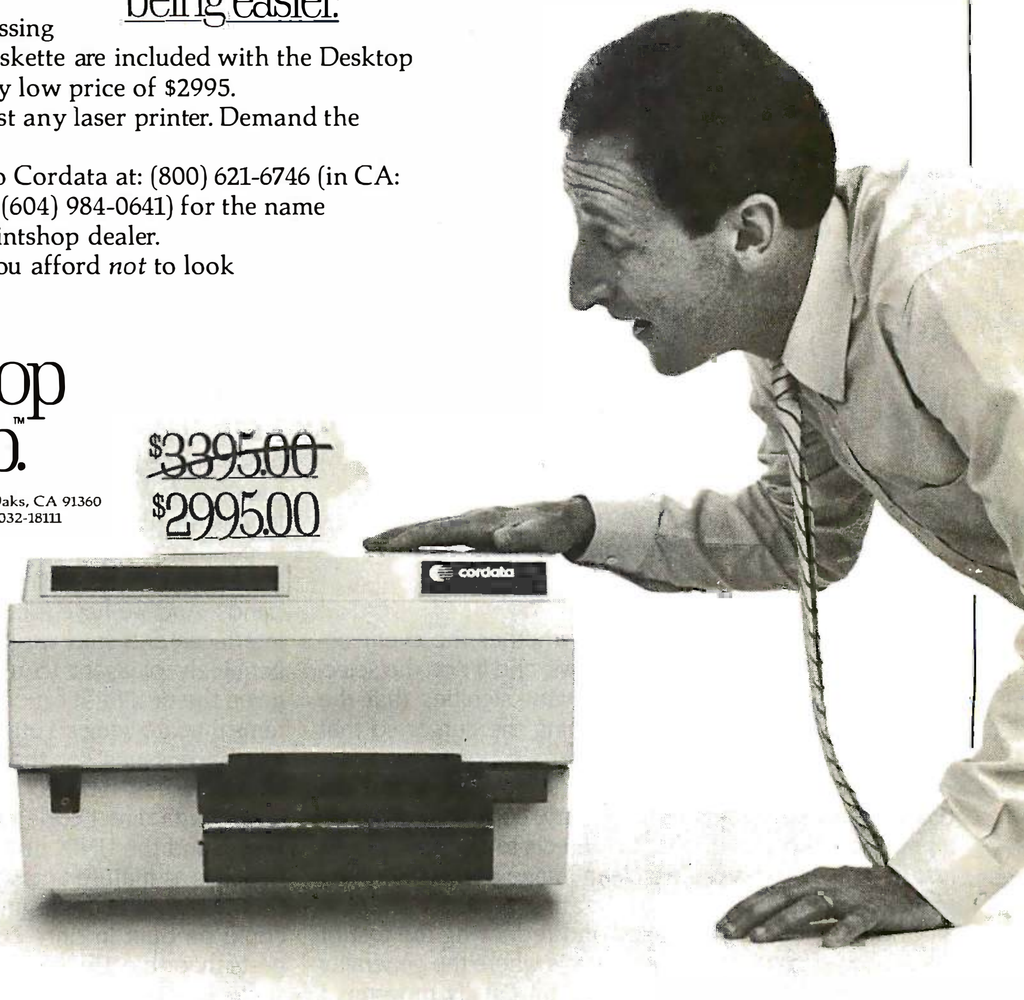

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USER INTERFACE PERFORMANCE ISSUES

BY JOHN UEBBING AND CHARLES YOUNG

The human visual system has several characteristic limits that should be accounted for in building responsive iconic interfaces. For example, changes occurring in less than 20 milliseconds are perceived as instantaneous. If successive frames of a moving image are redrawn in less than 50 milliseconds, the object is perceived as moving smoothly. If feedback to user-initiated events is produced in less than 300 milliseconds, it is perceived as occurring instantaneously. These speeds represent significant qualitative thresholds past which objects move smoothly without flicker and do not interrupt the user's train of thought.

For example, Hewlett-Packard 9000-310 workstations are based on a 10-MHz Motorola 68010 chip that executes an Objective-C message in about 0.04 milliseconds. If a drawing of an animated mechanical robot consists of 100 lines, and if each line is implemented as an object and manipulated by messages, 4 of the available 20 milliseconds could be wasted just in message-passing overhead.

It would pay to avoid this overhead by implementing only the robot as an object, storing the lines as C data structures to be accessed by a high-performance polyline procedure. On the other hand, dispatching a mouse event to one of 25 objects would spend only 1.0 of the available 300 milliseconds in messaging. Even a complex series of messages, redrawing 20 objects with 10 messages per object, would consume only 8.0 milliseconds in messaging. The lesson is to use messaging extensively for flexibility in things like menus and mouse event dispatching where messaging time is small relative to response times of the human visual system, and to avoid messaging in critical loops like displaying individual lines and characters. By judiciously combining messaging and high-performance C and assembly code, it is possible to build very flexible and powerful human interfaces with fully adequate speed using today's low-cost hardware. A general rule is to start out by using messaging, time the execution of the critical parts, and then substitute C, assembly code, or even special hardware to bring performance to the needed level.

John Uebbing and Charles Young, who have both worked extensively in electronic displays, are now involved with advanced user interface concepts. They can be contacted at Hewlett-Packard Research Laboratory, 1651 Page Mill Rd., Palo Alto, CA 94304.

```
            if (delta != 0) {
                [selectedViews eachElementPerform:
                    @selector(motionBy:)
                    with:delta];
                [selectedArea moveBy:delta];
                old = event.origin;
            }
        }
        [selectedViews eachElementPerform:
            @selector(motionEnd)];
        return YES;   // consume the event
    }
    [self free];
    return NO; // not over selected view
}
```

The opening if statement tests whether the event occurred over one of the selected views, and if not, the selection is undone. Otherwise, the event signifies that the selected items should begin tracking the cursor so that the user can drag them to new screen positions.

Dragging is hardly as simple as it may seem, but the complications are handled in generic code that all views inherit from the View class. The objects to be moved must first be erased to produce a clean image of the stationary objects, and this is done by creating a clipping region around the views to be erased and redrawing the rest of the hierarchy inside this region (this is where the generality of the displayExcept: method pays off). Finally, movement is simulated by repeatedly drawing each view with exclusive-or raster operations to toggle the pixels beneath them on and off without losing information. This lets them glide across the screen without damaging their background.

SUMMARY

The design and construction of pleasant user interfaces is a remarkably deep and complicated topic, and this article has only skimmed the surface. The user interface library contains many kinds of components that have not been mentioned like menus, choice boxes, verifiers, text editors, etc., but describing these could easily take as much space as the simpler components that have been presented. We have not discussed several technical challenges in the Workbench application, such as how dependency lines between views are redrawn while views are being moved such that the lines behave like rubber bands. And we have focused only on how to build iconic interfaces and said very little about how to make them genuinely pleasant to use. This is especially important given the proliferation of poorly designed but flashy systems that are seen so often today. For a discussion of performance issues, see the text box "User Interface Performance Issues" above.

Although direct code size comparisons between Workbench and the UNIX utility make should wait until Workbench is as mature and widely used as make is today, we find it highly encouraging that its iconic user interface could be built in only 262 lines of new code. This suggests that object-oriented programming, and its ability to capture large quantities of reusable code in generic Software-IC libraries, may actually reduce development costs to the point that iconic interfaces may become as prevalent as text-oriented interfaces are today. ■

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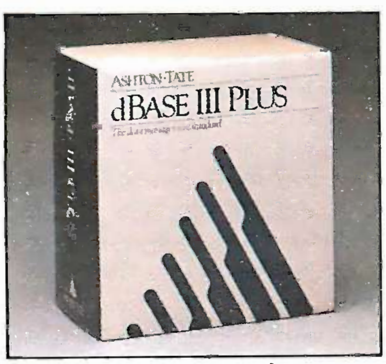

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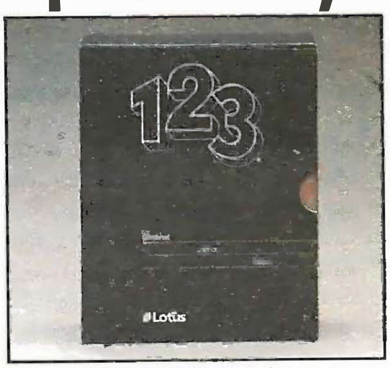

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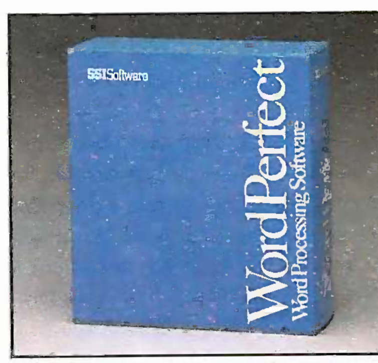

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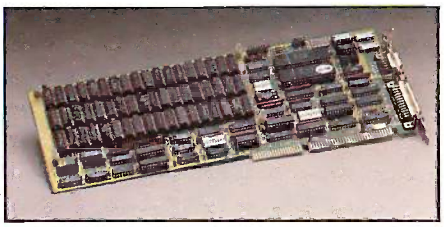

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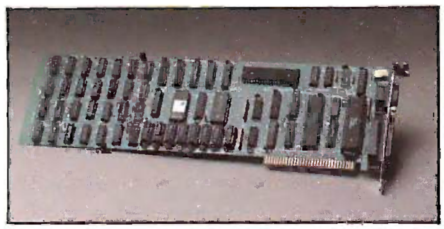

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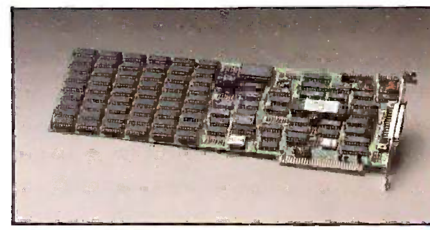

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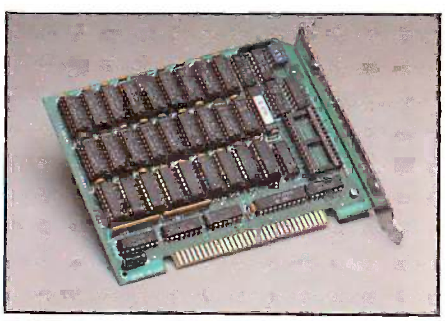

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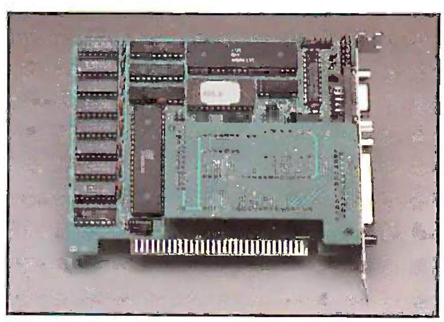

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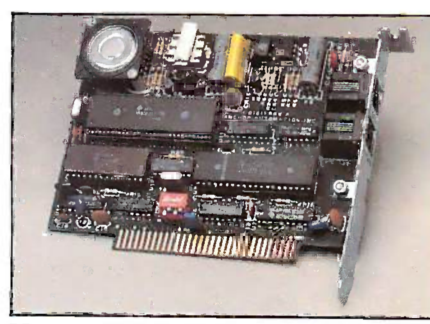

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OBJECT-ORIENTED LANGUAGES FOR THE MACINTOSH

BY KURT J. SCHMUCKER

An overview of the languages and their capabilities

CURRENTLY, A LARGE NUMBER of object-oriented languages are available, and more are being designed and implemented every year. Some of these languages now on the market or in development are for the Apple Macintosh, an ideal computer for object-oriented languages because of its processing power and the nature of its user interface. In this article I will survey some of the Macintosh object-oriented languages. I will also present a table detailing each language's object-oriented characteristics, such as whether it can access the MacApp class library (see my article "MacApp: An Application Framework" on page 189) or whether it provides for class methods. After describing the languages, I will discuss the mechanics of programming with them on the Mac.

SMALLTALK

The Smalltalk language is the ancestor of all object-oriented languages. It was implemented on the Macintosh by Apple as part of an experiment to demonstrate Smalltalk's portability and debug the Smalltalk specification. Apple currently distributes Smalltalk for the Mac as an unsupported, low-cost product, but a fully supported and greatly enhanced version is expected soon. A fact sheet on Smalltalk and the other languages I describe in this article is presented in table 1.

Smalltalk has a message-sending syntax that often seems unusual to the novice object-oriented programmer, but it quickly becomes the natural way of doing things. Smalltalk syntax and the syntaxes of all the languages I discuss herein are shown in table 2.

New classes and methods are defined by editing standard templates in an interactive source-code browser. The class library for the Macintosh version of Smalltalk contains over 300 classes with special classes for accessing the Macintosh file system, the Macintosh Toolbox (including the QuickDraw routines), and the AppleTalk network added by Apple. Since Smalltalk has been described in previous BYTE articles and elsewhere, I will not elaborate on its language features.

OBJECT PASCAL

Object Pascal is Apple's second object-oriented extension of Pascal. (The first, Clascal, was only for the Lisa Office System and thus is no longer supported by Apple.) The syntax for Object Pascal was jointly designed by Apple's Clascal team and Niklaus Wirth, the designer of Pascal, who was invited to Apple's Cupertino headquarters specifically for this project. In addition to implementing Object Pascal on the Mac, Apple has put the Object Pascal specification in the public domain and encouraged others to implement compilers and interpreters for it. Several such developments are under way.

Object Pascal implements classes as an extension of

(continued)

Kurt J. Schmucker, director of educational services for Productivity Products International (Severna Park Mall, H & R Block Office, 575 Richie Highway, Severna Park, MD 21146), teaches seminars on object-oriented programming. Kurt has written three books on computer science, including the forthcoming Object-oriented Programming for the Macintosh *(Hayden, 1986).*

Pascal's RECORD structure. In Pascal, records have only data as their component fields, but in Object Pascal, object types (as classes are called in Object Pascal) have data fields (instance variables) and method fields. Messages are sent using the same syntactic construct used in ordinary Pascal for field qualification—the period.

Thus, in Object Pascal, accessing an instance *variable* and accessing a method (that is, sending a message) are accomplished with the same syntax.

New classes are defined using one new compiler key-

Table 1: *Summary of object-oriented languages.*

		Smalltalk-80	Object Pascal	Neon	ExperCommonLISP	Objective-C	Object Assembler	Object Logo
General	Developer	Apple Computer	Apple Computer	Kriya Systems	Exper-Telligence	Productivity Products	Apple Computer	Coral Software
General	Base language	None	Pascal	FORTH	LISP	C	68000 assembler	Logo & CommonLisp
General	Current version	0.2	1.0	1.5	2.0	3.1	1.0	1.0
General	Toolbox access	Yes, but difficult	Yes	Yes	Yes	Yes	Yes	Yes
General	Supports 128K ROM	No	Yes	Yes	Yes	Yes	Yes	Yes
Object-oriented Information	Instance variables and instance methods	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object-oriented Information	Class variables	Yes	No	No	Yes	Yes, but cannot be inherited	No	Yes
Object-oriented Information	Class methods	Yes	No	No	Yes	Yes	No	Yes
Object-oriented Information	Multiple inheritance	No	No	No	No	No	No	Yes
Object-oriented Information	Unique instance methods	No	No	No	No	No	No	Yes
Object-oriented Information	Number of classes in class library	Approx. 300	Approx. 30	Approx. 40	Approx. 45 in ExperCaste	Approx. 25	Approx. 30	Approx. 30
Object-oriented Information	MacApp access	Yes	Yes	Planned	Planned	Planned	Yes	Planned
Summary	Greatest strength	compatible with other Smalltalks	simplicity of design	speed	object-oriented features; library size	portability to other machines	speed	uniform treatment of objects
Summary	Greatest weakness	speed	limited object-oriented concepts (no class methods)	"unusual" syntax of FORTH	LISP still an "unusual" language	not a native compiler	limited object-oriented concepts (no class methods)	longer learning time for experienced object-oriented programmers
Summary	Other	requires 1000K of RAM for serious work	supported by Apple Computer	numerous user groups, bimonthly newsletter	(note: not shipping at press time)	—	(note: not shipping at press time)	(note: not shipping at press time)

word, OBJECT. The basic schema is

```
TYPE
    ClassName = OBJECT (SuperclassName)
      < instance variable declarations >
      < method header definitions >
    END;
```

where < > denote optional portions of this schema. Methods are defined as ordinary Pascal procedures or functions that have been qualified with the name of the class:

```
PROCEDURE ClassName.ProcedureName(argumentList);
BEGIN
 .
 .
 .
END;
```

Object Pascal is a "bare bones" object-oriented language. It makes no provision for class methods, class variables, multiple inheritance, or metaclasses. These concepts were specifically excluded in an attempt to streamline the learning curve encountered by most novice object-oriented programmers.

The Object Pascal class library is MacApp.

NEON

The language Neon is, depending on your programming-language point of view, either an object-oriented extension to the FORTH language or an incisive and efficient implementation of Smalltalk as a threaded interpreted language. Regardless of which view you take, Neon is a remarkably concise language that nicely bridges the gap between the object-oriented languages (à la Smalltalk) and the threaded languages (à la FORTH). Neon was developed by Kriya Systems expressly for the Mac and was first shipped in 1984.

The basic Neon syntax shows its strong FORTH heritage: From the point of view of most of the other languages discussed in this article, Neon's syntax is backward. (To be fair, many programmers consider the Smalltalk syntax, which has the object precede the message, to be backward compared to the procedure call used in most languages, so perhaps Neon, with the message preceding the object, is one of the few object-oriented languages to get it right!)

New classes and methods are defined using special Neon compiler words that delimit class definitions (:CLASS and ;CLASS) and method definitions (:M and ;M). The basic schemas are

```
:CLASS ClassName <Super SuperClassName < n Indexed>
        <instance variable names >
        < method definitions >
;CLASS
```

and

```
:M Selector: < { named arguments \ local variables — results } >
        < method body >
;M
```

where < > denote optional portions of these schemas.

One of the most useful features of Neon is the provision for both named arguments and local variables in methods. Named arguments let you associate a name with the arguments placed on the stack prior to the invocation of the method and then simply refer to these arguments by name when you need them in the body of the method. Local variables let you declare and use temporary variables in the method body. Both features simplify the use of Neon compared to the complex stack manipulations often required in FORTH.

Neon allows you to choose between the efficiency of static binding and the flexibility of dynamic binding (called *early binding* and *late binding* in the Neon manual) on a message-by-message basis. Early binding will resolve at compile time a message sent to a given object into an invocation of a particular method in a particular class; late binding will leave this resolution until run time. The compile-time determination is made based on the declared classes for the reference variables. (Thus, Neon is like Object Pascal, which allows a reference variable to be declared of a certain class, and unlike Smalltalk, in which all object references are equal.) The Neon line Get: myInt will send the Get: message to the object referred to by myInt, with the resolution of that message determined at compile time by the declared class of myInt. The line Get: [myInt] will send the Get: message to the object referred to by myInt, with the resolution of that message determined at run time by the run-time class of myInt. Late binding can be used with any construct that generates an object reference, such as Get: [i at: myArray] to send the message Get: to the object referred to by the *i*th element of the array object myArray, with the resolution of that message determined at run time by the run-time class of the object stored at that element in the array.

The basic approach of the current Neon class library—unlike that of MacApp, which provides a completely functional application framework—is to "lift" the Toolbox data types to the level of classes. Accordingly, Neon has classes like Point, Window, Dialog, and Event, which provide a more functional set of building blocks than do the basic Toolbox data types and procedures for the Pascal or C

(continued)

Table 2: *A comparison of the syntax of each language. The message,* msg, *with argument,* arg, *is sent to the object referenced by* obj.

Syntax	Language
obj msg: arg.	Smalltalk
obj.msg(arg);	Object Pascal
arg msg: obj	Neon
(obj 'msg <arg>)	ExperCommonLISP
[obj msg: arg];	Objective-C
MOVE.W arg(A6),-(SP) MOVE.L obj(A6),-(SP) MethCall msg	Object Assembler
tell :obj [msg "arg]	Object Logo

programmer, but not quite the type of building blocks that the MacApp classes provide for the Object Pascal programmer.

ExperCommonLISP

The language ExperCommonLISP is one of the most comprehensive object-oriented languages for the Macintosh in that it implements all of the features of object-oriented languages (except unique instance methods), provides a set of classes that mirror the Toolbox data types, and, with the next release, will provide MacApp access. ExperCommonLISP was developed by ExperTelligence expressly for the Mac. It was derived from the ExperLISP product available for the Mac since early 1985.

ExperCommonLISP syntax shows its strong LISP heritage: Message sending, setting object reference variables, accessing instance variables, and other object-oriented programming language features are accomplished with list functions.

(setq Triangle (send Object 'subclass)) defines a new subclass of Object, named Triangle, by sending the message subclass to the Object class. (setq tri1 (send Triangle 'New)) instantiates a new instance of the Triangle class and stores a reference to this new instance in the variable tri1. (send tri1 'height) sends the message height to the object referenced by tri1.

Actually, the definition of a new class in ExperCommonLISP can be much more detailed than this simple example shows. The full class-definition schema includes provisions for instance and class variables and instance and class methods.

Note: LISP users will observe that this schema uses terms like arg__lists rather than the traditional lambda-list style common to LISP. The lists are written here in a nonrigorous, informal notation. This is to make this explanation of ExperCommonLISP more understandable to those who do not have a reading knowledge of LISP.

```
(setq NewClass(CLASS (superclass_1 superclass_2...superclass_n)
        (IVS (iv_1)(iv_2)...(iv_n))
        (Methods     (method_1(arg__list)(body))
                     (method_2(arg__list)(body))
                     .
                     .
                     .
                     (method_n(arg__list)(body)))
        (CVS (iv_1)(iv_2)...(iv_n))
        (Metamethods(method_1(arg__list)(body))
                     (method_2(arg__list)(body))
                     .
                     .
                     .
                     (method_n(arg__list)(body))))
```

where

- IVS is a keyword for the instance-variable-definition clause. Each portion of that clause names an instance variable and provides its initial value and attributes.
- Methods is a keyword for the method-definition clause. Each portion of that clause defines a message, its argument list, and the method that will be invoked when that

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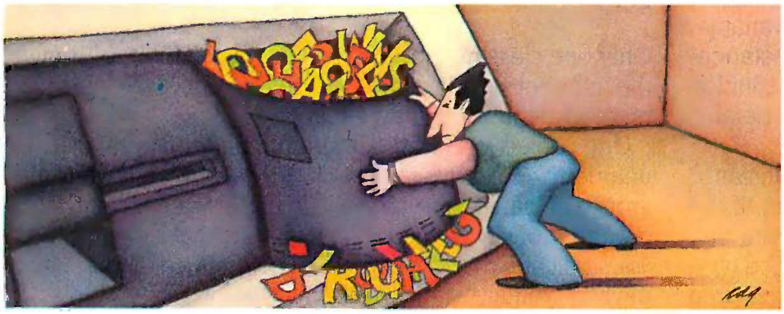

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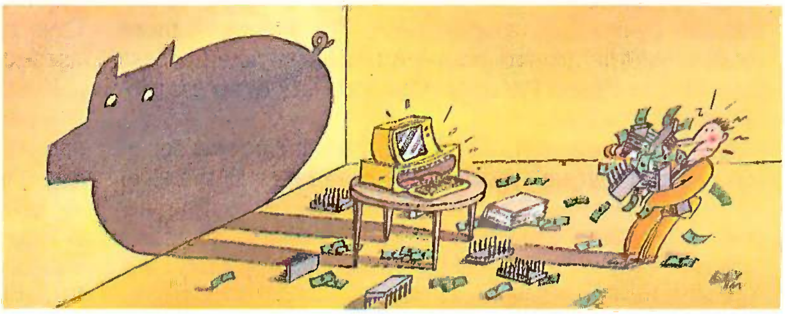

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Perhaps the greatest strength of Objective-C is that it is available on a large number of machines.

message is received by an instance of this class.

- CVS is a keyword for the class-variable-definition clause. Like the instance-variable-definition clause, each portion of the CVS clause names an class variable and provides its initial value and attributes.
- Metamethods is a keyword for the class-method-definition clause. Each portion of that clause defines a class message, its argument list, and the class method that will be invoked when that message is received by the class object.

Even this detailed schema does not present a full picture of the facilities in ExperCommonLISP. As one example of a capability in ExperCommonLISP that is not exhibited by this schema and is not present in any of the other object-oriented languages discussed in this article, consider the more detailed format of the following instance-variable-definition clause: (IVS (instance-variable$_1$-definition) (instance-variable$_2$-definition) ... (instance-variable$_n$-definition)) where an instance-variable definition has the form (< instance-variable-name > < default-value-form >< set >< get >).

The keywords get and set specify whether the instance variable can be accessed from outside the object. If the keyword get is used, the variable can be read from outside; if the keyword set is used, the variable can be written. Thus, the degree of encapsulation can be set on a class-by-class basis, and within a class on an instance-variable-by-instance-variable basis. This is a much more flexible middle ground between the unrestricted access provided by Object Pascal and the total lack of access provided by Smalltalk.

The ExperCommonLISP class library includes a set of classes that "lift up" the Toolbox data types to the level of objects as well as the MacApp classes. As with Smalltalk, Neon, and Object Logo, this MacApp access is achieved by a reimplementation of the MacApp class functionality by ExperTelligence.

OBJECTIVE-C

Objective-C brings the basic notions of object-oriented programming to the C language in a manner that is machine-independent. This is accomplished by a compiler that accepts Objective-C source code and outputs an equivalent C source code. The resulting C source code can then be compiled for execution on the target machine. This has resulted in a language that can (and does) exist on both the IBM PC and the VAX-11/780 and on many machines in between. Objective-C was developed by Productivity Products International (PPI) and first shipped in 1983.

The Objective-C language is a strict superset of the C language. The object-oriented extensions are achieved by adding a new expression type to the C language, the message expression. Syntactically, this message expression is delimited by brackets (see table 2). The message expression brackets can be distinguished from the standard-array subscripting brackets used in ordinary C by context. The internal message syntax is similar to that of Smalltalk; it even follows Smalltalk's syntax for keyword messages. This new expression type exists on an equal level with all C expressions. The result is that an Objective-C statement message expression can be used anywhere that an expression can be used in C. A sample statement that shows the resulting flexibility is: [Point x: foo( ) + 7 y: [box top]]. In this statement, the keyword message x:y: is being sent to the Point class. The first argument (of the x: portion) is the result of a function call and an addition (foo( ) + 7). The second argument (of the y: portion) is the result of sending the message top to the object referred to by box.

New classes are defined in a special class-description file of the following form:

```
= ClassName: SuperClassName (PhylaList) { Instance Variable Declarations }
+ ClassMethodName {Method Implementation}
- InstanceMethodName {Method Implementation}
=:
```

Only one class may be defined in any such file, although the number of class-method definitions and instance-method definitions may vary.

One object-oriented programming concept that is unique to Objective-C is *phyla*. Phyla in Objective-C are groups of classes, just as phyla in biology are higher-order organizations than the biological notion of a class. When you indicate that a new class belongs to a particular phylum, you are stating that this class will often be used together with the other classes in that phylum. When the Objective-C source code is compiled, this information is used to generate a more efficient method table structure.

The Objective-C class library consists of some 25 classes that implement collection classes, basic geometric notions, and standard data structures—all in a machine-independent way. The fact that the Objective-C language is available on a large number of machines and that its class library is machine-independent is perhaps its greatest strength. Productivity Products International coined the term "software-IC" to describe such a machine-independent class, although the term is now used to describe any well-designed class. (The concept of a software-IC has been described in "Software-ICs" by Lamar Ledbetter and Brad Cox, June 1985 BYTE.)

OBJECT ASSEMBLER

Object Assembler is a set of macros for the Motorola 68000 assembly language that provides easy access to the MacApp class library and to class-definition facilities. It is built on top of the macro assembly language provided

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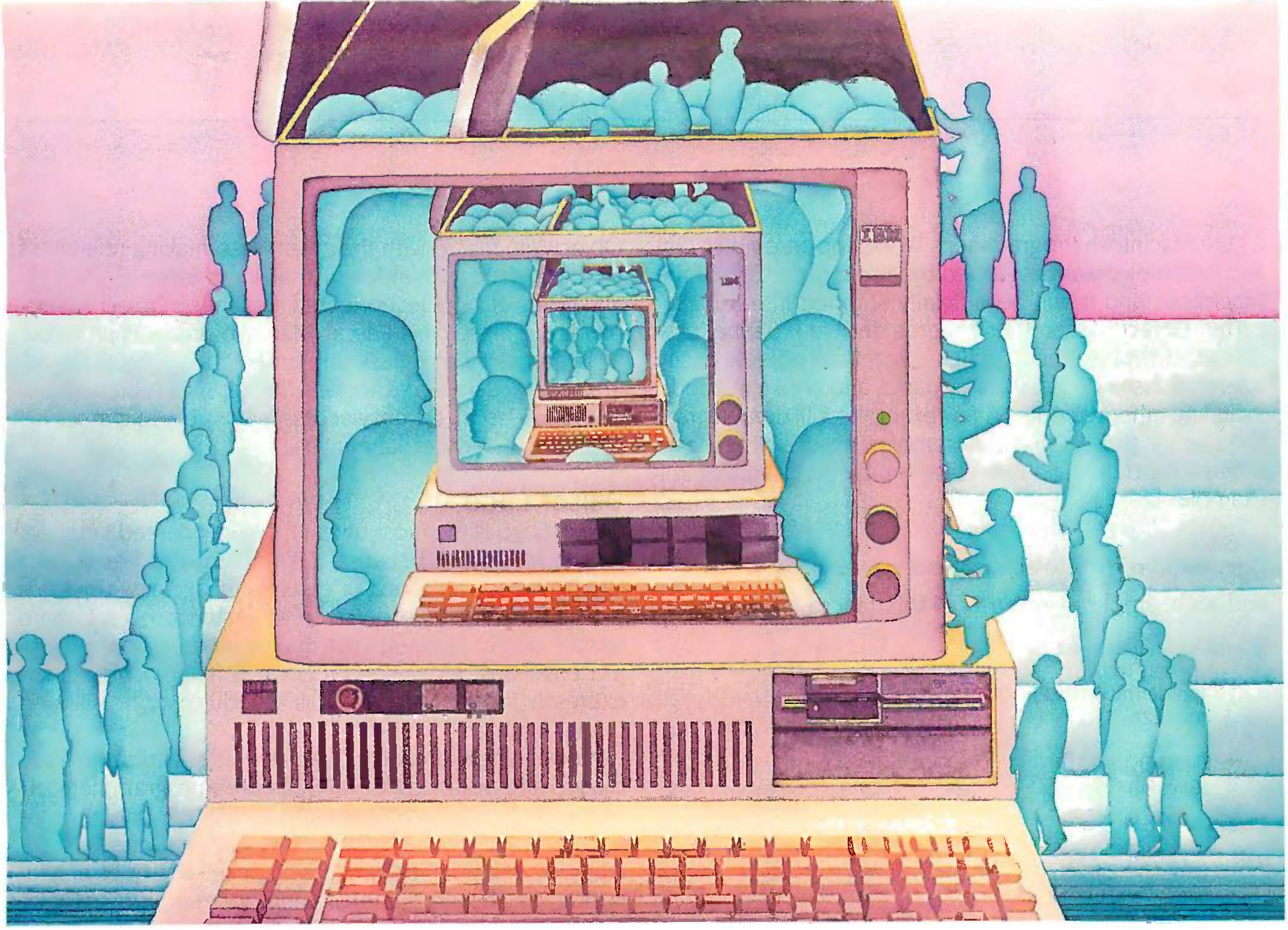

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by the Macintosh Programmer's Workshop assembler. Object Assembler was developed by Apple expressly for the Macintosh and it will be officially shipped late in 1986.

The Object Assembler macros let you define new classes, define method bodies, instantiate objects, easily reference instance variables by name, and invoke methods, including inherited ones. A few examples will demonstrate the use of these Object Assembler macros. The basic schema for defining a new class in Object Assembler, for example, is

```
MACRO
ObjectDef &TypeName,&Heritage,&FieldList,&MethodList
```

and an example of the use of this macro is:

```
ObjectDef Shape,Object,              \
        ((boundRect,8),              \
         (borderThickness,2),        \
         (color,2)),                 \
        ((Draw),                     \
         (MoveBy),                   \
         (Stretch))

ObjectDef Arc,Shape,                 \
        ((startAngle,2),             \
         (arcAngle,2)),              \
        ((Draw,OVERRIDE),            \
         (GetArea),                  \
         (SetArcAngle))
```

(The backslash is required by the assembler when continuing a statement from one line to the next.)

Let me demonstrate defining a method and referencing an instance variable by name with some examples.

Defining a method:

Schema

```
MACRO
&ProcName ProcMethOf &TypeName

MACRO
EndMethod
```

Example

```
Draw ProcMethOf Arc
<code>
EndMethod
```

Accessing an instance variable:

Schema

```
MACRO
ObjectWith &TypeName

MACRO
EndObjectWith
```

Example:

```
ObjectWith Arc
MOVE.L startAngle(A1), -(SP)
PEA    boundRect(A1)
EndObjectWith
```

In this example of accessing an instance variable, A1 must already be loaded with an arc object reference. The ObjectWith macro simply qualifies startAngle and boundRect for you. Note that the ProcMethOf (and the corresponding FuncMethOf) macros automatically invoke the ObjectWith macro with the given class, making references to the instance variables of that class easy.

In terms of its object-oriented semantics, Object Assembler is just like Object Pascal. MacApp access is provided, as is access to any class implemented in Object Pascal. It also is possible to subclass Object Assembler classes in Object Pascal. No easy access is possible to classes implemented in other languages.

OBJECT LOGO

Object Logo is the most unusual object-oriented language for the Macintosh because it is implemented as a classless language—an object-oriented language in which there is no firm distinction between an instance object and a factory object (a class) that makes those instances. Object Logo was developed by Coral Software Corporation expressly for the Mac, and it is scheduled to be shipped in the summer of 1986.

In designing a language that has no distinction between classes and instances, Coral Software's programmers left out a concept that is commonly used in the implementation of object-oriented languages. Classes, after all, are really an implementation convenience—a way of economizing on the amounts of memory required to write object-oriented programs. From Coral's point of view, the conceptual issues in using an object-oriented language are more important than implementation efficiency concerns. By removing the class "artifact," Coral has designed a language in which all objects are treated uniformly, which it believes is easier to learn than traditional object-oriented languages.

There are a number of technical consequences of this philosophical decision to remove distinctions between classes and objects. In Object Logo, objects can be given instance variables and methods "on the fly" during an interactive session. You could, for example, create an object, give it two instance variables, then define a couple of methods, use those methods, clone the object (i.e., copy all relevant object information), *add some instance variables, remove some methods*, and then clone the object. In terms of the vocabulary I have developed up to this point, you have created an instance (from no template), redefined the structure of an instance while it existed, added new methods while it existed, and then used it as a factory to produce a new instance just like itself—all notions that don't make sense with the traditional object-oriented vocabulary. The problem isn't with the vocabulary. The problem is that many of the notions of object-oriented programming that we have spent so long acquiring just don't apply to Object Logo as well as they do to other languages. Consequently, Object Logo is somewhat harder to learn than the other object-oriented languages described in this article, *if* you are already familiar with other object-oriented languages. Object Logo requires that you unlearn some concepts about object-oriented programming and learn some new ones that don't fit in with your conceptual model of how objects, classes, messages, and methods interrelate. For example, Object Logo is the only language described in this article that provides for unique instance methods—methods not associated with a data structure shared among objects with a similar format, but rather methods directly "attached" to objects. In Object Logo, such a concept is natural; in the other languages discussed here, it is most unusual.

Because conceptual simplicity was one of the major goals in the design of Object Logo, Object Logo adds only a few new primitives to the Logo language.

KINDOF anObject creates a new object which inherits from anObject. TALKTO anObject makes anObject the "current object." (At any time during the execution of an Object Logo interactive session, there is exactly one current object. All references to variables and procedures are resolved in the context of this current object.) HAVE word thing adds the instance variable word to the current object. The initial value of word, in the context of the current object, is thing. HOWTO procedureName adds the method procedureName to the current object. USUAL invokes the inherited method. (This is essentially equivalent to the Object Pascal INHERITED and to sending messages to super in Smalltalk.) And TELL anObject InstructionList executes a list of instructions in the context of anObject without making anObject.

Object Logo is one of the few languages in this article that implements multiple inheritance. In Object Logo, a subclass can invoke *all* methods for a message common to its immediate ancestors. This style differs considerably from that of Smalltalk. (For legal reasons, the version of Smalltalk for the Mac does not have multiple inheritance. This is the only major technical difference with other Smalltalk implementations.)

At the time of this writing, no comprehensive listing of the Object Logo class library was available. However, the plans for Object Logo class library include a complete reimplementation of the MacApp classes using their Logo primitives for accessing the Toolbox. Like Neon and ExperCommonLISP, this reimplementation will produce a semantically similar set of classes so that the MacApp programmer could move from Object Pascal or Neon to Object Logo with very little additional training about the MacApp class library.

PROGRAMMING WITH A MAC OBJECT-ORIENTED LANGUAGE

Object-oriented languages for the Macintosh can be divided into two sets—those that have interactive interpreters and those that don't. The languages with interactive interpreters—Smalltalk, Neon, ExperCommonLISP, and Object Logo—have self-contained development environments consisting of a text editor, an interpreter, a compiler (sometimes), and other application building tools. These development environments are generally in accordance with the Macintosh User Interface Standard. New classes are developed interactively with reasonably functional debugging facilities. When debugged, the new classes are loaded into a working image that then can be saved in a snapshot. Many such snapshots can be saved on disk, each representing a different development effort, a different project, and so on. Classes are used as incremental building blocks: As soon as a new class is defined, it is available for use. The results of developments in different images can be combined in a single image, usually by recompiling the source code versions of the new classes and methods. None of these languages can use procedures written in standard languages like Pascal or C, or classes written in other object-oriented languages, with the exception of ExperCommonLISP, which can access Pascal and C procedures.

In the languages that do not currently have interactive interpreters on the Macintosh—Object Pascal, Object Assembler, and Objective-C—classes are developed first (using a standard text editor) and compiled with the appropriate compilers. Then a main program using these classes is written, compiled, and linked with the classes. All of these languages can access procedures and functions written in either Pascal, C, or assembly language.

Most of these languages, whether compiled or interpreted, contain all the facilities to construct a stand-alone Macintosh application. For example, they have special routines to construct menus and to link the choice of a particular menu item with the execution of a certain method. Each of these object-oriented languages has its particular strengths and weaknesses as an implementation language depending on your application and background. ■

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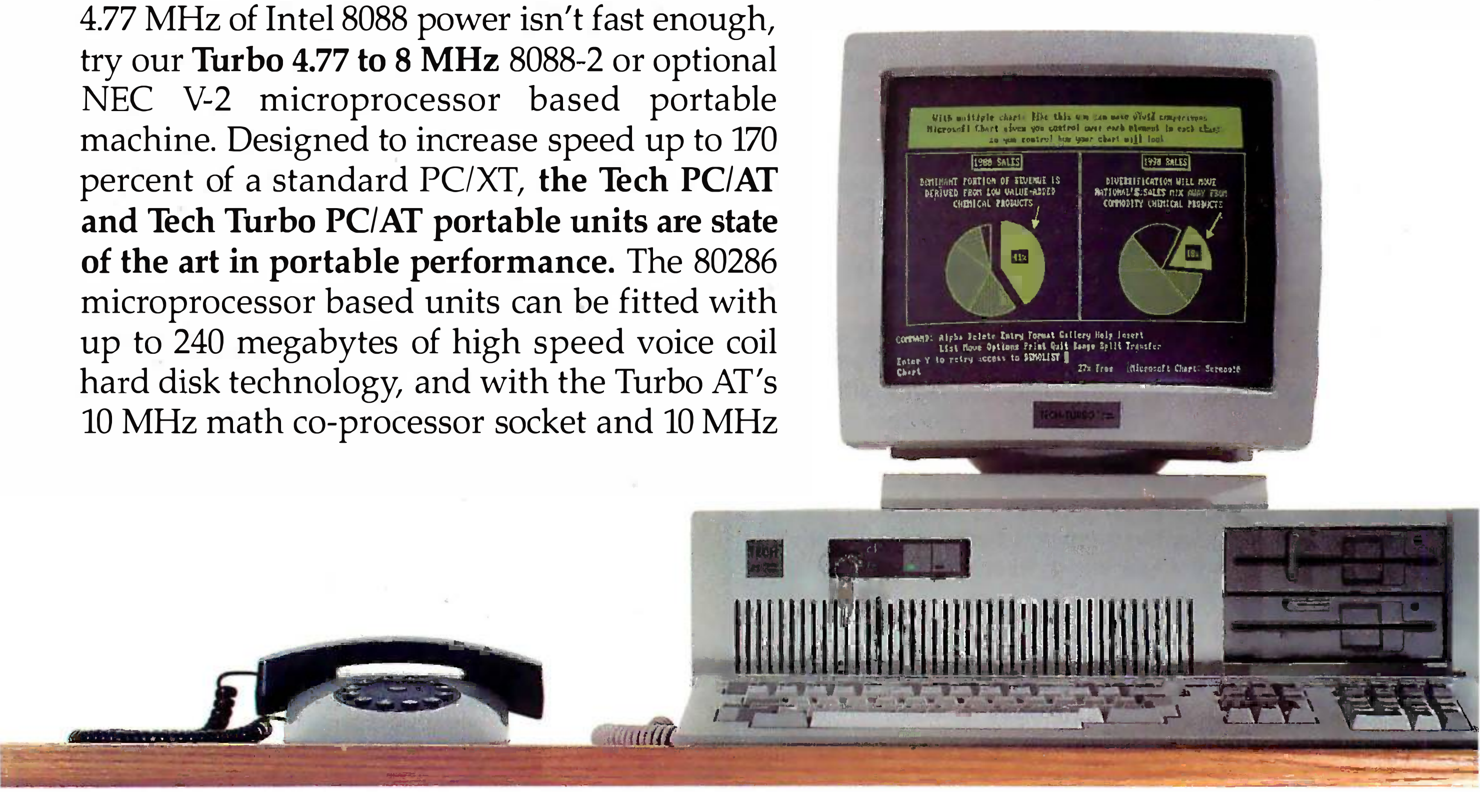

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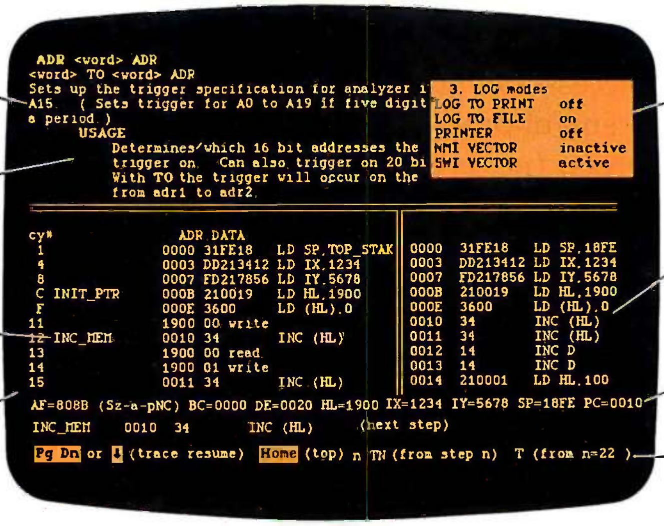

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MACAPP: AN APPLICATION FRAMEWORK

BY KURT J. SCHMUCKER

This application can significantly reduce Macintosh program development time

ONE FASCINATING and potentially far-reaching use of object-oriented programming is in the design of an application framework for a personal computer or workstation. Several examples of such frameworks exist, such as the Lisa Toolkit, discussed in "Software Frameworks" by Gregg Williams (December 1984 BYTE), and more are being designed all the time. This article examines one specific application framework for the Macintosh, MacApp—The Expandable Macintosh Application from Apple.

The average end user does not generally use or even know about application frameworks. They are tools for developers who design the software for end users. In theory, an application framework can be developed for any personal computer. However, they are especially useful on those with a well-defined user-interface specification.

WHAT IS MACAPP?

The MacApp framework is basically a complete, self-contained application that implements most of the Macintosh user-interface standard. It has menus that pull down and windows that scroll and can be moved about the screen, it works correctly with desk accessories and with Switcher, and it prints on the Imagewriter and the LaserWriter. The only things missing from a complete application are the contents of the windows and the items on the menus. An application framework is only the shell of a real application—a shell that you can easily customize into a true application. This customization process differentiates an application framework from a set of merely useful subroutines.

For example, let's examine the way in which an application framework supports undoing commands. MacApp knows that after you choose a menu command, the Undo command should reverse the effect of the command. But a general application framework can't know how to undo, or do, all the commands. These operations are accomplished with the dynamic binding present in an object-oriented language. The application framework "knows" about command objects and it knows that when a command is to be performed or undone, it should send the message DoIt or UndoIt to the current command object. The application framework defines the basic skeleton of the application, but it leaves the specifics—for example, the actual details of undoing the Double Space command—to the command object. To build a specific application from this framework, you need to design only the objects that perform these specific actions and then install them into the framework.

The framework knows in general what a Macintosh application is supposed to do. It knows how to make the menus work, how to give up control when a desk accessory is activated, how to scroll windows, and so on—all the things that are common to

(continued)

Kurt J. Schmucker, director of educational services for Productivity Products International (Severna Park Mall, H & R Block Office, 575 Richie Highway, Severna Park, MD 21146), teaches seminars on object-oriented programming. Kurt has written three books on computer science, including the forthcoming Object-oriented Programming for the Macintosh *(Hayden, 1986).*

Macintosh applications. The framework knows that the most recent command should be undone when you choose the Undo menu item and that the current selection should be highlighted when you activate a window. However, it doesn't know how to reverse the actions of particular commands or how to highlight the current selection. The *objects* you install in your customization of the application framework determine these actions. For example, to undo the last command, the application framework sends the message UndoIt to the current command object. The dynamic binding of this UndoIt message to a method at run time invokes the routine you have designed to handle undoing this particular command. The application framework proceeds without knowing what that command, or that selection, really is.

The application framework is more than just a skeleton with a fixed number of pluggable slots for commands and selection. Using the techniques of object-oriented programming, you can override every major decision (and many minor ones). Any application on this framework can take control at any decision point in the program by overriding the preprogrammed method to perform a user-written application-specific method.

To give it this flexibility, the application framework is set up as a group of classes, or class library, that you can use and specialize while developing a new application. If you want your application to behave in some unique, specific way, you can add some new objects into the framework to provide this behavior. If you don't want anything unusual, the application framework will handle the application correctly as is.

The Basic Structure of MacApp

The class library that is MacApp contains more than 30 different classes and over 450 methods. (Figure 1 shows the inheritance structure of these classes.) However, if you understand the operation of just three of these classes—TApplication, TDocument, and TView—and seven of their methods, you will be able to build your own application on top of the MacApp framework. The class TApplication takes care of things that are the responsibility of the application as a whole. This includes launching the application, setting up the menu bar, deciding which documents to display in the "Open Which Document?"

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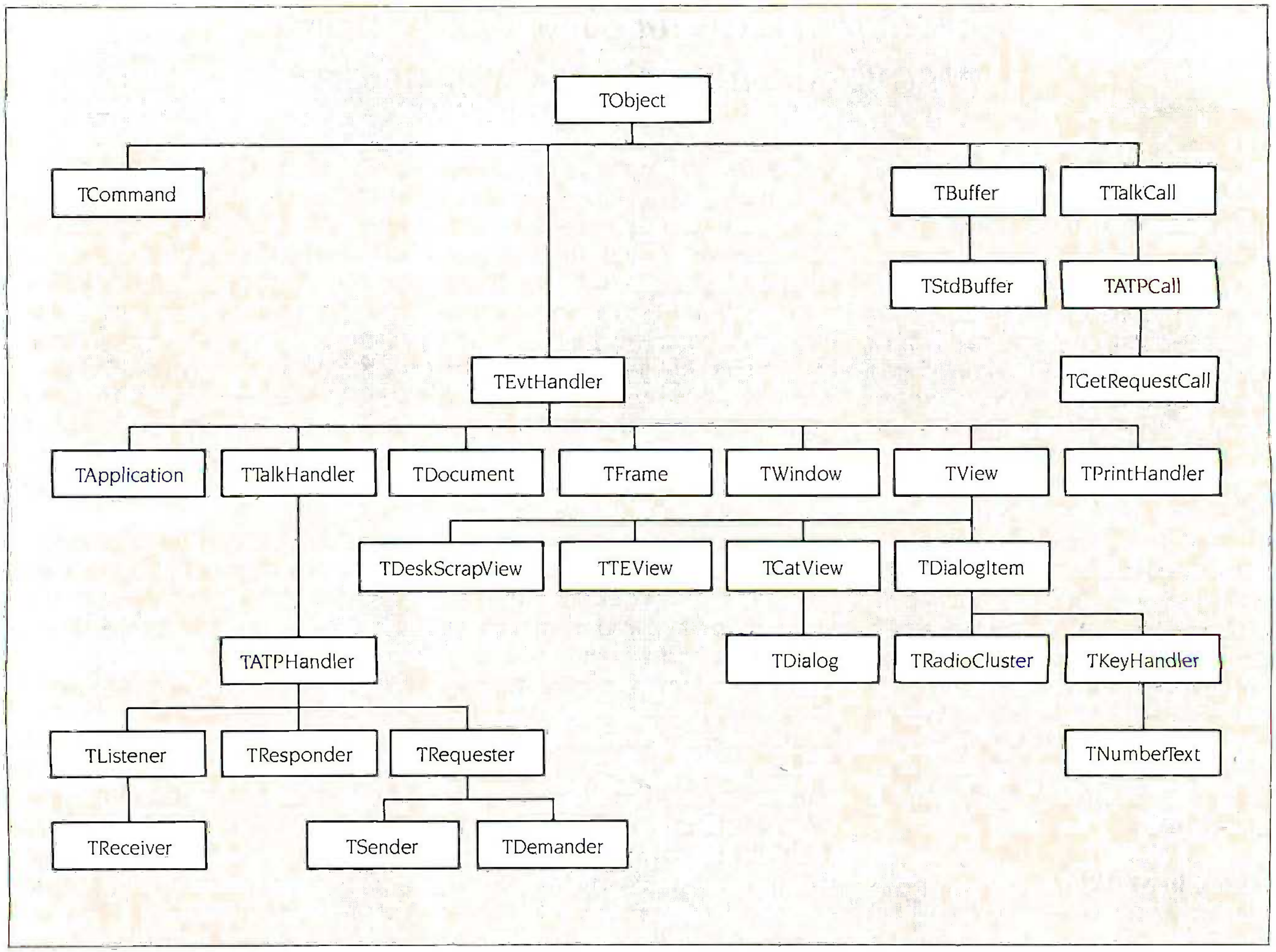

Figure 1: *The inheritance tree of the MacApp classes.*

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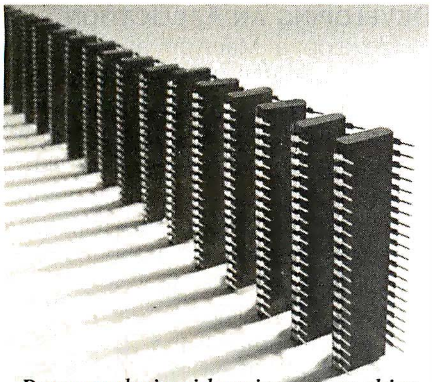

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dialog box, and so on. You design your own special subclass of TApplication, overriding whatever methods you choose in order to specialize any of these behaviors. One behavior you must always override is the type of document that holds your application's data (the method DoMakeDocument).

The class TDocument processes commands like Save and Close, which are specific to each of the documents that are open at any one instant. (MacApp applications can usually deal with multiple documents being open at once.) Two behaviors that you must override in your subclasses of TDocument are the types of windows that display the data stored in the document (the method DoMakeWindows) and the contents of the windows (the method DoMakeViews). (The DoMake-something MacApp methods are the ones you *must* override.)

The class TView takes care of everything inside your windows—drawing the images, highlighting the selection, handling mouse interaction with those images, and other things. TView knows when a portion of the window needs to be redrawn and when the selection should be highlighted. It doesn't know exactly how to do these things. It relies on you to override the methods that supply these behaviors in your subclasses of TView. These methods are Draw, HighlightSelection, and DoMouseCommand.

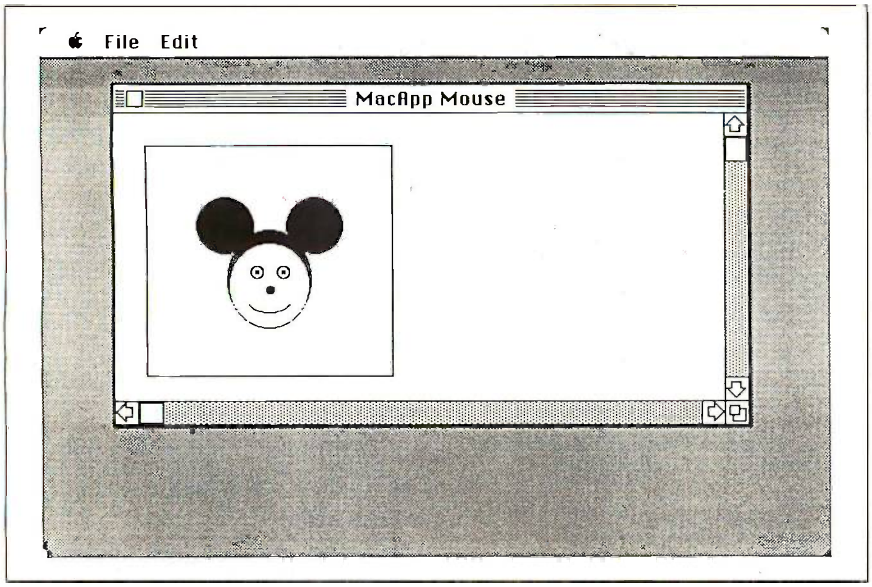

Figure 2: *SmallApplication—the smallest MacApp application.*

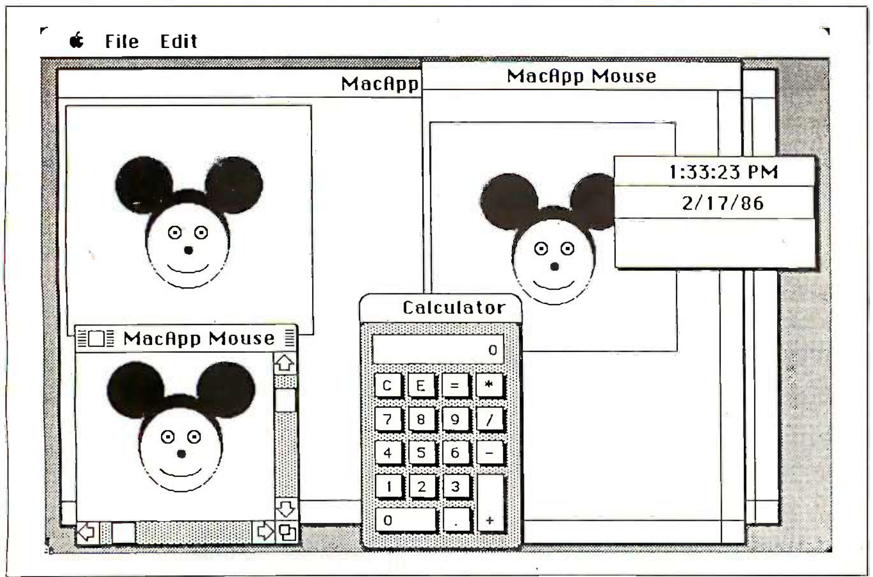

Figure 3: *MacApp applications typically work with multiple documents and always work correctly with desk accessories, even multiple ones.*

DEVELOPING AN APPLICATION

To develop a MacApp application, you must design your own subclasses of TApplication, TDocument, and TView. It is traditional in MacApp programming to name these new subclasses so that you can easily determine their respective superclasses. Therefore, I have used the names TSmallApplication (a subclass of TApplication), TSmallDocument (a subclass of TDocument), and TSmallView (a subclass of TView). The application is called SmallApplication, and its entire source code requires only 87 lines of Object Pascal. (For a discussion of Object Pascal and other object-oriented languages, see my article "Object-oriented Languages for the Macintosh" on page 177.) Two printouts of screen shots from SmallApplication are shown in figures 2 and 3. [*Editor's note: The entire source listing for SmallApplication is available in a variety of formats. See page 405 for details.*] Let's look at two representative methods from this application—the DoMakeViews method of the class TSmallDocument and the Draw method of TSmallView.

DoMakeViews is one of the methods MacApp needs to access one of the classes designed specifically for SmallApplication. I call this kind of method a MacApp *hook* method. Listing 1 contains the full text of SmallApplication's DoMakeViews method. This method generates, initializes, and installs one instance of TSmallView. MacApp sends the message DoMakeViews precisely so it can obtain one of these and use it to draw inside the window. If this method seems rather short, that is a common characteristic of object-oriented programs, especially those

Listing 1: *The full text of* DoMakeViews.

```
PROCEDURE TSmallDocument.DoMakeViews(forPrinting: BOOLEAN); OVERRIDE;
VAR smallView: TSmallView;
BEGIN
   NEW(smallView);                 { Create a new instance of TSmallView }
   smallView.ISmallView(SELF);     { Send new view object its init message }
   SELF.fSmallView := smallView;   { Install this view object in document }
END;
```

Listing 2: A *procedure that overrides* TSmallView's Draw *method to draw a picture of a mouse.*

```
PROCEDURE TSmallView.Draw(area: Rect); OVERRIDE;

   FUNCTION MakeRect(top, left, bottom, right: INTEGER): Rect;
   VAR r: Rect;
   BEGIN
      SetRect(r, left, top, right, bottom);
      MakeRect := r;
   END;

BEGIN
   PenNormal;
   PaintOval(MakeRect(74, 72, 139, 127));      { Outline of the mouse head }
   EraseOval(MakeRect(84, 74, 138, 125));      { Outline of the mouse face }
   FrameOval(MakeRect(109, 84, 129, 115));     { Mouse mouth (part 1 of 2) }
   EraseRect(MakeRect(109, 84, 123, 115));     { Mouse mouth (part 2 of 2) }
   FrameOval(MakeRect(98, 87, 107, 96));       { Left eye }
   FrameOval(MakeRect(98, 104, 107, 113));     { Right eye }
   PaintOval(MakeRect(101, 90, 104, 93));      { Left pupil }
   PaintOval(MakeRect(101, 107, 104, 110));    { Right pupil }
   PaintOval(MakeRect(111, 97, 117, 103));     { Nose }
   PaintOval(MakeRect(53, 52, 91, 90));        { Left ear }
   PaintOval(MakeRect(53, 110, 91, 148));      { Right ear }

   FrameRect(MakeRect(20, 20, 170, 180));      { A bounding rectangle }

END;
```

designed to be overridden for many different purposes. Instead of hard coding many decisions, the designer of a class will make each such decision a method. You can change such a decision by creating subclasses and overriding the appropriate method.

The Draw method of the TSmallView class is a method for which MacApp cannot possibly provide a generic version. You can't draw anything in a window that would be useful to all Macintosh applications. In such cases, MacApp provides a stub method that does nothing, a *null* method. You don't have to override a null method like you do a hook method, but if you don't override this one, part of your application may appear to do nothing. The code in listing 2 overrides TSmallView's Draw method to draw a picture of a mouse.

If you continue this process for five other methods, you will have developed SmallApplication, an application that draws a picture of a mouse. SmallApplication is a stand-alone Mac application that works correctly on 128K-byte and 512K-byte Macs, the new Mac Plus, and the Mac XL. It works with Switcher and with any number of desk accessories, prints on the Imagewriter and the LaserWriter, supports multiple documents, and allows you to resize and move windows and use menus. As trivial as the application itself may seem, it does illustrate the flexibility of the MacApp framework.

The Benefits and Costs of Using MacApp

Early studies indicate that MacApp can reduce application development time by a factor of four or five. MacApp also decreases the amount of source code you need, again by a factor of four or five. It maintains consistency with respect to the Macintosh user-interface standard and provides error handling and an interactive debugging facility, which are useful during development. It provides a conceptual framework that lets you concentrate on your application rather than on Macintosh internals.

Some feel that these gains are at the expense of performance in the finished application and of a large amount of additional memory. In fact, many MacApp programs actually run faster than their non-MacApp versions, despite the run-time overhead of messaging. MacApp applications are usually somewhat larger than their non-MacApp versions—about 10K to 15K bytes. But for most end-user applications, this is not a large penalty when weighed against the decrease in development time. ■

PROGRAMMING EXPERIENCES

BY LARRY TESLER

Programmers using object-oriented languages say the benefits make the learning worthwhile

WHAT IS IT LIKE to write a program in an object-oriented language? I posed that question to several people who program in Objective-C, C++, Object Pascal, and Smalltalk, hoping to gain insight into how different programmers think about object-oriented design. Their experiences had more in common than you might expect.

I asked each person to describe his project and discuss how object-oriented programming affected its progress. Their recollections tended to support oft-heard claims that object-oriented languages can be a boon to large programming projects. The software development benefits stem from three properties of object-oriented programs: object-based modular structure, data abstraction, and the ability to share code through inheritance.

The term *modularity* refers to the factoring of a large program into units that can be modified independently. In an object-oriented system, every module is an object, that is, a data structure that contains the procedures that operate upon it. Object-oriented design is the process of identifying objects that constitute a useful model of the problem at hand. In the early stages of designing a program, the need to partition the problem into objects stimulates the designers to identify its principal constituents and to specify their behavior and interaction.

Data abstraction is the process of hiding a data structure behind a set of procedures through which access to the data is forced. In this way, the "concrete" representation chosen by the programmer is replaced by an "abstract" catalog of available operations. The advantage of data abstraction is that at any time the programmer can change representations without having to change other programs that relate to the operations. Data abstraction is a natural concomitant of object-oriented programming because each object contains not only its data structure but also the procedures that operate upon it. These procedures, often called methods, are usually the only aspects of the object accessible to other objects.

All object-oriented languages can share code through *inheritance*; that is, object-oriented languages provide the ability to define one type of object as a variation of an existing type. The new object type is called a *subclass* of the old, and the old type a *superclass* of the new type. Objects in the subclass inherit all the properties of the superclass, including the implementations of methods. The subclass can define additional methods and redefine old methods by providing so-called *overrides*. By using inheritance during the development of an object-oriented program, code can be shared among similar objects. Later, certain kinds of enhancements can be made simply by creating new object types as variations of existing ones.

A WINDOWING SYSTEM

The first person I interviewed was Gary Walker, Manager of Primary Interaction Development in the Distributed Systems Group at Burroughs Corporation in Boulder, Colorado. He and his group of nine programmers were assigned the task of implement-

(continued)

Larry Tesler, currently Manager of Advanced Development at Apple Computer, previously managed the development of Lisa applications, the Lisa Toolkit, and MacApp. He can be contacted at Apple Computer, 20525 Mariani Ave., Dept. 5770, Cupertino, CA 95014.

ing a general windowing environment, featuring menus, check boxes, buttons, and the other trappings of a see-and-point user interface. After conducting a comparative study of the available object-oriented languages, his group chose C++, an object-oriented extension of C inspired by Simula-67 and developed by Bjarne Stroustrup at Bell Laboratories in Murray Hill, New Jersey. Only object-oriented languages were considered for the project. "In a windowing system," Walker explained, "you want to instantiate objects for windows, each with its own private data. By defining separate types of windows as different classes, they can inherit common characteristics and still possess their own special properties."

Walker found data abstraction to be the most significant advantage of using C++. Smalltalk and some other object-oriented languages force data abstraction upon the programmer by hiding the internal structure of one object from other objects. For example, to move a chess piece, a Smalltalk program must invoke a method such as move_to, passing the destination square as a parameter. It cannot use an assignment statement to modify the data structure describing the chess piece's position. The advantage of the restriction is that both the representation of chess pieces and the implementation of move_to can be changed without having to alter the code in other objects that access them.

Unlike Smalltalk, Object Pascal and C++ allow objects to access part or all of the internal data of other objects. However, many textbooks warn against direct data access except when performance considerations are paramount. Walker's group found through experience with C++ that interobject direct data access is usually a detriment to modularity. "If you want to get at somebody else's variables," he said, "you should go through access functions [methods]."

Another property of object-oriented programs that benefited the windowing system project is modular structure. It gave the designers the ability to create what Walker calls "isolated

(continued)

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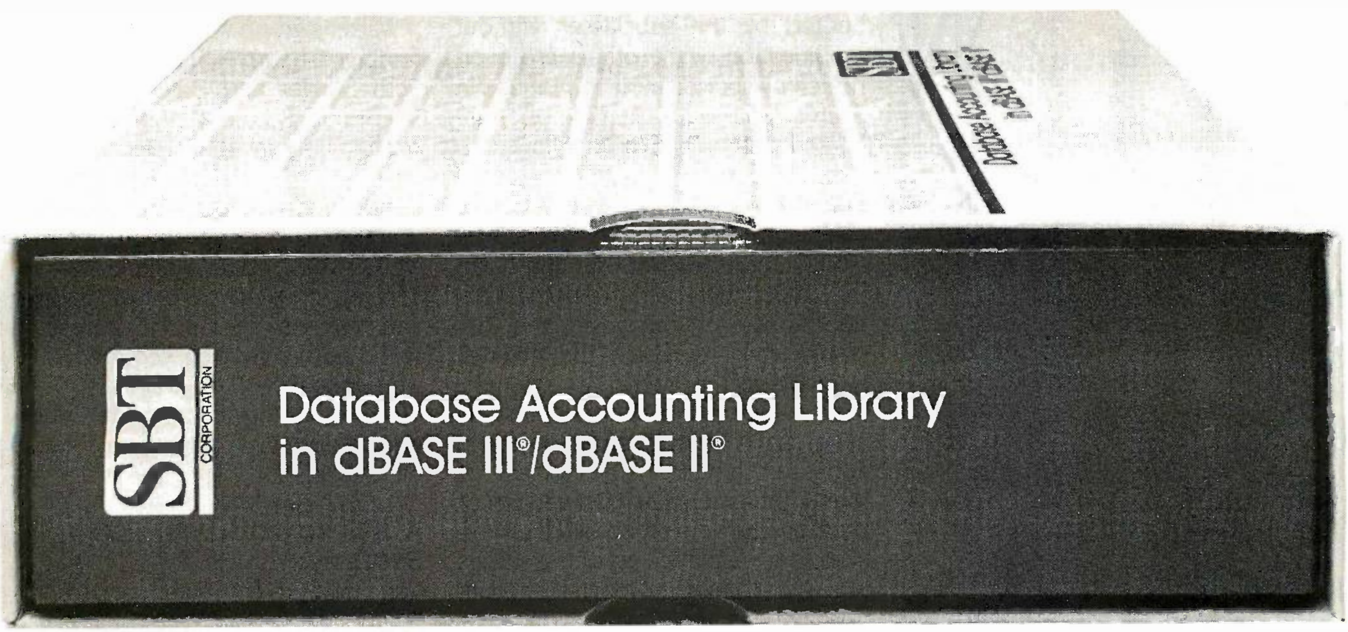

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worlds of data and functions."

Walker also suggested a more pragmatic advantage of modularity based on objects: cutting down on the number of global variables in the program. The advantage of avoiding global variables in an interactive system is that multiple instances of each object can easily be created. It would be quite difficult to support multiple windows if the data describing a window resided in global variables. According to Walker, if you follow the advice of many software engineering books and avoid global variables, you usually end up passing too many parameters to functions. With C++, Walker explained, data can be "private" to an object, and all functions of that object can access its data without passing parameters.

Having heard Walker mention inheritance as a key factor in his choice of the object-oriented paradigm, I asked him for an example of its use in the windowing system. He cited the class Menu, a data abstraction with several subclasses, including VerticalMenu, RadioButtons, and CheckBoxes. The system displays each type of menu a different way, and the user interacts with each a bit differently. But all serve the same basic purpose: They give the user choices, and they report the user's choice to the object in the application program.

Some methods of Menu are inherited by the subclasses without modification, while others are overridden by special implementations in each subclass. An example of an inherited method is selectionTitle, which returns the string containing the user's menu choice. The implementation of selectionTitle is shared by Menu and all its subclasses. An example of an overridden method is prompt, a function whose arguments are the text strings that represent the choices available in the menu. For example, my__menu.prompt("sherbert","cheese cake","torte") specifies the choices in a dessert menu. Each subclass of Menu implements its own version of prompt. The version in the class VerticalMenu displays a list of the strings in a style similar to Macintosh pull-down menus, while the version in the class CheckBoxes displays the strings side by side with a check box beside each one, similar to Macintosh dialogs.

The variable my__menu is declared to be of the type Menu, but at different times during execution its value may refer to objects of different subclasses of Menu. Whenever the my__menu.prompt is executed, it will invoke the version of prompt associated with the class of the object that is currently referred to by my__menu. This is one of several cases where Walker's group found a use for the so-called polymorphic property of objects. Polymorphism refers to the ability of one procedure call to invoke different procedures at run time depending on the type of one of its parameters. In object-oriented languages, polymorphism is achieved by letting different classes implement methods that have the same name and formal parameters but different implementations.

The ability of subclasses to inherit from superclasses can also simplify the maintenance of large object-oriented programs. The Burroughs team found that by making a change to the superclass, in effect they changed all the subclasses at once, and if they made changes to one of the subclasses to get distinctions they wanted, the code in the superclass and the other subclasses remained safe.

Walker's group was not alone in that finding. I heard similar claims from Seth Snyder and Dale Peterson of Recording Studio Equipment Company based in Miami, Florida, who used an object-oriented language to implement an integrated application that controls a spectrum analyzer while managing time billing for a recording studio. According to Snyder and Peterson, when new features had to be added to their program, they were able to add them reliably, without any risk of affecting the performance of features they had implemented earlier.

A Shipboard Navigation System

Carl Nelson, a computer consultant in Seattle, Washington, was approached

(continued)

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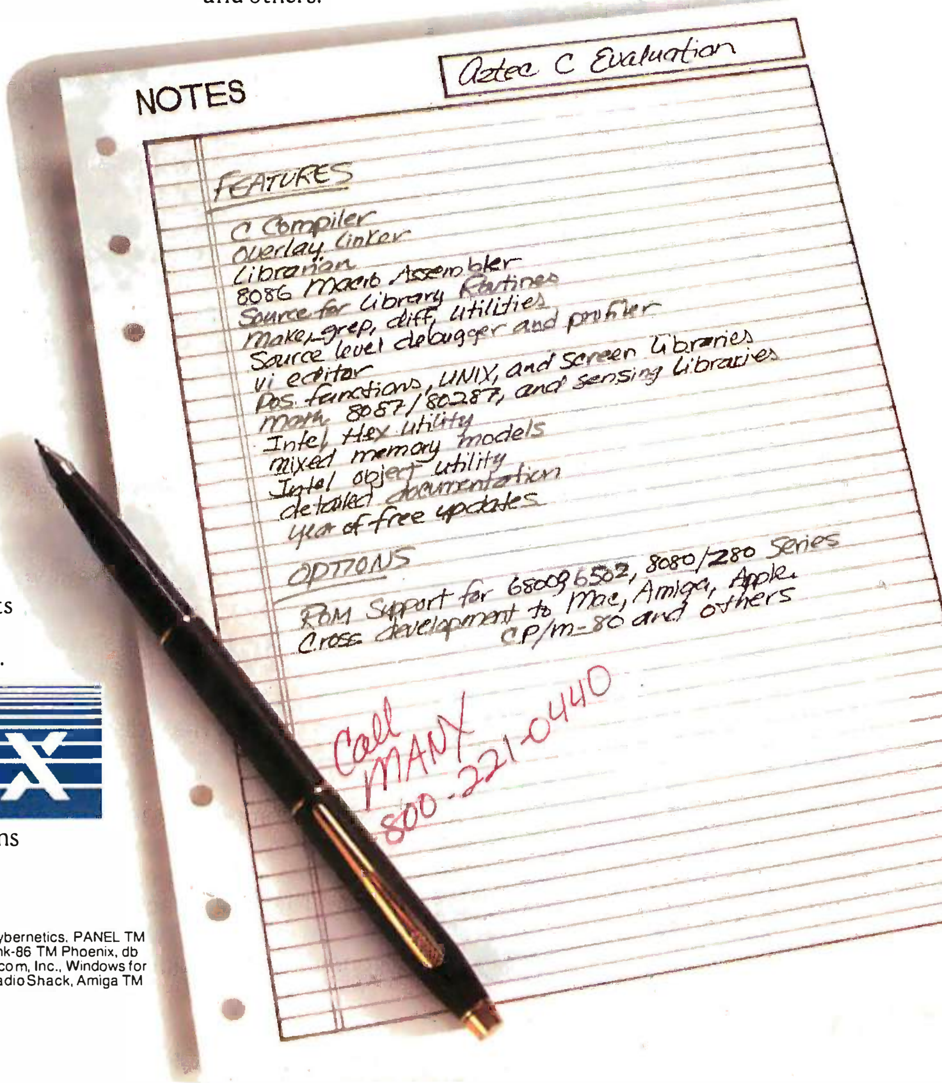

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by a group of investors for his assistance in building a computer-assisted navigation system. The envisioned system, to be installed on boats in coastal waters, would consist of a Macintosh connected to a loran. A loran collects data on a ship's position from a radio receiver tuned to three or more land-based transmitters. Using a combination of triangulation and dead reckoning, it displays the ship's position and bearing on a simple (one- to three-line) display. The captain can key in the latitude and longitude of points along the desired course, and thereafter the loran will display the current heading and the distance to the next point in the course. If connected to an autopilot, the loran can command it to steer the vessel along the planned route.

The clients told Nelson that even though the loran and autopilot are mainstays of navigation for many boat owners, the equipment can be tedious and time-consuming to use. The digital information on the display does not relate to a position on a navigational chart at first glance. A "what you see is where you are" system—one that displays the chart on the screen with the present course lines superimposed on the image—was needed. Such a system would allow a navigator to plan a course on the chart with a mouse and then would transmit the coordinates electronically to the loran. The system would save time, increase accuracy, and avoid problems that arise when incorrect coordinates are entered.

The entrepreneurs used a Thunderscan digitizer to transfer images of nautical charts into MacPaint files, and they wrote a utility program to convert those files to a format usable by the application. One of the investors already had a Macintosh connected to the loran on his boat and recorded the telemetry of one day's voyage on a floppy disk. That disk enabled Nelson to test his program in the comfort of his office. For testing, Nelson used two computers. The main computer displayed the chart and allowed the course to be specified with a mouse. The other Macintosh served as a loran simulator, playing back the recorded telemetry through one of its serial ports to the main computer.

All that was left was to program the application and the simulator. Because he had only four months from project start to public demonstration, Nelson needed a software development environment that enabled rapid prototype development and implementation. He chose MacApp, an object-oriented software framework for the Macintosh (see "MacApp: An Application Framework" on page 189), and Object Pascal, the only language available then (mid-1985) that could be used with MacApp.

To understand MacApp, you must be familiar with certain standard concepts underlying Macintosh applications, including the concepts of document, view, window, and command. A document in the Macintosh corresponds roughly to a file in a traditional computer. The programmer must design a file format for storing it on disk and a data structure for storing it in memory. The programmer must also provide one or more ways to represent the document visually on the display and on the printed page.

Each different visual representation is called a view. For example, an array of floating-point numbers can be viewed as a tabular column of text containing digits and decimal points, or as a pie chart with shaded wedges of varying size. The size of a view often exceeds the size of the screen, but you can see portions of it through a window that you can scroll and resize. Using the mouse and the keyboard, you can issue commands that change the document. The changes are reflected in all views of that document that are presently displayed.

MacApp defines the abstract classes Document, View, Window, and Command, corresponding to the above concepts. A class includes a set of methods that define what the class can do. For example, a document can open and save, a view can draw and print, a window can resize and move, and a command can do and undo. To use MacApp, you must structure the application in a modular fashion in terms of these objects. Once that is done, the application can inherit an extensive library of user-interface and

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According to Nelson, the framework provided by MacApp gave him a structure to plug things into. As he studied the navigation problem, he asked himself, "What do I have in this application that maps onto objects supplied by MacApp?" After identifying all the concepts that mapped easily into MacApp objects, he found that the whole user interface was accounted for. The only code that remained to be designed was that which manipulated internal data structures unrelated to the user interface.

In the navigation application, the most important subclass of the class View was easy to identify: a digitized chart with latitude and longitude lines. The window in which that view was displayed was a little harder to design, because it had to provide nonstandard controls for scrolling around a spherical world. The command objects were easily determined by enumerating the commands available in the user interface, such as place marker and show navigation info. The choice of document objects was not so clear-cut.

A document in MacApp is an object that manages the principal data structures of an application both in RAM and in file storage. In Nelson's application, several different files are employed, including the digitized nautical chart image with added annotations, and a trip file, which consists mainly of the trail of coordinates recorded during a specific voyage. Nelson had to decide whether the document object of his application should be of the class NauticalChart or of the class Trip, or whether his application should support both kinds of documents. He based his decision on an analysis of the operations associated with each type of object. For example, he wanted the client to be able to save the history of a trip in a file and then reopen that file by clicking an icon in the Macintosh Finder. But he also wanted the client to be able to open a chart file to review the annotations that had been made on the chart. He concluded that both the trip and the chart are appropriate document objects, and his application defines both as subclasses of Document.

The chart file consisted of a digitized image plus markers indicating significant locations such as reefs and buoys. Once the program was running, Nelson and his client realized that not all markers should be associated with the chart file. It made sense for a marker labeled "lighthouse" to be stored with the chart, but a marker labeled "caught 30 lb salmon" really belonged with the trip. Nelson decided to divide all markers into two subclasses of the object class Marker, namely, TripMarker and ChartMarker. He analyzed what the two kinds of markers had in common—for example, the display algorithm and the routines to edit an annotation—and implemented that common behavior in the superclass Marker, from which the subclasses could inherit it. He also determined what differentiated them—for example, the shape of the displayed icon and the file used for storage—and implemented that special behavior as overrides in the subclasses. Nelson called the differentiation process "pushing down the details" from superclass to subclass (see figure 1).

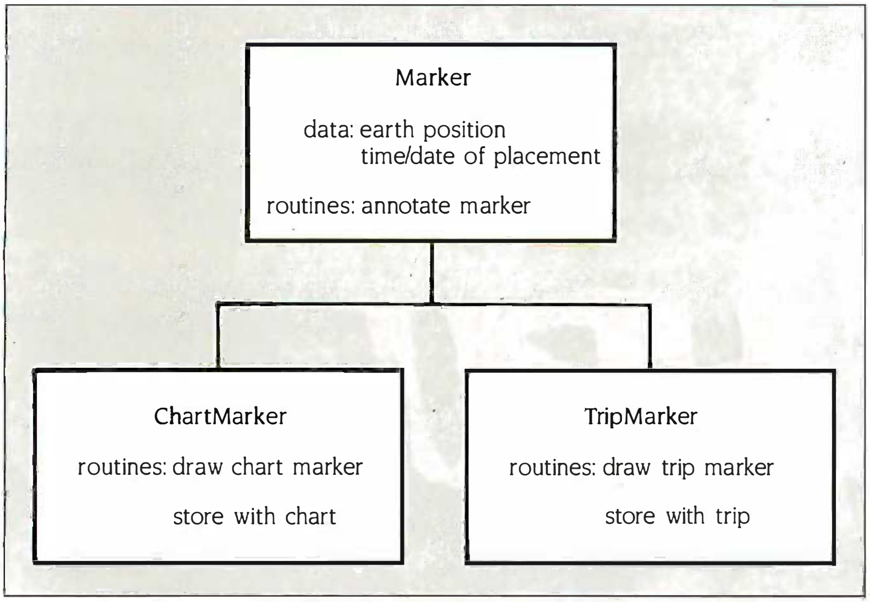

Figure 1: *An example of class hierarchy.*

A CAD System

At Artecon Inc. in Carlsbad, California, a group of 20 programmers led by Dana Kammersgard used an object-oriented language on Sun-2 and Sun-3 workstations in the development of ArteMate, an integrated CAD and office automation system. To make the system as portable as possible, Kammersgard's graphics group coded their routines according to an industry standard called GKS (Graphical Kernel System). GKS provides a way to construct images by transforming and combining primitive forms such as lines, polygons, curves, and ellipsoids. The standard specifies a device-independent set of procedure calls, leaving to each implementation the task of interpreting those calls in a manner appropriate to the available output devices.

According to Kammersgard, his team wanted the CAD portion of ArteMate to display two-dimensional and three-dimensional graphics on a wide variety of plotters and screens. To obtain that flexibility, an object-oriented approach seemed best. The language they chose for their implementation was Objective-C, developed by Productivity Products International of Sandy Hook, Connecticut, and available on a variety of computers and operating systems.

The first question Kammersgard's group addressed was how to organize the code for a number of graphics devices, including the CalComp 1043

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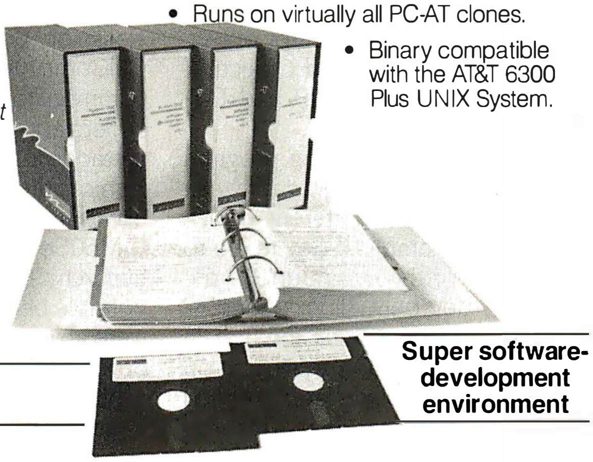

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and 1044 and the HP 758X models, in such a way that it could perform both input and output to a number of black-and-white and color display systems, including the Sun Color Graphics Processor and the IBM 5080. The programmers decided that each type of device should be represented by a different type of object. Accordingly, they defined Objective-C classes such as SunGP and CalComp1044.

At different times during program execution, a program variable can contain pointers to different device classes. For example, if dev refers to an instance of the class SunGP, the statement dev poly_line: coordList invokes a device-specific method in class SunGP to display a polygon on the Sun screen. If dev is later assigned a reference to a CalComp 1044, the statement dev poly_line: coordList invokes a device-specific drawing method in the class CalComp1044 to drive the pen plotter along a polygonal path. To support a new device, the the programming team can simply define a new class without modifying existing code.

Kammersgard says that where they could take advantage of special hardware features, they implemented a device-specific method in the class. For example, the method poly_line normally has to apply transformations to the coordinates supplied in its parameter list to account for the visual perspective of the viewer. To calculate these transformations involves matrix multiplications, which are time-consuming operations in a conventional computer. Because the Sun Graphics Processor implements a three-dimensional transformation pipeline in hardware, the class SunGP overrides the standard implementation of poly_line, substituting a version that is shorter and faster than transformations performed wholly in software.

Like biologists who classify life forms into species, group similar species into a genus, group related genera into a class, and so on, object-oriented programmers design hierarchies of classes according to the similarities and differences they perceive between objects. In the Artecon system, specific output devices are the species of the graphics kingdom, and company product lines are the genera. Since different devices from the same manufacturer often have similar interface specifications, Kammersgard's team defined the class CalCompPlotter as a superclass of both CalComp1043 and CalComp1044. They moved methods common to both models up to the superclass and left model-specific methods in the subclasses. In a similar fashion they added generic classes like HPPlotter, SunDisplay, and IBM50SeriesDisplay to the class hierarchy. By sharing as much code as possible between device classes, they were able to reduce program size and development time considerably.

The hierarchy of device classes continues for two more levels. At the level above product lines, all kinds of plotters are grouped into one class, and all kinds of interactive displays into another; display classes implement methods for user input, while plotter classes do not. At the highest level is the class GKSWorkstation, which is the ancestor of all other device classes. At that level, device-independent operations are implemented—for example, the GKS primitives that change display attributes in data structures in memory without communicating to the devices.

In any graphics application, another obvious application of objects is to represent the graphical components of the drawing. For example, all ellipsoids ought to be instances of the class Ellipsoid, and all cylinders ought to be instances of the class Cylinder. In the Artecon system, all geometric modeling classes are grouped together under a superclass called GeometricObject. Geometric objects respond to messages such as draw, rotate, and store.

But a CAD system must do more than a simple drawing program. It must allow the user to indicate relationships among design components. Kammersgard's group found themselves adding "links" to geometric objects and to other objects within the system, such as instances of the class ViewPort. After a while, they realized

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that the various implementations of links could be combined by embodying Geometric_Object and ViewPort in a new superclass called AssociativityObject. An associativity object contains a set of links and supports operations such as add_link, remove_link, and modify_link. A member of any subclass, say, Cylinder, inherits the ability to contain links as well as the routines for manipulating them. Adding the class AssociativityObject required a modest restructuring of existing code. According to Kammersgard, it is common to restructure the class hierarchy to take advantage of newly discovered opportunities for sharing code through inheritance.

A Knowledge-Based Application

Bill Hutchison, a behavioral psychologist living in Silver Spring, Maryland, is implementing a knowledge-based system on the IBM PC. The system organizes information in a way that allows a seemingly rational response to stimuli. After considering a number of development systems, Hutchison decided upon Methods, a Smalltalk dialect developed by Digitalk Inc. of Los Angeles, California. I spoke to Hutchison after he had been using Methods for four months. "I like the way I can think about the problem," he said. "I map out the general problem in my head and can almost extract the objects from how I write it down in English. I make an object for each physical thing, process, or activity that I am dealing with."

I asked him if Smalltalk was difficult to learn. Hutchison, who has programmed extensively in assembly language, COBOL, BASIC, PILOT, and PLANIT, said he found Smalltalk "the most natural way" to program. He admits, however, that most of his learning time went to mastering Smalltalk's extensive class library. Large libraries are typical in object-oriented systems because they are extremely easy to build and maintain using subclassing and inheritance. The library that comes with Methods includes classes that are similar in purpose to those of MacApp. That allowed him to implement the user interface of his application easily and give it fancier features than he had first thought possible.

Hutchison said he structured the application's objects in a modular way. Knowledge is stored in association networks that relate situations, conclusions, and responses. He first developed a basic Network class able to represent simple domains, and he said that doing so was not as difficult as he had expected. Later, when he decided to tackle more difficult problems, complex networks became subclasses of the basic version. The first subclass he defined was InteractionNetwork, which adds the ability for parts of networks to interact with each other. That class was itself subclassed to define MultiResponseInteractionNetwork, which permits the system to respond along multiple dimensions.

At each stage he had to restructure existing definitions a little to allow the new class to inherit as much as possible from the old classes. The modular structure of the application made it easier to change one part without affecting others. "Sometimes," Hutchison said, "a radical change that I was dreading took me only an hour or less to accomplish." But Hutchison added that to make the program that modular, he had to develop the discipline to confine knowledge of an object's internal structure to its own class—only after having done that could he make changes to an object's structure without affecting others.

Object-Oriented Future

Certainly, object-oriented programming offers a great deal to software developers who want to manage large software projects or create prototypes quickly. Now that several suitable languages are widely available, many programmers will likely invest the time necessary to acquire the skill of using them. The interviews I conducted encouraged me to believe that these languages can be applied effectively in diverse situations by people of varied technical backgrounds. Even though the learning curve is high, most programmers can easily exploit the full potential of object modularity, data abstraction, and inheritance offered by object-oriented languages. ■

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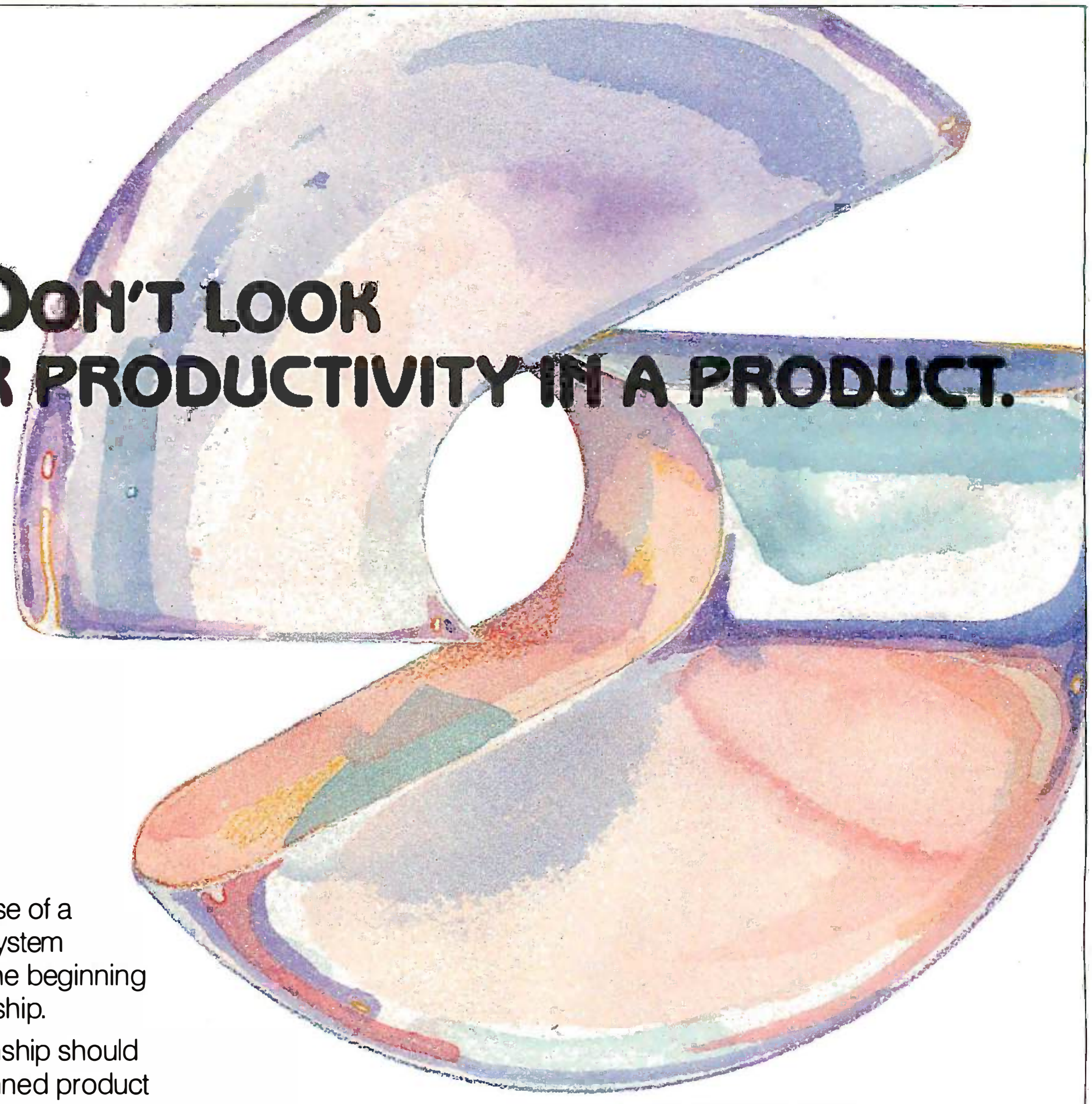

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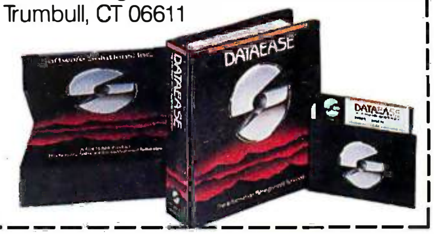

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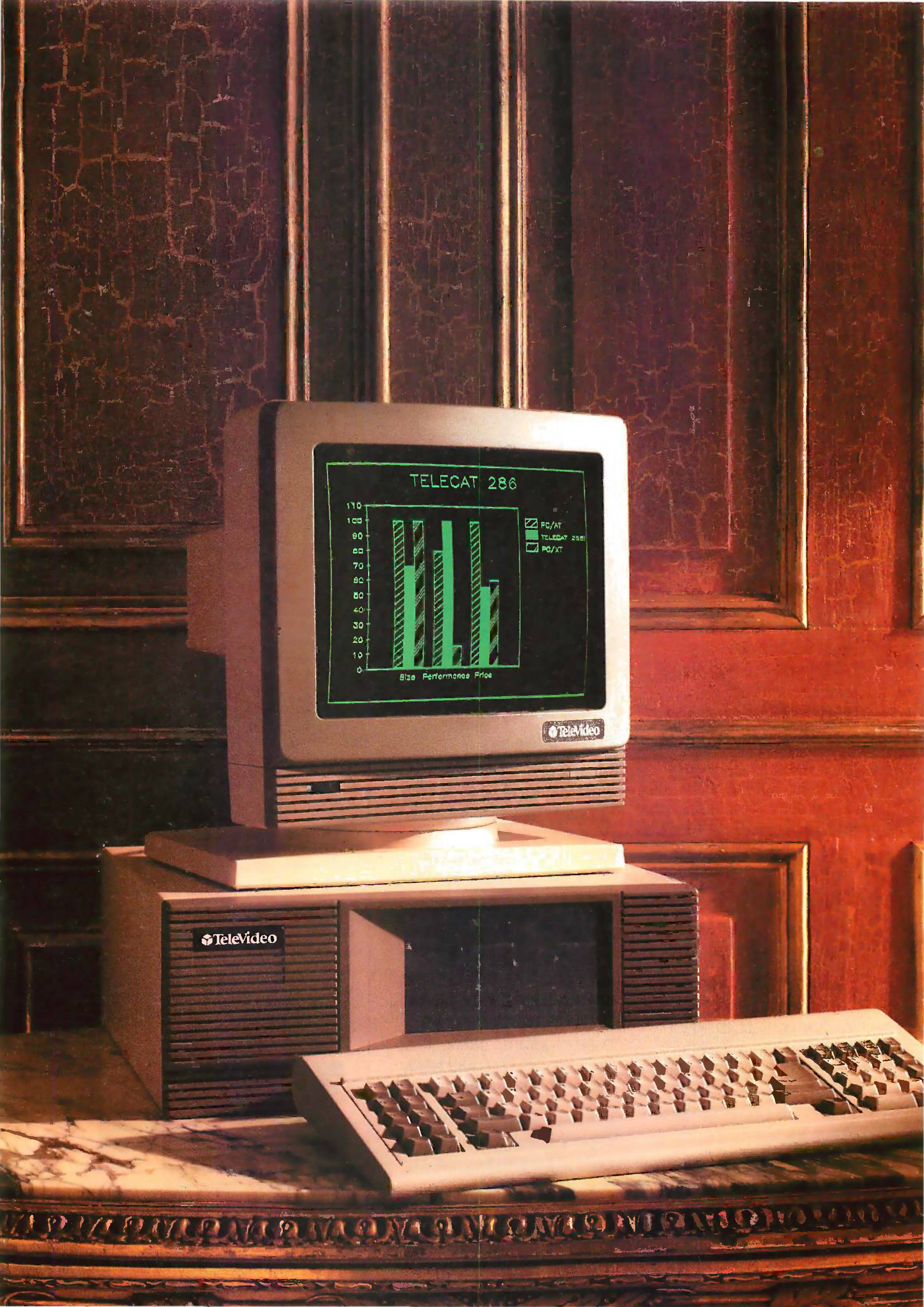

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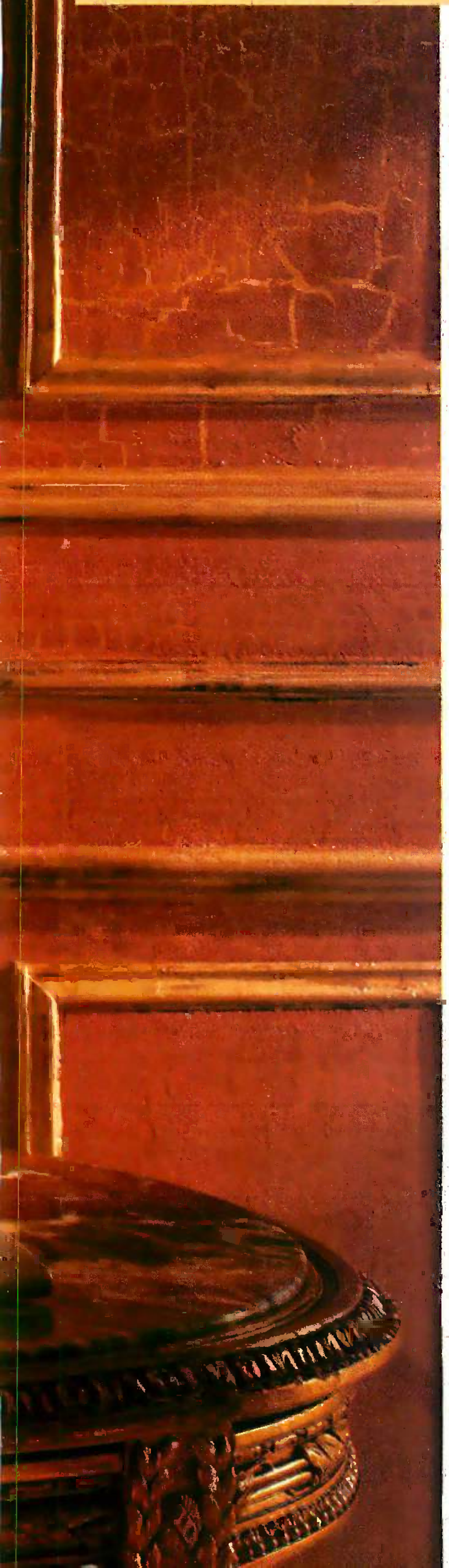

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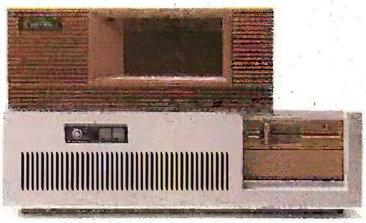

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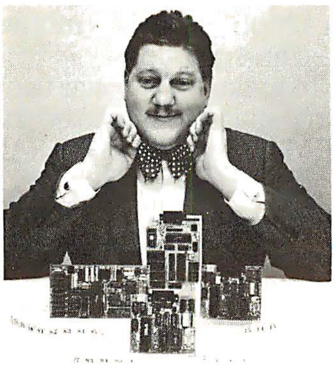

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DESIGNING AN EFFICIENT LANGUAGE

BY CHARLES B. DUFF

A language designer discusses the inefficiencies of Smalltalk and suggests ways to improve upon them

ALTHOUGH SMALLTALK is the mother of modern object-oriented languages, and is certainly the best-known, its use in the microcomputer world has been limited, primarily because of its size, relative inefficiency, and fairly long learning curve for new programmers. These problems are partially the result of a philosophy that emphasizes theoretical consistency and universal application of a few principles. By modifying this design philosophy somewhat, it is possible to develop a new language that combines the benefits of an object-oriented language and the efficiency of a popular production language such as C or Pascal.

Over the past two years, my company, The Whitewater Group, has been at work on a new language called Actor, which is targeted for artificial intelligence work on microcomputers. Our goal was to make use of the consistent object-oriented philosophy of Smalltalk but to incorporate some architectural changes that might enhance efficiency, ease of use, and accessibility for the average programmer. In this article I will discuss some of the design details of Smalltalk and point out how we attempted to improve upon them.

The issues under discussion include garbage collection, late versus early binding, and models for the interpreter. I'll also look at the relative advantages of a token-threaded interpreter over Smalltalk's byte-code interpreter in creating a language that supports early binding and other optimizations.

GARBAGE COLLECTION

Smalltalk, like other sophisticated languages such as LISP and Prolog, includes a garbage-collection facility that automatically reclaims data structures that have been created by the programmer but are no longer needed. This is a tremendous advantage in a large, complex application because you never have to worry about memory management (unless, of course, memory becomes exhausted in spite of garbage collection).

The Smalltalk-80 specification includes a reference-counting garbage collector but does not mandate this approach. A reference-counting system keeps track of the number of pointers to each object in the system. When the pointer count drops to 0, the object is deleted.

Unoptimized reference-counting collectors can consume up to 70 percent of total execution time because of the constant maintenance of reference counts. The University of California at Berkeley has published a number of clever optimizations that minimize the reference-counting overhead in Smalltalk. Nevertheless, reference counting has a serious chronic effect on the efficiency of the language. Anyone who attempts to create a more efficient object-oriented language would do well to consider alternate architectures for garbage collection.

THE BAKER COLLECTOR

Henry Baker at MIT developed a method of garbage collection for LISP

(continued)

Charles B. Duff (The Whitewater Group, 906 University Place, Evanston, IL 60201) is a systems programmer whose last product was the language Neon for the Macintosh. His new language, Actor, should be available for the IBM PC in October.

that involves splitting memory into two spaces. As an application executes, objects that are known to be "alive" (i.e., accessible to the program) are copied from one space to a new one. Eventually all active objects are copied to the new space. The copying process is then reversed, copying back into the original space and writing over the "dead" objects.

The principal advantage of this approach is that the collection process can be performed incrementally as the program executes, allowing even real-time applications to make use of garbage collection. Also, compaction occurs naturally as a result of the copying. The efficiency of Baker's method, however, is dependent on how many objects remain alive as opposed to how many die. Highly volatile objects such as contexts (see below) may well come and go before they are copied, thereby requiring no maintenance overhead. The difficulty comes in when a large number of objects with long lifetimes are created, resulting in much copying activity. Each application has a unique profile with respect to object lifetimes.

The best solution for this problem seems to be a variation of Baker's approach suggested by Henry Lieberman and Carl Hewitt of MIT and first applied to Smalltalk by a team at DEC. In this approach, objects that have been around for a long time are migrated to an area that is rarely checked for dead objects, thus minimizing useless copying of permanent objects and directing the energies of the collector where it can be most effective. In our design of Actor's garbage collector, we employed an approach similar to this.

CONTEXTS

Any stack-based language must have a run-time facility to create activation records for each procedure that is executed (see figure 1). This is an area at the top of the stack that contains current values of variables and parameters to be used by the procedure. As long as a simple stack allocation discipline is used, these structures do not require any sophisticated memory management; they come and go with procedure calls and returns.

In Smalltalk, the activation record is called a context and is actually an object (see figure 2). Every time a method begins execution, a new context object must be created. The context actually combines a traditional activation record with a local work stack for use during the method's execution. Space for the stack is allocated from the context's indexed instance variables. Thus, each invocation of a method has its own private stack.

Even after a method finishes executing, its context can persist and be sent messages as a full-fledged object. A debugger can exploit this fact to reconstruct the state of a method that had a problem. On the downside, however, objects are much more expensive to allocate than stack space. Since a context is created with each method activation, it is no surprise that the Smalltalk garbage collector spends much of its time managing context objects alone. One study indicated that method contexts are responsible for 97 out of every 100 words of object space allocated.

Since the performance consequences of straying from a stack-based allocation discipline seemed too severe in relation to the benefits, we decided not to implement method contexts as objects in Actor. We did, however, implement block contexts as objects, because these contexts are used less frequently and do not conform to stack-based allocation strategies. These contexts are created only when a block is passed to another method, or function, for repetitive execution. (In this article, we will use the terms method and function interchangeably.)

As a consequence of our decision, however, the process of constructing a debugger is less elegant, requiring us to make use of assembly language primitives to access the stack. Alternatively, we could use Actor to construct an emulator that would treat contexts as objects for the sake of

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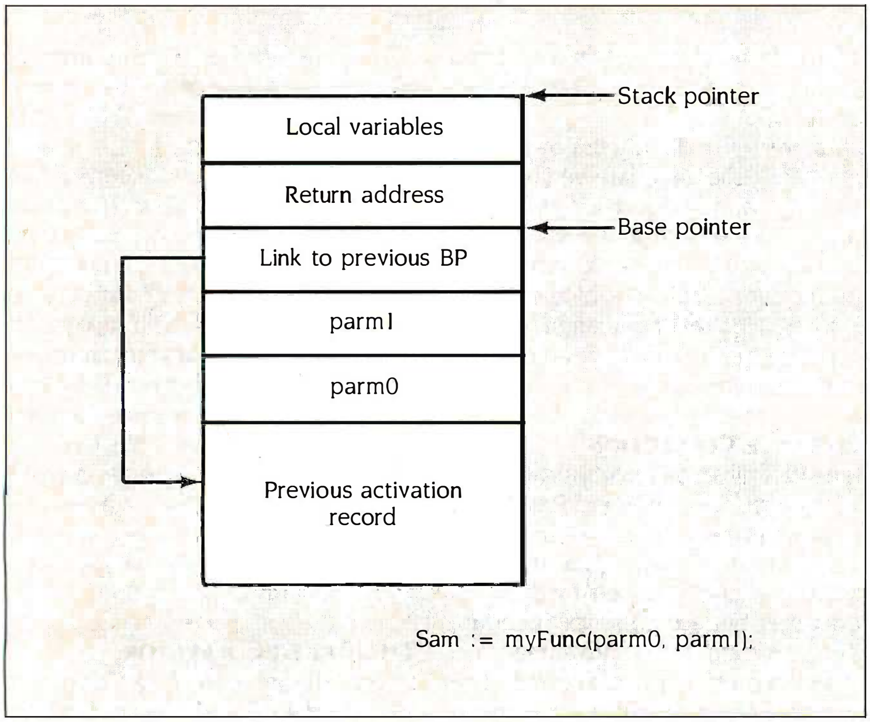

Figure 1: *A typical activation record in a compiled language. When a function* (myFunc) *is executed, the parameters passed to it by the calling routine are placed on the stack, along with the return address. The function then allocates space for its local variables. The base pointer serves as a fixed location from which to index both the passed parameters and the local variables. Below is the activation record for the function that called* myFunc.

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debugging. We have yet to find that step necessary, however.

Early and Late Binding

When you call a function in a typical high-level language such as C, the compiler and linker actually generate a subroutine call to a physical address. This is very efficient, but you must be careful to associate functions with the appropriate data structures. For example, if you were to pass an array to a function that was designed to work on strings, trouble would surely result. The problem would most likely be caught at compile time by the type-checking facility of the compiler. Of course, in an untyped language such as FORTH, the problem wouldn't be caught at all until the program started behaving strangely.

Smalltalk relieves the programmer of this burden by automatically calling the appropriate method for a given data structure. The programmer uses generic names for operations, and Smalltalk uses the class of the receiving object to look up the method having the correct name. Since the lookup occurs at run time, however, it carries a rather severe efficiency penalty with respect to the previous technique.

We decided to implement a facility that combines the merits of each approach. We designed our compiler to automatically associate, or bind, a generic operation name with a physical function in the manner of Smalltalk. But, unlike Smalltalk, the programmer can choose on a case-by-case basis whether this occurs at run time (late binding) or at compile time (early binding).

Advantages of Late Binding

Late binding has some notable advantages. Since all references are symbolic, a method can be recompiled without having to recompile all of its callers. More important, the same symbolic name can be used for a similar operation in several different types of objects. This is possible in Smalltalk because each object's class has, as one of its private variables, a dictionary associating names with methods. When a message is sent, the interpreter determines the class of the receiver and finds this dictionary, which it then uses to look up the method for the symbol sent.

The fact that a single message can invoke any of several methods is known as polymorphic behavior and is probably the most powerful feature of object-oriented programming. It allows code to be written that is insensitive to the type of object receiving the message. Of course, if the object doesn't happen to have a method for the name sent, an error will occur at run time. This can be disturbing to a programmer who is accustomed to such problems being resolved at compile time. But for certain types of problems, late binding greatly simplifies the code. A lot of control structure, such as if and case statements, simply vanishes, because the logic is incorporated into the distinction between classes.

Unfortunately, late binding is not very efficient. Even the best algorithms for searching the dictionary are several times slower than simply executing the method without a search. Much research, however, has been done in Smalltalk with respect to method caching, which greatly speeds message-sends. Caching uses a hash table to store the most recently used methods, avoiding the more time-consuming dictionary lookup. Caching and other optimizations have greatly improved late-binding performance, but the performance penalty remains severe.

Early Binding

A sensible compromise can be made with respect to late binding. It is possible to forego the consistency of uniform polymorphic behavior in return for a good deal more efficiency. In a previous language I wrote for the Macintosh called Neon, which had object-oriented facilities and a FORTH-like syntax, I allowed the programmer to select early or late binding in each message. This has proven to be a workable and efficient solu-

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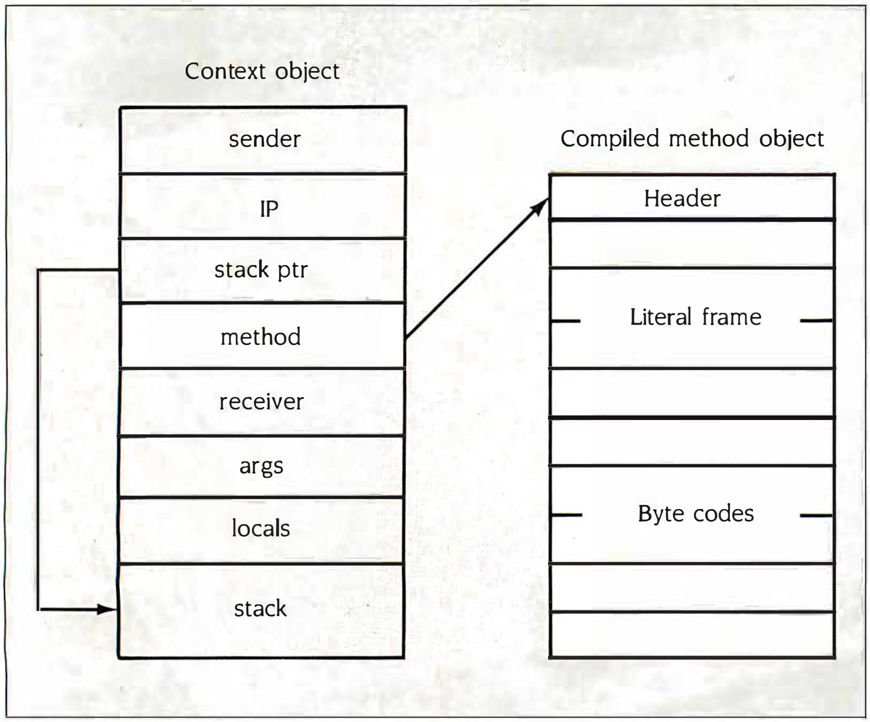

Figure 2: *An activation record in Smalltalk. Instead of allocating activation records on a single continuous stack, in Smalltalk each method activation causes the creation of a method context, which is actually an object. Each method activation has its own private stack, which includes space for the instance variables designated by the Context class of objects. This arrangement, with its consequent garbage collection, is much less efficient than simple stack allocation.*

tion. Neon makes no attempt, however, to ensure that the class of the receiver is appropriate at run time for the method being called. In general, the philosophy in Neon was to provide minimal protection at run time, which allows maximum efficiency. Most FORTH systems have taken this approach, but it is an unsuitable environment for complex AI work.

Even in Smalltalk, polymorphism is really used in only about 15 percent of the code. The rest of the system makes implicit assumptions about an object's class and could just as well be early-bound. Other researchers have speculated on various ways in which this fact could be exploited for more efficiency.

Our goal was to provide selective early binding with protection against class mismatches at run time. For instance, if at compile time we bound a call to a method in class Rectangle, and, at run time, an Array was actually the receiver, serious consequences could result. Either every method has to check that its arguments are of the proper class at run time, or the compiler has to ensure integrity at compile time. Run-time checking is a burden that would eat up much of the efficiency gained in early binding. And since compilation can usually be done in relatively small chunks in an object-oriented system, compilation efficiency isn't of much concern.

Listing 1: *Examples of function definitions as they might be written in Actor, illustrating how early binding may be specified. In the function* append, *the variables* self *and* arg, *along with the result of the function, have been "typed" as instances of class* ListCell.

```
/* this version of append assigns types (classes) to its
arguments.  carVal and cdrVal are the two private
variables in class ListCell.  Typing permits the compiler
to generate much more efficient code for messages
involving typed parameters.  */

Def append(self:ListCell, arg:ListCell):ListCell
{  ^cons(carVal, append(cdrVal, arg))
}

/* cons is an example of ACTOR's optimization of private
variable references.  The form cell.cdrVal is a very
efficient way of referring to the cdrVal private variable
in the local variable, cell.  If the programmer were to
assign a type to cell, an even more efficient machine
language primitive would be compiled.  */

Def cons(self, arg | cell)
{  cell := new(ListCell);
   cell.cdrVal := arg;
   cell.carVal := self;
   ^cell
}

/* The do function performs a post-order traversal of a
list by executing a passed-in block at each leaf (non-
list) node.  */

Def do(self, aBlock)
{  if  isAtom(carVal)
   then  eval(aBlock, carVal);
   else  do(carVal, aBlock);
   endif;
   if  cdrVal
   then  do(cdrVal, aBlock);
   endif
}
```

Listing 2: *Another definition for* append. *In this case neither the parameters nor the return value of the function are typed, and as a result, all messages will be late-bound.*

```
Def append(self, arg)
{  ^cons(carVal, append(cdrVal, arg))
}
```

We decided to develop a scheme whereby the programmer can, at compile time, selectively bind "types" (classes) to variables and to the values returned by functions. This scheme is similar to type declaration in Pascal and allows the compiler to ensure the integrity of an early-bound method call at run time. We also decided to equip the compiler with a sort of miniature expert system that allows it to selectively early-bind method calls. In cases where the early binding criteria fail, it defaults to late binding.

For example, in listing 1 we have a number of list-handling method definitions, as they might be written in Actor for a class called ListCell. (Note, however, that the actual function names are different in Actor; I have used the equivalent LISP function names here to make the code more familiar to LISP programmers.)

We specified all Actor function (method) definitions to consist of the word Def followed by the name of the new function, followed by a list of formal parameters enclosed in parentheses. The first parameter is always self, because that is where the receiver appears in the method call.

The body of the function is delimited by curly braces (which are optional in the case of a single statement). A caret causes the function to return the value of the next statement.

You will notice that in the list of arguments for the append function, the formal parameters, self and arg, are followed by :ListCell. As in Pascal, this assigns a type to the formal parameters. In Actor, types are actually classes, so the definition says that at run time the formal parameter must be of class ListCell.

(continued)

We designed the compiler to enforce this by requiring that any early-bound call to append (i.e., a message to a typed variable) must pass a ListCell as its argument. If append is invoked as the result of a late-bound message, a type-checking routine will ensure the class integrity of its parameters. This check is performed only if a function with typed parameters is invoked in a late-bound message-send.

We can control the early binding of messages to self by typing the self formal parameter. It is usually desirable to leave self untyped, however, to allow redefinition of a function in a subclass. If typed, the message to self will be bound at compile time.

Listing 2 shows an alternative version of append whose parameters are untyped and that does not use early binding.

USING EARLY BINDING

We designed the typing facility to be most effective when used during program optimization. During initial development, the programmer can leave all variables and functions unbound. This makes the code easier to change and debug and minimizes dependencies between the various parts of the application. After the code is debugged and has become fairly stable, the programmer can then isolate areas that are heavily executed and begin optimizing them. Variables and functions can be bound in the time-critical methods, allowing the compiler to generate more efficient early-bound references. To attempt even better performance, high-level functions might be converted to primitive functions, until performance is acceptable. The latter step is not possible in standard Smalltalk-80, which allows the user to write only high-level methods.

INTERPRETER MODELS

Smalltalk works by compiling the source code for methods into an intermediate language. This language consists of a set of basic operations, such as fetching and storing variables, fetching literal objects, sending messages, and manipulating the stack. Theoretically, users could write in this language, but then they would be working directly with the stack in the manner of FORTH and would be without the protection and sophisticated features provided by the compiler.

The job of the interpreter is to scan the intermediate code and execute machine code to make the language perform. This situation is entirely analogous to a microprocessor scanning machine instructions and executing microcode. In fact, the interpreter has a register, called the interpretive pointer (IP), that is the equivalent of the instruction pointer register in a microprocessor.

THE BYTE CODE INTERPRETER

Smalltalk's intermediate language consists of byte codes—that is, a series of bytes, each of which encodes an elementary operation in the Smalltalk "virtual machine." A compiled method consists of two data areas. First there is the "literal frame," an area in which the method stores any objects that are referred to as literals in the method. (Literals are objects created without a name, such as "A string", 12000, or #aSymbol.) This is followed by the byte code area, in which the compiler places the compiled code for the method. Several byte codes are dedicated to accessing the objects in the literal frame.

Let's examine what a small piece of compiled Smalltalk code would look like. Suppose that, in the middle of a method, the compiler sees the phrase

myFile : = File new name: "users.txt"

In this phrase, myFile is the name of the zeroth local variable allocated by this method in its private stack. What gets compiled is a series of 5 byte codes and 3 words of literal data, for a total of 11 bytes, excluding the header (figure 3).

The first byte code fetches the contents of literal location 2 (the string "users.txt") and places it on the stack. This will later serve as the parameter for the name: method. The next method fetches the contents of an Association object that identifies the class File in the main dictionary, Smalltalk. This is the receiver for the new method, sent by the next byte code (several byte codes are dedicated to sending common messages like new or at:).

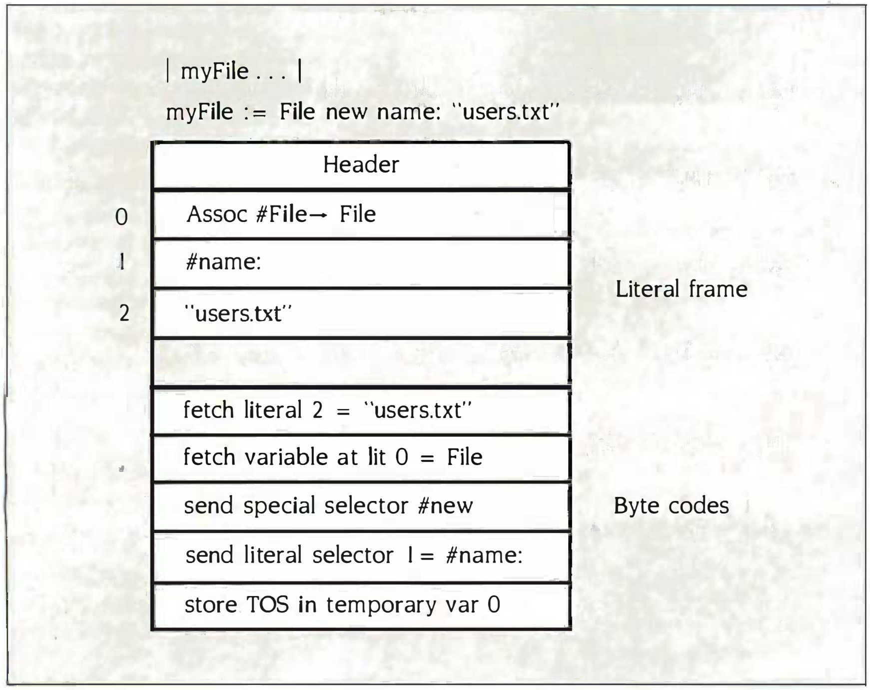

Figure 3: A *sample of compiled code in Smalltalk. The compiled method consists of two data areas: the literal frame (for literal data) and a series of byte codes (1-byte instructions).*

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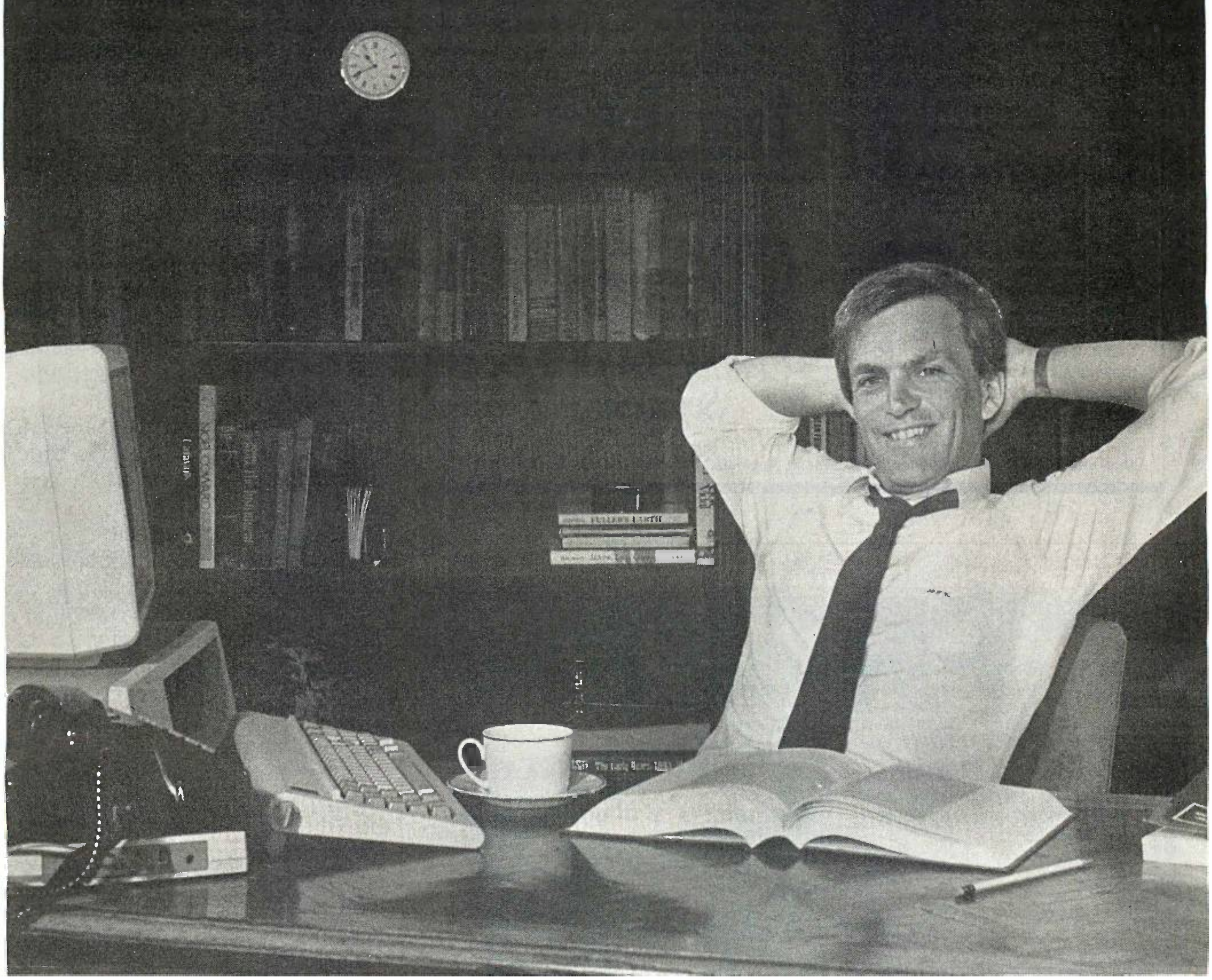

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The next byte code sends the #name: selector that is stored in the literal frame at location 1. This is how any send not involving the "special" (frequently used) selectors is compiled. Finally, the result of the name: message is stored in myFile, which is temporary variable 0.

Several things are noteworthy about this arrangement. First, the literal frame is required, because only byte codes can be executed by the interpreter. Anything not a byte code (e.g., the string "users.txt") has to be stored in the literal frame and fetched by one of the access byte codes, which introduces a certain amount of overhead. Second, because the byte codes are only 1 byte in length, only 256 operations are available to the interpreter. Third, because the size of the literal frame can vary for each method, the interpreter has to calculate the address of the start of the byte code area whenever a method is executed.

THREADED INTERPRETERS

In our design of Actor, a principal goal was an efficient implementation of early binding. This led us away from the byte code interpreter to a threaded model. Early-bound function calls and literal references can be more efficiently implemented with a threaded interpreter.

There are several varieties of threaded interpreter. All models share the "threaded" aspect, which connotes building a procedure by stringing together a list of virtual or physical addresses of other procedures. At execution time, the interpreter scans through the list, picking up each thread in turn and executing it.

In a threaded environment, every object in the system, whether code or data, is assigned a "thread value." Generally, the result of executing a data object is simply the placement of its address on the stack. This works very well in an object-oriented system—a literal object simply stacks its address, which can be used as a parameter in a message.

In Smalltalk, the set of byte codes is closed and cannot be extended. In a threaded system, however, every code routine, whether primitive or

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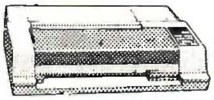

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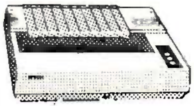

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high-level, is assigned a thread value. Any high-level routine or primitive can be called (early-bound) by compiling its thread value in-line. There is a certain elegance in referring to system primitives and user routines through the same mechanism.

Another benefit that threading provides is the ability to add primitives to the system easily. In Smalltalk, a special mechanism is used for dispatching primitives, and there is no provision for users to add their own. But in FORTH users can recode certain time-critical words in machine code. Because this can be done so easily, it is an effective and powerful technique for improving performance.

TOKEN THREADING

Using physical addresses as thread values is difficult, however, in a garbage-collected system. We need to be able to move objects around very easily without having to update a lot of references to the obsolete addresses. This is the rationale for the object table in Smalltalk. An object is referred to via its object pointer (OP), which is an index into the object table. That location contains the physical address of the object and is the only place that requires updating if the object is moved.

This architecture is very reminiscent of what is called a token-threaded system in the world of threaded languages. A token table fills the same role as the object table in Smalltalk. However, in Smalltalk the object table is discrete from the byte code interpreter. For instance, you could not compile an object pointer in-line in a Smalltalk method and expect the code to execute properly. Object pointers are passive, serving only as a means of finding an object's data address. Tokens, on the other hand, are associated with executable machine code, regardless of whether they point to data or a routine.

In our design of Actor, we integrated the concepts of object table and token table, along with the byte code and primitive dispatch tables from Smalltalk (see figure 4). Every type of object, primitive, or high-level routine has an entry in the object table and is active in the sense that its object pointer can be executed. Each object also belongs to a family that describes its behavior when interpreted. The family code is embedded within the object table entry and is used to dispatch a machine language routine in the interpreter.

This architecture makes it very easy to accomplish early binding. To bind a function call at compile time, its object pointer is simply compiled in-line. A function is then an object whose family behavior is to execute itself. When the interpreter hits the function OP, it executes code that causes the old IP to be stacked and the IP is set to the beginning of the function's data area, which may contain a series of threads to other functions and objects. By contrast, a late-bound send is compiled as the OP of a machine

(continued)

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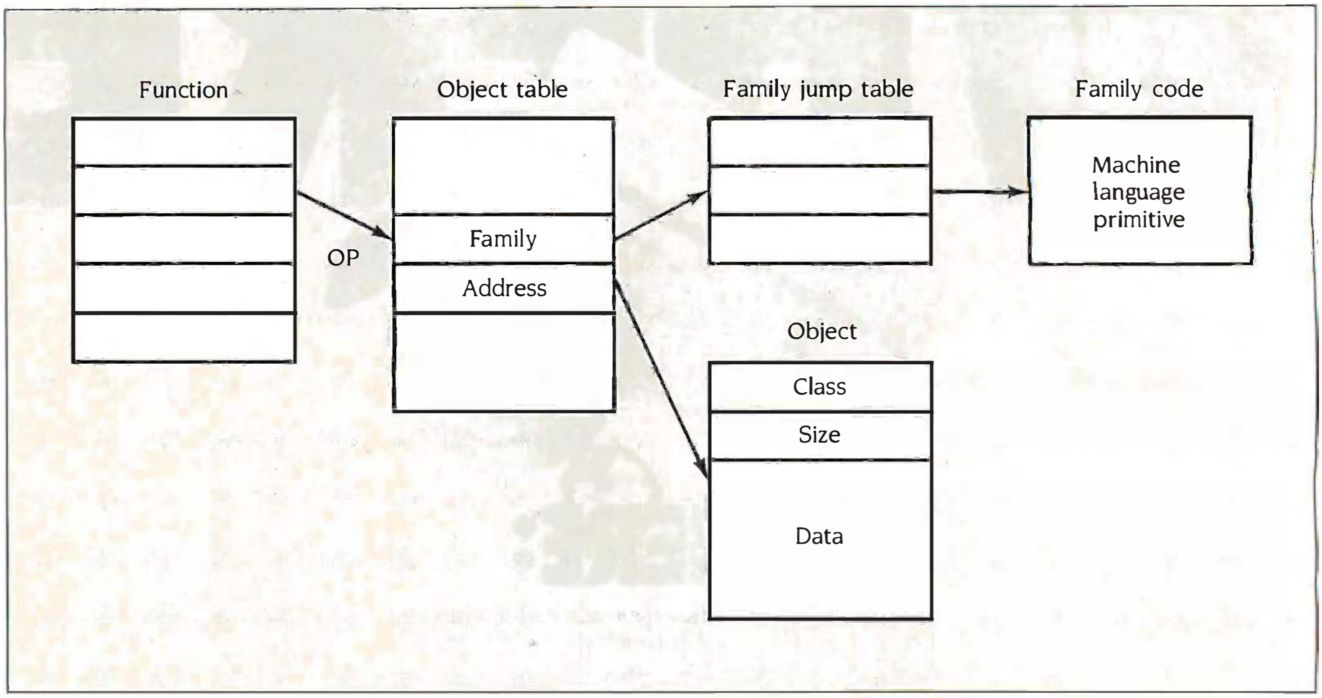


Figure 4: *An example of token threading as implemented by Actor. Here a function consists of a list of object pointers (OPs), which are offsets into the object table. The interpreter scans through the OPs and executes the code relating to the "family" for each OP. If the OP is in the Primitive family, its respective data consists of machine code, which is executed directly. If the OP is in the Function family, the current instruction pointer is placed on a stack and the interpreter begins executing the OPs within that function. For most objects, the family code simply places the OP on the stack so it can be passed as a parameter or used as a receiver of a message.*

language primitive followed by the OP of a symbol.

Because of this difference in design, a piece of compiled code in Actor would look much different from an equivalent piece of Smalltalk code. The Actor code would lack the literal frame. This means that all functions have their code starting at the same offset. It also simplifies the construction of the interpreter and the compiler.

If early binding is used, the compiled Actor code fragment should actually be shorter than the equivalent Smalltalk code, even though each "operation" code is 2 bytes long instead of 1! The threaded model also allows more extensive optimization on the part of the compiler and allows for easy extension should the current set of primitives prove incomplete.

SYNTAX

Another aspect of efficiency relates not to the performance of a particular application, but to the time required to train a programmer how to write that application. Smalltalk's syntax can be initially confusing to the casual reader. It is sometimes difficult to sort out the relationships between identifiers in a moderately complex phrase, since the infix notation fails to make the precedence explicit.

In our design of Actor, we decided to use a conventional, Pascal-like syntax as a means of reducing the learning load on new programmers. There is enough to absorb in learning the object-oriented paradigm itself, along with the hundreds of classes and their methods, without having to learn a completely new syntax.

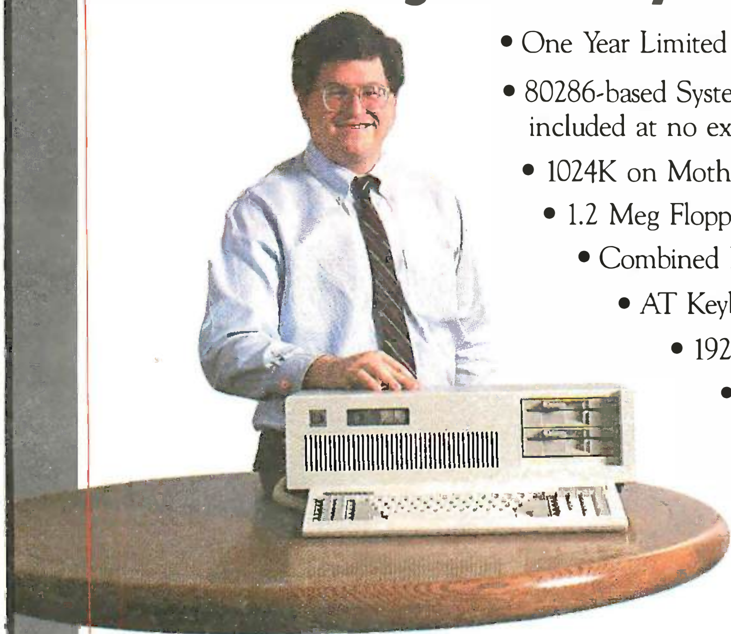
CONCLUSION

There are several areas in which the basically successful model of object-oriented programming developed in Smalltalk could be made more suitable for personal computing environments. In our design of a new language called Actor, we have implemented some of these.

Our goal was to design a threaded interpreter with an intelligent compiler that could support user primitives and optimize message passing by using early binding. We also designed an incremental garbage collector with sensitivity to object lifetimes that eliminates the long pauses and general inefficiency of other garbage-collection techniques. Finally, a syntactical model that is closer to Pascal reduces the learning load for new programmers.

There seems to be a critical mass of interest developing in object-oriented programming. It is my belief that more efficient and accessible implementations of object-oriented languages will promote their much wider use in solving sophisticated personal computing problems.

Editor's note: Actor is scheduled to be available from the Whitewater Group (906 University Place, Evanston, IL 60201) for the IBM PC, XT, and AT in October. It will include the Microsoft Windows environment and provide interactive access to Windows system routines. It will also include a set of classes designed to support list processing and predicate logic for AI applications. ■



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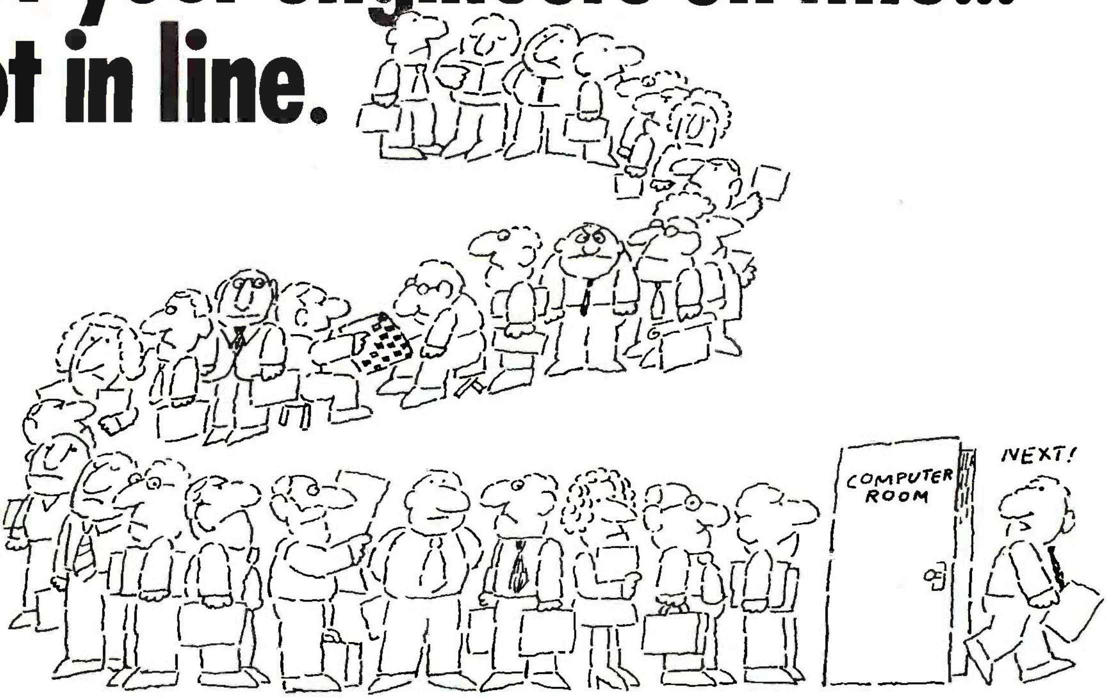

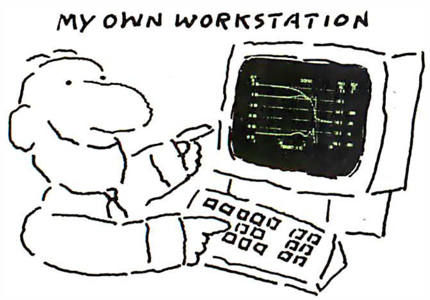

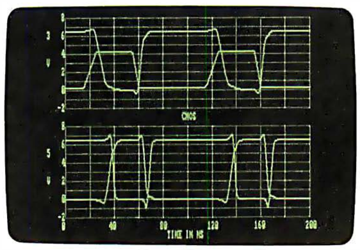
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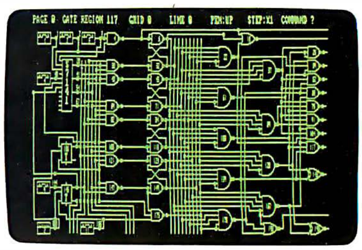
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OBJECT-ORIENTED FORTH

BY DICK POUNTAIN

A new mechanism for designing and writing FORTH *programs*

THE FORTH EXTENSIONS I describe in this article introduce object-oriented features that greatly simplify the design and coding of many data-intensive programs. When compiled into a FORTH-83 standard system, these extensions add a new mechanism for defining abstract data types, which are well suited to the description of real-world objects.

For programmers already familiar with FORTH, the new mechanism enables you to write object-oriented programs similar in some ways to Smalltalk-80 programs, although it does not include the full power of Smalltalk. In fact, the mechanism is closer to the "package" mechanism used in Ada, but since it's written in FORTH, it's fully interactive.

ABSTRACT DATA TYPES

An abstract data type describes a class of program objects in two ways. First, it describes the representation of such objects, that is, the shape and size of memory that they're made of. Pascal records and C structures are examples of such descriptions from other languages. Second, an abstract data type describes the operations that can be used to access objects. These operations are hidden from the rest of the program—an object can be accessed only by these operations and by no others. This provides great security; it is not possible to corrupt complicated data structures by using the wrong methods to access them.

But before anyone starts to panic that I'm about to launch into a computer science lecture, let's look at an example of an abstract data type definition.

A good example to start with is the complex number, and for the sake of simplicity, I'll restrict it to an integer complex number. A complex number is represented by two components, its real part and its imaginary part. Thus, its representation will consist of two integer variables called REAL and IMAG.

I could define any number of operations on complex numbers, but for now I'll define just the equivalent of FORTH's @ (fetch) and ! (store) operations and call them COM@ and COM!. The definition looks like this:

```
TYPE> COMPLEX
2 VAR REAL
2 VAR IMAG
OPS>
: COM@  REAL @ IMAG @ ;   ( --- n n )
: COM!  IMAG ! REAL ! ;   ( n n --- )
ENDTYPE> COMPLEX
```

The definition of COMPLEX is in two parts, separated by the word OPS>. Between TYPE> and OPS> is the description of the representation, namely two variables, each 2 bytes in size (2 VAR), called REAL and IMAG. Between OPS> and ENDTYPE> are the operations permitted on the type, in the form of two normal FORTH colon definitions that use the variables REAL and IMAG. Such operations can freely use any words from the normal FORTH vocabularies but cannot "see" the operations inside another type.

TYPE>, VAR, OPS>, and ENDTYPE> are some of the new words defined in the source code that accompanies

(continued)

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this article, which needs to be compiled before you can define any types. [*Editor's note: The source code for the program examples,* TYPES.DOC *(an ASCII file), is available in a variety of formats. See page 405 for details. The source code compiles to less than 1500 bytes, so it can be used on quite small* FORTH *systems.*]

When a type definition such as COMPLEX is compiled in a FORTH system, inspection of the dictionary will reveal only the single word COMPLEX. All the internal detail—REAL, IMAG, COM@, and COM!—is hidden from view and from use. If you try to enter the word REAL, for example, FORTH will tell you that it's undefined.

Your system will warn you that COMPLEX has been redefined when you compile this definition. This makes the syntax prettier, and it also places a copy of the type name inside the operations vocabulary, which can be used by various debugging tools.

To use this type definition you have to create an instance of the type, which you do by using the word COMPLEX. If you say

```
COMPLEX FRED
```

a new complex variable called FRED will be created in the dictionary. This variable responds to the messages COM@ and COM!. Note that the message-passing syntax is reverse Polish, so if you say

```
23 45 FRED COM!
```

the numbers 23 and 45 will be stored in FRED as its real and imaginary parts. Saying

```
FRED COM@
```

results in 23 and 45 being placed on the stack. In other words, FRED behaves like a FORTH variable, but one with an internal structure. What's more, you can access this internal structure only by the operations COM@ and COM!. If you say FRED @ or FRED + or follow FRED by anything other than COM! or COM@, then an "undefined operation" error message will be issued.

You can create any number of named complex variables, just as you can create any number of ordinary FORTH variables. The complex variables all have the same internal structure (i.e., two 16-bit integers), and all respond only to COM! and COM@.

It is often convenient when using structured variables like this to initialize them to default values. Otherwise, you might waste a lot of code initializing them—don't forget that they could be much bigger and more complicated than COMPLEX. (Note that the ordinary FORTH word VARIABLE allows initialization in FIG-FORTH but not in FORTH-79 or -83.) For this reason I've included the special operation INIT. If this operation is added to a type definition, it will be executed automatically when a new instance is created. So if you say

```
TYPE> COMPLEX
2 VAR REAL
2 VAR IMAG
OPS>
: COM@   REAL  @  IMAG  @ ;   ---  n  n )
: COM!   IMAG  !  REAL  ! ;   ( n n ---  )
: INIT   0 IMAG ! 0 REAL ! ;
ENDTYPE> COMPLEX
```

then FRED or any other instance will be created with zero values for its two parts, rather than random values. You can place INIT anywhere between OPS> and ENDTYPE>.

Another useful and powerful facility would be the ability to create arrays of structured data objects of type COMPLEX, and the word ARRAY-OF allows just this. The statement

```
20 ARRAY-OF COMPLEX JIM
```

creates an array of 20 objects of type COMPLEX. You can access the individual objects by prefixing the name JIM with an index (starting with 0). Thus 0 JIM is the first object in the array, while 19 JIM is the last object. The objects otherwise behave just like simple objects of type COMPLEX, so

```
23 45 5 JIM COM!
```

stores 23 and 45 in the sixth element of the array. Of course, we could also say

```
FRED COM@     5 JIM COM!
```

When compiling references to an array, you can indicate that the index is a constant known at compile time as follows:

```
: TEST     VAL[ 3 ] JIM COM@ ;
```

This permits compilation of the actual address of the element and gives better performance than

```
: TEST     3 JIM COM@ ;
```

although both lead to the same result.

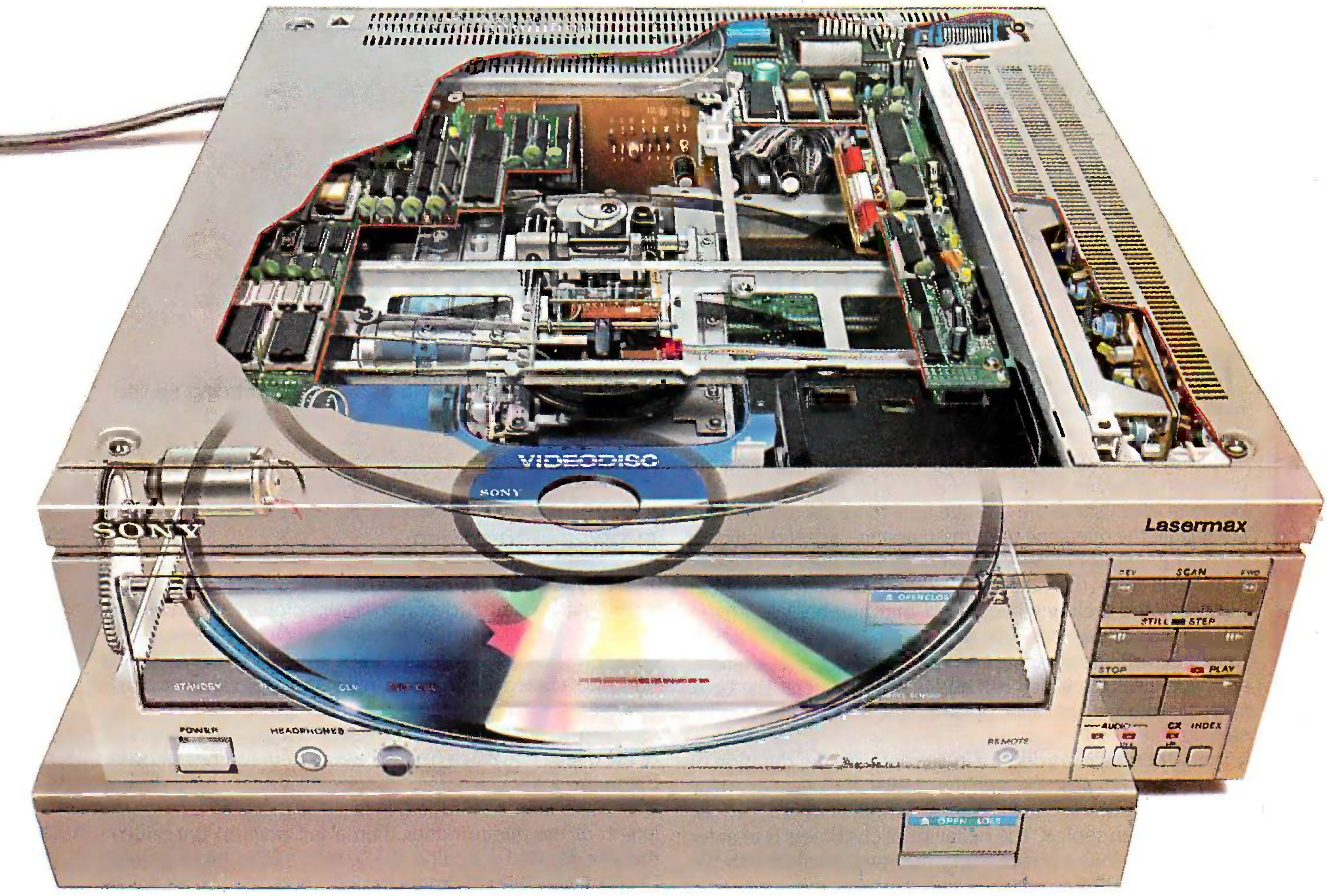
A word of warning: The system as given here has no array-bounds checking, so you could say 30 JIM and blow the system away. This was done deliberately for efficiency and to keep the code simple. In true FORTH style, you have a choice. Either you can do array-bounds checking at the application level, or you can add a bounds check to the word INDEX+ in screen 10 of the source code.

COMPOUNDING TYPES

The mechanism already looks useful, since it provides a secure way to handle complicated data structures in FORTH. But we've only begun to see its potential. It's also possible to use a previously defined abstract data type as an instance variable in a new type. *Instance variable* is just another name for a variable, like REAL and IMAG, that is used to describe the representation of an object. Every instance of the type gets its own private set of instance variables, which are copies of those in the type definition. The instance variables, however, are anonymous, the names being kept in the type definition.

Suppose, for example, you're writing an application that calls for pairs of associated complex numbers to be used

(continued)



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Queue Simulation: A Sample Object-oriented Program

This sample program is a simple discrete simulation of customers queuing in a bank. Customers arrive singly at random intervals and go to a random cashier's window, where they queue if necessary until served. Each customer takes a finite but variable time to be served, which is random but constrained within limits. By playing with the average time between arrivals and the average time to be served, you can investigate the queueing patterns. (I assume a pseudorandom number generator called RANDOM is available, which takes a number from the stack and returns a random number between [and including] zero and that number.)

The program uses two type declarations: type CUSTOMER, which records the attributes and the behavior of customers, and type CASHQ, which is a queue of customers. The bank is represented by an array of CASHQs, with an element for each cashier.

The attributes recorded for customers are the duration of their intended transaction with the cashier, their time of arrival in the bank, and a status flag that determines whether or not they have been served. The behavior of customers is to enter the bank and join a queue, carry out a transaction with the cashier when they reach the head of the queue, and reply to the query "Are you finished?" Here's the declaration for type CUSTOMER:

```
10 CONSTANT TDELAY -- upper limit for transaction time
TYPE> CUSTOMER
2 VAR TRANSACT.TIME-- duration of desired transaction
2 VAR ENTRY.TIME    -- time bank entered
2 VAR DONE          -- flag for completion of
                       transaction
OPS>
                            -- introduce a new customer
: JOIN   CLOCK @ ENTRY.TIME ! -- record entry time
         TDELAY RANDOM 5 +  -- a number between
                               5 and TDELAY+5
         TRANSACT.TIME !    -- initialize duration
         FALSE DONE !  ;    -- not served yet
-- carry out one time slice of a transaction
: TRANSACT  -1 TRANSACT.TIME +! -- decrement by
                                   one time unit
         TRANSACT.TIME @
         IF  FALSE DONE !       -- still being served
         ELSE TRUE DONE !       -- finished
         ENDIF ;
-- test for completion of transaction
: DONE?       DONE @ ;
ENDTYPE> CUSTOMER
```

The type CASHQ describes a circular queue created according to standard textbook principles. A queue data structure is a collection of items to which new items can be added (called *enqueuing*) and from which old items can be removed (called *dequeuing*). Unlike the case with a stack, however, the first item into a queue is also the first to be removed. Like a stack, a queue requires a pointer to the head of the queue (the place from where an item can be removed), but unlike a stack, a queue also requires a pointer to its tail, where new items are added. In fact, the program records the length of the queue rather than a tail pointer; the tail can then be found by adding the length to the head pointer. Circularity is achieved simply by performing all such arithmetic on the pointers, modulo (size of the array).

CASHQ has an enqueue operation that merely performs JOIN on the first free customer in the queue. In other words, we do not actually create any new instances of CUSTOMER but simply reuse the queue elements as if they were new objects. Similarly, the dequeue operation merely moves the head pointer and does not return any object (our customers vanish into thin air after they've been served!). Here's the declaration of CASHQ:

```
TYPE> CASHQ
2 VAR HEAD
2 VAR LEN
20 CONSTANT MAXQ
MAXQ ARRAY-OF CUSTOMER QBODY

OPS>
: FULL?  LEN @ MAXQ = ;        -- is queue full?
: EMPTY? LEN @ 0= ;            -- is queue empty?

: DQ     EMPTY? NOT IF HEAD @ 1+
```

a lot. You can define a type COMPAIR as follows:

```
TYPE> COMPAIR
COMPLEX A
COMPLEX B
OPS>
: COMP@ A COM@  B COM@ ;   (--- n n n n)
etc. . . .
```

I've defined only one possible operation, COMP@, which puts both the complex parts of a COMPAIR on the stack. This demonstrates that the instance variables A and B are used in the operations exactly like objects of type COMPLEX (i.e., FRED) and "understand" only the operations COM@ and COM! defined for COMPLEX.

You can also use ARRAY-OF inside a type definition, with the one proviso that the size of the array be fixed at the time the definition is compiled; that is, it must be a constant value. For example:

```
TYPE> COMSTACK
```

```
                MAXQ MOD HEAD !         -- bump head
                    -1 LEN +!           -- decr. length
                ENDIF ;
: NQ        FULL? NOT IF HEAD @ LEN @
            + MAXQ MOD                  -- get tail
                QBODY JOIN              -- add customer
                1 LEN +!                -- bump length
              ENDIF ;
: SERVE     HEAD @ DUP QBODY TRANSACT
                                        -- serve head of
                                           queue
            QBODY DONE? IF   SELF DQ
              ENDIF ;                   -- vanish if done!
: SHOWQ     EMPTY? NOT                  -- display queue
            IF   LEN @ 0 DO ." #" LOOP
              ENDIF ;
: INIT      0 HEAD ! 0 LEN ! ;          -- initialize the
                                           queue pointers
ENDTYPE> CASHQ
```

Note that the INIT clause is actually superfluous because ARRAY-OF automatically initializes its elements to zeros. However, INIT can be used to write a word for wiping the array clean during a program run.

With these two types we can now produce the main program loop. The "bank" is an array of CASHQs. Concurrency is simulated by incrementing the variable CLOCK at the beginning of the loop, so that each pass through the loop represents one time slice. A NEXT.CUSTOMER variable is initialized with a random number, representing the delay before a new customer enters the bank. A test is made each time slice to see if a new customer is required. Next, an inner loop services the customers at the heads of all the queues, using up one time slice of their transaction time, and prints a character-graphic display of the bank.

```
-- working variables.
   VARIABLE CLOCK    VARIABLE NEXT.CUSTOMER
    VARIABLE LAST.CUSTOMER
-- maximum delay before new customer enters
   5 CONSTANT CDELAY
-- is a new customer due?                    ( --- flag )
   : TIME.FOR.NEXT?  CLOCK @ LAST.CUSTOMER @
       - NEXT.CUSTOMER @ > ;
-- set up the "bank"
   10 CONSTANT BSIZE
   BSIZE ARRAY-OF CASHQ CASHIER
-- main loop
   : QSIM        0 CLOCK !              -- initializations
       0 LAST.CUSTOMER !
       CDELAY RANDOM   NEXT.CUSTOMER !
       BEGIN
         1 CLOCK +!                     -- advance one tick
         TIME.FOR.NEXT?
           IF BSIZE RANDOM CASHIER NQ
                                -- new customer at random
             CLOCK @ LAST.CUSTOMER !
                                 -- record time of entry
             CDELAY RANDOM NEXT.CUSTOMER !
                                       -- time till next
           ENDIF
         BSIZE 0 DO I CASHIER SERVE
                                -- serve head customers
                      I . I CASHIER SHOWQ
                                      -- display queues
                   LOOP
       ?TERMINAL UNTIL ;
```

For portability, the display part of the program is left very crude. It merely produces a scrolling list of the queues, displayed by character graphics. If you have a cursor-addressable terminal and a FORTH that supports it, you can modifiy the final DO. . . LOOP to get an animated display of the queues. Simply reset the cursor to the top of the screen and blank the previous display.

Obviously, this simulation could be made much more sophisticated. It's easy to write a word FIND.SHORTEST to make a new customer go to the shortest queue. The time of entry could be used to "interview" customers as they are served and find out how long they had to wait. It's only when you come to make such modifications that the power of object orientation will be revealed to you.

```
2 VAR STACKPTR
100 ARRAY-OF COMPLEX STACKBODY
OPS>
: INIT       0 STACKPTR ! ;
: PUSH       STACKPTR @     STACKBODY COM!
                                 ( n n --- )
              1 STACKPTR +! ;
: POP        -1 STACKPTR +!      ( --- n n )
             STACKPTR @     STACKBODY COM@ ;
: EMPTY? STACKPTR @ 0 = ;        ( --- flag)
: FULL?    STACKPTR @ 99 = ;     ( --- flag)
ENDTYPE> COMSTACK
```

Here I've defined a type of stack that operates with complex numbers. You can create new complex stacks at will, as in COMSTACK CSTACK1.

For a more substantial example of the capabilities of the system, see the sample program in the text box "Queue Simulation: A Sample Objected-oriented Pro-

(continued)

gram" on page 230. The program is a discrete simulation of queuing in a bank and will give you a clear sense of the programming style that results from using objects.

Using the Source Code

The file TYPES.DOC contains screens 1 through 13 of the source code in ASCII form. To compile them into many FORTH systems, the carriage return/linefeeds will have to be stripped out. The code is written in Laboratory Microsystems' PC/FORTH and is 83-standard except for the word LIT" in screen 8, (INITIALIZE), which creates a string literal. Most good FORTHs have such a word, although it may be called ". If you do not have such a word, omit INITIALIZE.

The procedure for converting the code to 79-standard is straightforward. Replace all occurrences of the header field words (NAME>, >BODY, etc.) with their 79-standard equivalents (NFA, PFA, etc.), and replace ' >BODY by [COMPILE] '. There's a problem, however, with the word FIND, which behaves differently in FORTH-79. INITIALIZE cannot be made automatic in 79-standard since FIND cannot take a string argument from the stack, and the message INIT will have to be issued explicitly to newly created objects.

Limitations

I developed this system by simplifying a previous system, which was a direct emulation of the class mechanism of Smalltalk-80 in FORTH. While working on that system I discovered that by using existing FORTH infrastructures (in particular, the vocabulary mechanism), I could make a smaller and faster implementation with a more recognizably FORTH-like syntax.

As always, there is a price to pay, and with this system one price is that its inheritance mechanism is much less general and powerful than that in Smalltalk. In particular, inheritance is restricted to operations and does not apply to representation.

You can use the extra word INCLUDE> to make a type inherit all the operations of a previously defined type. However, if you also want the type to inherit all the instance variables of the previous type, you'll have to declare them all again inside the new type, in the same positions and order and with the same names. For example, you could define a type EXTRACOMPLEX

```
TYPE> EXTRACOMPLEX
2 VAR REAL
2 VAR IMAG
2 VAR WEIRD
OPS> INCLUDE> COMPLEX
: W!  WEIRD ! ;
: W@  WEIRD @ ;
ENDTYPE> EXTRACOMPLEX
```

and have it inherit all the operations of COMPLEX, while adding two new ones of its own.

Another limitation is the absence of an equivalent to Smalltalk's indexed variables. In Smalltalk such variables can be assigned a size at instance creation time, which

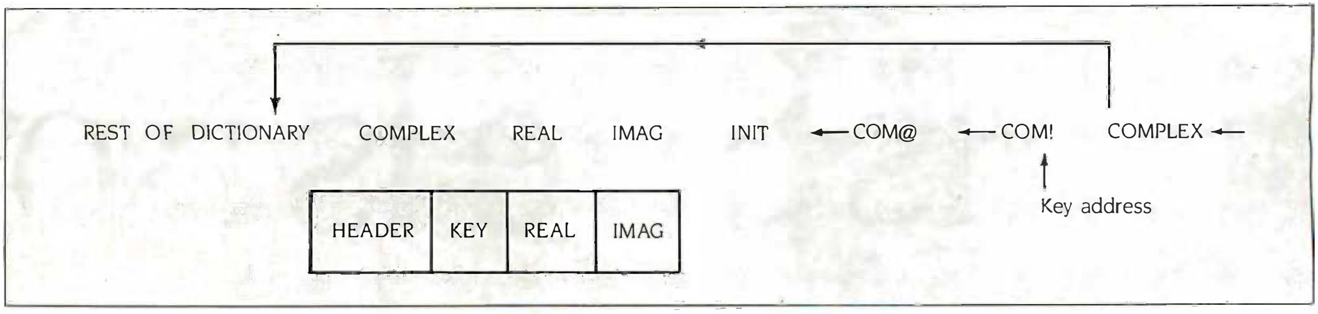


Figure 1: *The key to a type's sealed vocabulary is stored in the first two bytes in each of the type's instances (top). An instance such as* FRED *has an internal structure like that shown at bottom.*

allows different-size objects to be created from the same definition. An obvious application is type STRING, whose instances could be of different sizes. In my system, however, all types are of fixed size.

Another drawback, which sorrows me, is that you cannot pass types as parameters to other types, a capability that would be equivalent to Ada's concept of a generic package. For example, you could define a type GENSTACK that included the archetypical behavior of all stacks and then use it to create specific types of stacks, such as a stack of COMPLEX, by passing the item type at instance creation time.

Both these latter facilities can be added, but the extra complexity they introduced was too great a price to pay for my purposes here.

HOW DOES IT WORK?

Briefly, TYPE> and ENDTYPE> manipulate the dictionary structure (by redirecting link field pointers) to conceal all the code between them from normal dictionary searches. The operations of a type then occupy, in effect, a sealed vocabulary that cannot be accessed by ordinary FORTH words. The key to this sealed vocabulary is the link field address of its last member, and this key is stored in all a type's instances, in their first two bytes (see figure 1).

When a message is sent to an object, the object uses its key to unlock the operations vocabulary and look up the compilation address of the required operation. If the object/message pair is found inside a colon definition, as in

```
: TEST     FRED COM@ ;
```

then this lookup occurs at compile time, and the actual address of the operation is compiled, which makes for much greater efficiency than if it were left until run time. This is known as *early binding*.

The performance cost of using types is hard to quantify, since they alter programming style to the point where it's difficult to write an equivalent plain FORTH program for comparison. Comparing trivial examples overestimates the overhead of types, which tends to be fixed and thus diminishes in importance as types and operations become more complex.

In storage terms, the overhead is 2 bytes per object, which is used to store the key. In a simple type like COMPLEX this amounts to a 50 percent overhead, but for COMSTACK it is negligible. Compound types store a single key, not a key for each typed field. Similarly, an ARRAY-OF has only one key, not one for each element (since they are all of the same type).

In execution terms, the overhead is due largely to the pushing and popping of a third stack called OSTACK, which holds the address of the current object. Each use of an instance variable also incurs an overhead, since an addition has to be performed at run time to calculate the variable's absolute address from its relative offset. Both of these problems can be improved by machine coding.

There is also a modest increase in code size due to the OSTACK pushing and popping code that's compiled for every object/message pair. This overhead increases as objects become more compound.

WHAT IS IT GOOD FOR?

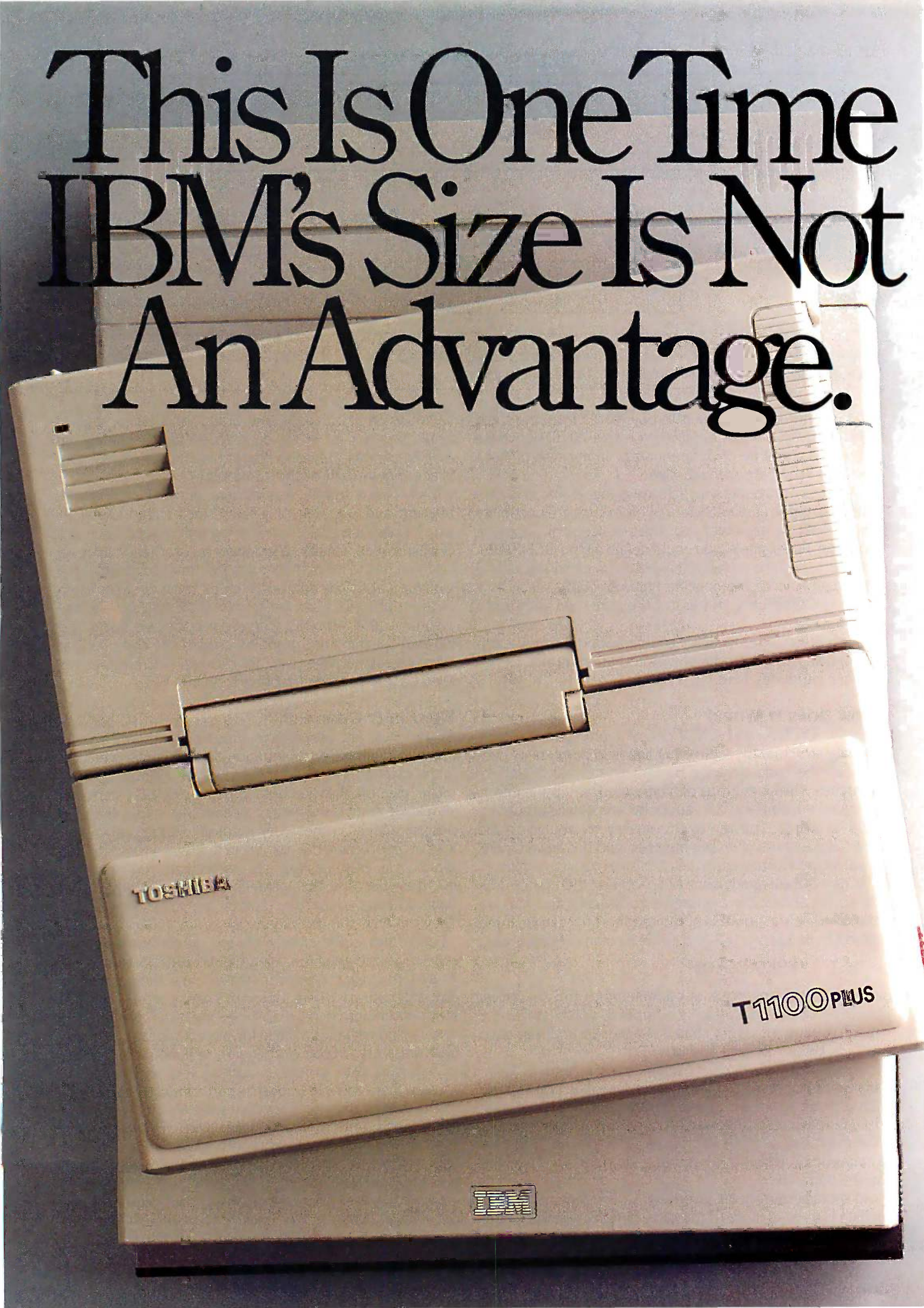
As with most programming methodologies, there's a temptation to push object orientation as a universal panacea. In the case of these FORTH extensions I will not go so far.

The use of abstract data types in FORTH certainly simplifies many kinds of programming, and I find the design process comes very naturally. For example, you look at an object in the real world that you wish to model. Which of its attributes (e.g., size, weight) are you interested in? They become the instance variables. Which of its behaviors (e.g., departure, arrival) are you interested in? They become the operations.

Fields that could clearly benefit, apart from discrete simulation, are graphics (using types for graphics objects), AI systems (using types for frames), and even commercial applications where types provide a more powerful abstraction than do records. Types are also invaluable for certain kinds of system work, for the extra protection they bestow is very welcome when you're handling potentially explosive data structures such as lists and heaps.

Given that types do impose a performance cost, it isn't worthwhile to use them for very simple objects. I would not, for example, define a type INTEGER, for which FORTH already has a good representation. But it takes a little practice to learn how to combine plain with object-oriented FORTH into an efficient hybrid programming style.

Editor's note: For a fuller version of this code and a detailed description of how it works, see Dick Pountain's *book* Object-Oriented FORTH, *soon to published by* Academic Press. ■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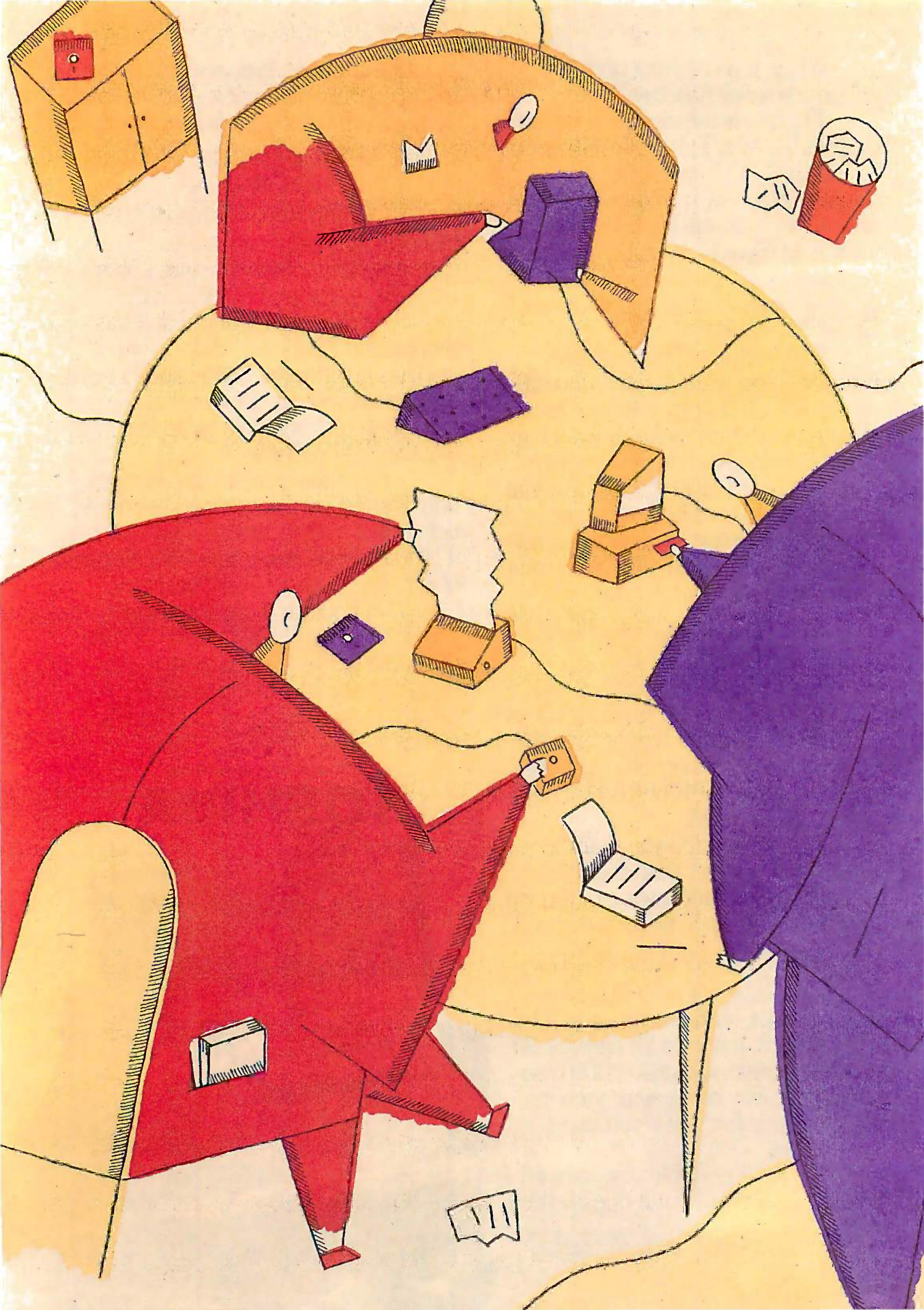

Reviews

The NCR PC6 is an IBM PC compatible with two clock speeds, 4.77 MHz and 8 MHz, a preconfigured hard disk and tape backup system, and a programmable user interface. The machine offers a good price and, especially at the higher clock speed, competitive performance. Arthur Little notes that the machine's most serious drawback is its mediocre documentation.

According to Frederick Davis, the Sperry PC/IT boasts a reasonable price and a significant increase in performance over the IBM PC AT. The computer has three clock speeds: 6 MHz with one wait state, 8 MHz with one wait state, and 7.16 MHz with no wait states. The benchmark results suggest that at the 7.16-MHz clock speed, the Sperry operates approximately 50 percent faster than the IBM PC AT. The computer has a true hardware reset button and nine expansion slots, seven with AT-style 16-bit data lines.

The DeSmet C Development Package for the Macintosh produces faster and more compact code than most Macintosh C compilers. Jonathan Robie reports that it also compiles faster, has a good programming environment, and gives good support for the ROM Toolbox. The author has noted important bugs and shortcomings, and he has compared the benchmark results to five other C compilers for the Macintosh.

TOPSI 2.0 is an implementation of the OPS5 production system language for MS-DOS. It includes all the core functions, and Leonard Moskowitz explains that you will be able to work around incompatibilities with standard OPS5. You can use it as a serious programming tool and as a learning aid for expert systems and artificial intelligence techniques.

Let's C is a $75 package that includes a screen editor, a full C compiler, an 8086/88 assembler, and a linker. For $75 more there is csd, a powerful C symbolic debugger. William G. Wong found the package to be of high quality with a good environment for learning C, yet with all the tools you will need to create applications. The main drawbacks include the lack of 8087 and IEEE floating-point support.

We take a look at three software packages this month.

NewWord 3 is affordable, versatile, and much faster and more full-featured than previous versions. John Heilborn and Nanci Reel note that the word processor now includes an in-text math calculator, enhanced menus, a spelling checker, a macro facility, and provision for computer-aided indexes and tables of contents.

Borland's Reflex permits effective control over five different "views" of your data. Rusel DeMaria found that this analytical database offers several unique features for interpreting your data.

And there is Guru, a very powerful integrated software package that offers an exceptional number of features.

Finally, we examine the Datran Modem Accelerator. With this add-on board plus software, you can shorten the time required to transmit text. The product can also conserve disk space by storing files in compressed form.

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Symphony	✓	✓	✓			✓		✓		✓	✓		695.00
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R·E·V·I·E·W·E·R'S N·O·T·E·B·O·O·K

This month we begin with a correction. In the July review "BYSO LISP and Waltz LISP" by William Wong, we incorrectly listed the price of BYSO LISP as $69.95. The correct price is $150. Our apologies to the Levien Instrument Company. Now let's take a look at some interesting and relatively inexpensive utilities and applications software we've received.

The Norton Commander ($75 from Peter Norton Computing, 2210 Wilshire Blvd., Santa Monica, CA 90403, (213) 453-2361) provides a very quick alternative to entering DOS commands on the IBM PC and compatibles. Using a simple intuitive approach, you can quickly view, copy, move, and delete files. Among its many uses, the product is a boon for cleaning up directories. You can delete selected files, directly edit a directory structure, or move files among subdirectories. The program is fully compatible with all memory-resident software because it is an application that you can load whenever you need it.

Point Five, priced at $195 by Pacific Crest Software (887 Northwest Grant Ave., Corvallis, OR 97330, (503) 754-1067), is an analysis and modeling system for the IBM PC and compatibles. At the heart of the application is a programmable calculator with 150 built-in mathematical, financial, and statistical functions. Using these functions, you can build complex models and programs. You can, for example, define and manipulate tables of data very quickly and then display data with a variety of bar graph functions.

Bridge Software (P.O. Box 118, New Town Branch, Boston, MA 02258, (617) 527-1585) offers Datasurf, a $125 surface sketching utility that generates three-dimensional graphic images. For the IBM PC and compatibles, Datasurf can read files created by word processors, spreadsheets, and languages. You can adjust the viewpoint and scale, rotate images, hide or restore lines, crosshatch surfaces, add and label axes, and print high-resolution (960- by 1056-pixel) images on most dot-matrix printers.

Mace + Utilities ($69.95 from Paul Mace Software, 206 Alicia Ave., Ashland, OR 97520, (800) 523-0258) prevents data loss on hard disks by moving data to safe areas before the sectors go bad. With this utility you can clean up directories, "undelete" files, compress and sort directories, and recover from an accidental formatting of your hard disk.

Tornado Notes (Micro Logic Corporation, P.O. Box 174, Hackensack, NJ 07602, (201) 342-6518) is a $49.95 RAM-resident productivity tool for the IBM PC and compatibles that lets you enter, edit, combine, and access notes. With this tool you can browse through text documents or search for notes by specifying key words or phrases. An import command allows you to import ASCII files into Tornado Notes; you can therefore use the utility to search for data within text files that may be structured in widely different ways.

Also for the IBM PC, for only $19.95, is PopDrop (InfoStructures Inc., P.O. Box 32617, Tucson, AZ 85751, (602) 299-5962), which lets you load and remove RAM-resident software and work with up to 1.5 megabytes of RAM. With this utility, you can avoid incompatibilities among your other utilities and create a series of useful environments without having to reboot your IBM PC.

We have also received some applications and utilities for the Atari 1040ST. Tom Hudson's work is always impressive, and his $49.95 CAD-3D (Antic Software, 524 Second St., San Francisco, CA 94107, (415) 957-0886) is no exception. With this program, you can design three-dimensional solid or wire-frame objects and specify multiple views and light sources. The package includes an animator. You can save your creations in either DEGAS or NEOchrome formats.

A whole range of other 1040ST utilities deserve mention here also. Solid Applications Inc. (1333 Moon Dr., Yardley, PA 19067, (215) 736-2449) has STKey, a memory-resident facility that provides user-programmable function keys, and Diskmenu, a file archive and backup utility. DOS Shell from MichTron (576 South Telegraph Rd., Pontiac, MI 48053, (313) 334-5700) provides a command-line interface that emulates MS-DOS. The MichTron Utilities allow you to change file contents, attributes, or names to restore deleted files and to recover data from damaged disks.

Finally, Hippopotamus Software (985 University Ave., Suite 12, Los Gatos, CA 95030, (408) 395-3190) supplies Hippo Disk Utilities, a collection of routines that you can use to recover lost data; to copy, move, or selectively delete files; and to edit RAM and disk storage directly.

Macintosh owners should note that there are three new BASIC compilers for the Macintosh. ZBasic and True BASIC now have Macintosh versions (see the reviews in the May 1985 and May 1986 issues of BYTE). In addition, PCMacBasic from Pterodactyl Software (P.O. Box 538, 200 Bolinas Rd. #27, Fairfax, CA 94930, (415) 485-0714) includes mouse-sensing commands, dynamic and pageable program arrays, and use of resource files to create icons, dialog boxes, and much more. We are planning a comparative review for an upcoming issue.

—Jon Edwards
Senior Technical Editor, Reviews

THE NCR PC6

BY ARTHUR LITTLE

A dual-speed IBM PC *compatible of robust design with two clock rates*

The NCR PC6 is an IBM PC compatible that, like the IBM PC, is an 8088-based system. Unlike the IBM PC, the PC6 has two clock rates, standard and high speed. The PC6 comes in three versions—one with two floppy disk drives (Model 1012), one with a floppy disk drive and a 20-megabyte hard disk drive (Model 1014), and a similar one that includes a 10-megabyte tape backup unit (Model 1015). Prices range from $2390 to $3690. I reviewed a Model 1015.

HARDWARE

The PC6 Model 1015 is no lightweight: The system unit tips the scales at a hefty 37 pounds, the monochrome monitor weighs 32 pounds, and the keyboard weighs 4½ pounds. Much of that weight is from the metal used in its construction. It is a solid unit.

Generally, the PC6 shows extraordinary attention to detail, from the XP (Extra Performance) switch and the speaker volume control on the front panel to the knurled plastic tips on the monitor cable screws. You'll never need a screwdriver to attach or detach the monitor cables.

Unfortunately, not all of the engineering is of the same caliber. The cabinet is attached to the chassis with three spring-loaded, quarter-turn screws. After I disengaged these screws, the cabinet would not slide forward for removal. I finally detached the cabinet by prying the case open with a screwdriver.

DISPLAY

The PC6 has four optional displays: a standard monochrome display with 25 columns of 80 characters for $195; a high-resolution (640 by 400 pixels) monochrome graphics display with an adapter for $849; a color graphics display for $659; and a high-resolution, 16-color graphics display plus adapter for $1260.

I reviewed a PC6 equipped with the high-resolution monochrome graphics display. The brightness and contrast controls are located at the top of the unit. Once you have them set to the desired level, you can push them in so that they are flush with the monitor's housing. The display's characters are sharp and readable but seemed a little too thin.

KEYBOARD

NCR chose to emulate most of the features of the IBM PC keyboard, with a few welcome additions. Between the QWERTY layout and the numeric keypad, there is a two-part cursor-key cluster. The top part is made up of separate keys for Del, End, PgUp, PgDn, and another Ctrl key. The bottom part has four cursor keys and a Home key. There are two other refinements over the IBM layout: The numeric keypad has its own Enter key and both the Num Lock and Caps Lock keys have LED indicators.

INTERNALS

The NCR PC6 uses an 8088-2 microprocessor that runs at two clock rates: 4.77 MHz, for complete IBM PC compatibility, or 8 MHz, NCR's XP (Extra Performance) mode. The motherboard has a socket for an 8087 math coprocessor. If you choose to add an 8087, be certain that it is rated at the 8-MHz clock rate. One feature that the PC6 lacks is a hardware reset switch.

The Model 1015 system comes standard with 512K bytes of RAM, as does the Model 1014 (although for some reason, my review machine had only 256K bytes of RAM, like the Model 1012). The PC6 can accommodate a maximum of 640K bytes of RAM. It also has 16K bytes of EPROM, which contains the BIOS and an empty socket for an additional 16K bytes of ROM.

The power supply for the NCR PC6

(continued)

Arthur Little (4 Seaway Rd., Squantum, MA 02171) is a former technical editor for BYTE *and a freelance writer. He has been manager of documentation for two software publishers.*

NCR PC6

Company
NCR Corporation
Personal Computer Products
1150 Anderson Dr.
Liberty, SC 29657
(803) 843-1751

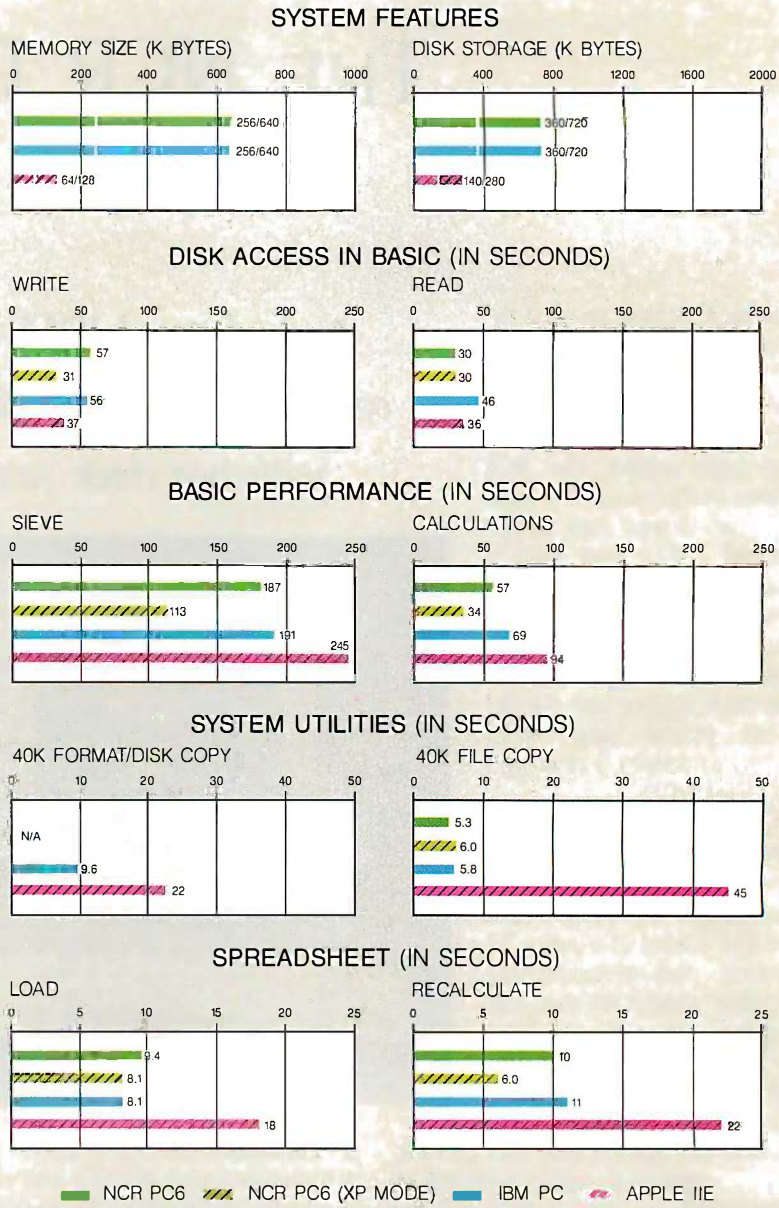
Size
19.5 by 15 by 5.5 inches; Model 1015 system unit: 37 pounds, monitor: 32 pounds, keyboard: 4½ pounds

Components
Processor: 8088-2 (4.77/8 MHz)
Memory: 256K RAM (Model 1012); 512K RAM (Models 1014 and 1015); 16K ROM (all models)
Mass storage: Two 360K-byte, 5¼-inch, half-height floppy disk drives (Model 1012); one floppy disk drive and one 20-megabyte half-height hard disk drive (Model 1014); or one floppy disk drive, 20-megabyte hard disk drive, and a 10-megabyte half-height cartridge tape backup (Model 1015)
Display: Monochrome with 25 rows of 80 characters, high-resolution monochrome (640 by 400 pixels), color, or high-resolution color; all optional
Keyboard: 95 keys, including 10 function keys; numeric and cursor keypads
Power source: 120 volts AC, 200 watts
Expansion: Eight PC-compatible slots
Interfaces: One RS-232C serial port; one Centronics-compatible parallel printer port

Software
NCR-DOS version 2.11.30, NCR User Interface, GW-BASIC, NCR Tutor, NCR Pal, Help program, User Diagnostics, tape backup and restore software

Documentation
PC6 *Owner's Manual*, 144 pages
NCR-DOS manual, 376 pages
GW-BASIC Manual, 424 pages

Price
Model 1012: $2390
Model 1014: $2990
Model 1015: $3690



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 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.

Note that the NCR PC6 Model 1015 tested had one floppy disk drive and one hard disk drive, so the standard Format/Disk copy benchmark was not applicable. Also note that the PC6 was tested in standard (4.77 MHz) mode.

is rated at 200 watts. The motherboard has eight IBM PC–compatible expansion slots. In my review unit, two of these slots were in use, one for the display card and one for the hard disk controller. Note that the floppy disk controller is located on the motherboard and does not require an expansion slot.

The PC6 comes with two interfaces: an RS-232C serial port and a Centronics-type parallel printer port that uses the IBM-standard DB-25 connector.

MASS STORAGE

The PC6 Model 1015 comes with three mass storage devices: one 360K-byte floppy disk drive, an internal 20-megabyte hard disk drive, and a tape backup system for the hard disk drive.

The PC6 is very much an OEM unit; NCR purchased all three mass storage devices from outside vendors. The floppy disk drive is a 360K-byte half-height unit manufactured by Teac. The hard disk is a 20-megabyte half-height unit from NEC. Both drives worked flawlessly during the course of their operation.

The 10-megabyte cartridge tape backup system is from Irwin Magnetic Systems. This built-in unit does not need an expansion slot for its controller, as it uses one of the floppy disk controller ports. The system uses the Irwin TC200 high-density data cartridge. These eight-track cartridges must be formatted prior to use, a process that takes over 16 minutes.

The tape system's software lets you back up files either as a disk image or as a group of files (by date and time or by directory). This backup is called a "saveset," and the entire saveset must be written to disk during a restore. Actual backup of 1 megabyte of data, in the form of a 180-file subdirectory, took 10 minutes and 31 seconds.

SOFTWARE

NCR-DOS is NCR's version of MS-DOS. The version used for this review was NCR-DOS version 2.11.30, which has the commands and features of MS-DOS version 2.11.

In addition to the standard MS-DOS command-driven interface, the NCR system comes with the NCR User Interface, which is a menu-driven shell to the MS-DOS operating system. This shell presents the user with the main menu, which leads to several submenus. These submenus let you do a number of things, such as define and use menus for applications programs; choose DOS commands; set the level of assistance you desire (novice, medium, or experienced); define up to 37 different key combinations using the Function, Shift, Alt, and Ctrl keys with macros of up to 127 characters; set the current time and date; turn the time and date display on or off; and change your default drive.

If you have problems with conflicts between the NCR User Interface and your applications programs, function key F1 displays a single page of "hints and kinks." A DOS command Help facility is also readily available, which covers 59 DOS commands.

The package also includes GW-BASIC, Microsoft's interpreted BASIC, which is directly comparable to IBM's Advanced BASIC. NCR supplies GW-BASIC version 2.02.30.

Finally, the system comes with software for the tape backup subsystem, which lets you format cartridge tapes, do file-oriented backup, do disk image backup and restore, and test the drive.

Although NCR is not bundling any specific business software with the PC6, they have included a fair amount of "get acquainted" programs designed for the end user. NCR Pal, for example, is a mini-tutorial and introduction to the operation of the PC6 computer. This program covers the keyboard functions and briefly describes NCR Tutor, the Help package, and the NCR User Interface. It also describes types of applications programs (spreadsheets, word processing, and BASIC) in detail. The last section of the Pal main menu is an overview of the computer hardware.

NCR Tutor comes on an auto-boot disk and provides an on-line explanation of much of the information contained in the NCR-DOS manual but with more examples. The concepts it covers include introduction to DOS, disks/directories/files, disk/file-related commands, system environment-related commands, special keys, EDLIN, batch commands, and redirection/filters/pipes. The Tutor has many hands-on examples that require your input to continue the tutorial. The material builds on previously learned information until it reaches some fairly sophisticated levels. It is well done.

The PC6's floppy disk controller does not require an expansion slot.

A User Diagnostics software package includes the Microsoft system diagnostics familiar to IBM PC users. However, all of the tests are presented via a Diagnostic Shell menu, which is more informative and simpler to use than its IBM counterpart. The package includes tests for both the XP mode and the tape backup subsystem.

DOCUMENTATION

Overall, the NCR documentation is a sincere but flawed effort consisting of three manuals: The *Owner's Manual*, the GW-BASIC manual, and the NCR-DOS manual. The two reference manuals from Microsoft (GW-BASIC and NCR-DOS) present the material in much the same way as the equivalent IBM manuals—if you liked those, you'll like these.

The *Owner's Manual* is the weakest of the three. The first chapter, "Historical Data," is bogged down with leaden prose such as ". . . Data are processed in the CPU. It contains all the arithmetic and logical circuitry in the computer, and often has a component called the Arithmetic and Logic Unit (ALU)."

Chapters 2, 3, and 4 are a little better, but the manual presumes too much technical expertise on the part of the user. Perhaps the documentation writers should have modeled their approach after that used in the Pal and Tutor software. The two high points of this manual are an 18-page

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glossary and an index.

The supplemental installation and operation instructions for the graphic controller and the monitor manage to be terse and cryptic in English, German, French, Italian, and Spanish.

BENCHMARKS

According to the BYTE benchmarks, the PC6 in its standard (4.77 MHz) mode is slightly, but consistently, faster than the IBM PC. When I ran the benchmarks in the XP mode (8 MHz, about 68 percent faster than the PC6's standard clock speed), the system performance increased noticeably.

Typically, the XP mode represented about a 40 percent improvement in performance (i.e., the XP times were only 60 percent of the standard mode times) on the in-memory benchmarks (BASIC Performance and Spreadsheet Recalculate). The differences between the standard and XP modes in the disk-related benchmarks ranged from the sublime (46 percent performance increase for the Disk Write test) to the ridiculous (12 percent performance *decrease* for the File Copy test). See the benchmark graphs for precise times and comparisons.

CONCLUSION

The NCR PC6 is a high-end machine designed for business applications that require performance, reliability, and IBM PC compatibility. Its 20-megabyte hard disk and 10-megabyte tape backup make it a system that is ideally suited for business and professional users.

The PC6's major assets are its dual-speed, IBM PC–compatible system of robust design; its preconfigured fixed disk and tape backup system; and its programmable User Interface, which simplifies interaction with DOS commands.

The PC6's greatest liability is its mediocre documentation. A previous problem, high cost, has already been solved: NCR recently announced significantly lower prices for all three models, which are reflected in this review. Although not the most inexpensive IBM PC compatible around, the PC6 is at least competitive now, especially among the major vendors of compatibles. ■

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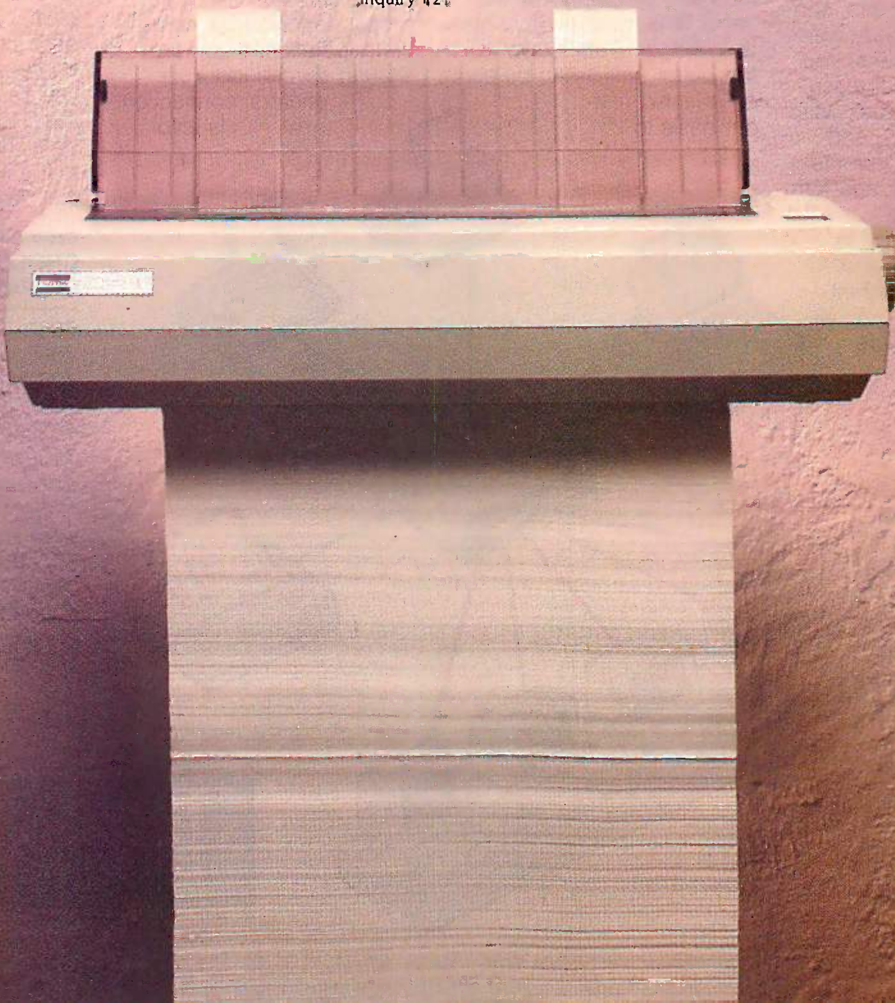

THE SPERRY PC/IT

BY FREDERICK D. DAVIS

A fast, reasonably priced IBM PC AT compatible designed for multiuser applications

The Sperry PC/IT is a reasonably priced IBM PC AT compatible designed for multiuser environments. Like Sperry's previous desktop computer, this new machine is manufactured by Mitsubishi in Japan and offers a significant increase in performance over the machine it emulates. The system also supports more serial ports and has a larger hard disk.

Externally, the IT has one major feature that distinguishes it from the IBM PC AT—a genuine recessed hardware reset button. This reset button works even when the Ctrl-Alt-Del reset interrupt is wiped out.

Inside, there are other differences. The IT's 80286 microprocessor can process data at three different rates. By setting two DIP switches on the main board, you can set the clock speed to either 6 MHz with one wait state, 8 MHz with one wait state, or 7.16 MHz with no wait states (see table 1).

The 7.16-MHz rate is the fastest of the three. Sperry claims that the IT runs 45 percent faster than the IBM PC AT. In the spreadsheet test, however, the Sperry was actually more than twice as fast. The IT also features a socket for an 80287 floating-point processor.

The system has a built-in clock with a rechargeable battery system that keeps the clock powered for about 30 days, even if the system is unplugged from the power outlet. The battery also maintains some CMOS memory that contains system configuration data such as quantity and type of disk drives and memory. [*Editor's note: Unlike the PC AT, a small array of DIP switches sets some of the configuration information.*]

Sperry has provided a total of nine expansion slots, seven of which have AT-style 16-bit data lines, while two have IBM PC–style 8-bit connectors. All board slots are full-length. A double-width slot is taken up by an interface board with two serial ports and one parallel port. The serial ports have male DB-9 connectors, and the parallel port has a female DB-25. After a monitor controller and a hard disk controller are added, six slots are available. [*Editor's note: Sperry reports that some early purchasers had complained that they could not install an internal modem because they could not disable one of the serial ports. The company now says that this problem has been fixed.*]

The IT has one full-height and three half-height slots for mass storage devices. Each drive is designed to slide into its slot on plastic rails mounted on the sides. Installation is quick and easy. There is a 195-watt power supply that should be ample for most needs.

An exhaust fan in the cabinet pulls air into the front of the chassis and through the power supply before exiting. The only problem with this arrangement is that there is no easy way for the air supply to be filtered. All of the dust and other particles in the air get sucked into your computer and deposited on its innards. This is not a desirable situation. The only way to filter the air supply for this machine is to completely enclose at least the front of the chassis with some sort of filtration device.

DISK DRIVES

The hard disk is a fast (30-millisecond average seek time) 44.6-megabyte formatted MiniScribe. You can select 15 different hard disk types from the configuration program. The documentation does not describe these, but it does suggest that other hard disks may be added to the machine in the future.

The IT comes in two standard disk configurations: the basic configuration, which features a single high-density 1200K-byte floppy disk drive, and the enhanced system, which has the single high-density drive together with a 44.6-megabyte hard disk. You can have up to two floppy disks in the IT. They may be any mixture of 360K-

(continued)

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and 1200K-byte floppy disks. The floppy drive controller is built into the main board.

In addition to the disk drives, Sperry offers a 60-megabyte half-height ¼-inch tape drive. The tape drive controller occupies one board slot.

You can also have two hard disks of mixed types in the IT. Each hard disk can occupy either the full-height device slot or two half-height device slots. The tape drive and the floppy drives each occupy one half-height device slot. If the designers had thought things through a little more, they could have included another half-height device slot so that you could have one tape, one floppy disk, and two hard disk drives.

After I finished reviewing the machine, I was told by a Sperry distributor that the new ITs were being shipped with new ROM chips. These chips reportedly speed up disk access by about 5 percent, although I was not able to confirm this.

MEMORY

The main board has room for 1 megabyte of memory. All versions of the IT are shipped with 512K bytes of memory and sockets for another 512K. You can set the second bank of 512K bytes to be used as an additional bank of 128K bytes for a total of 640K bytes available to DOS, or as 512K bytes of extended memory for use as a RAM disk or other 80286 applications. You can install two more boards of 2 megabytes each for a total of 5 megabytes of main memory.

KEYBOARDS

Three Key Tronic–style keyboards are available from Sperry for the IT: a standard IBM PC–style keyboard, an IBM PC AT–style keyboard (called the PC/IT), and the "Professional" keyboard (also called the "PC Enhanced"). I worked only with the PC/IT keyboard (see photo 1). The main distinction of the Professional keyboard was that it had separate cursor and numeric keypads, and the function keys were across the top instead of clustered on the left.

The PC/IT keyboard has the same key placement as the original IBM PC AT keyboard, including the strange placement of the left single quote (') key at the left end of the number row, and the Escape key over the numeric keypad. The Return key is very large, as are both Shift keys. I found the keyboard to be quite comfortable to use, except for the awkward placement of the Escape key.

Table 1: *The effect of clock speed and wait states on processor performance for the Sperry PC/IT. Shown are the times, in seconds, required to finish two BASIC benchmarks—the Sieve of Eratosthenes and Floating-Point Calculations. Note that the 7.16-MHz clock speed without wait states is significantly faster than the speeds that involve wait states.*

Clock speed (MHz)	Wait states	Sieve of Eratosthenes	Floating-point calculations
6	1	67.4	22.0
7.16	0	44.4	14.4
8	1	49.6	16.0

Photo 1: *The PC/IT keyboard for the Sperry PC/IT. Two other keyboards are also available for this system.*

MONITORS

Sperry offers three monitors—monochrome, medium-resolution RGB, and high-resolution RGB. Corresponding monitor adapter boards are also available. These monitors correspond to the IBM PC monochrome, color graphics, and enhanced graphics monitors.

I worked only with the monochrome monitor. It is functionally identical to the IBM monochrome monitor, except that it has a very effective antiglare coating. Also, the phosphors are yellow-green with a moderate consistency. When scrolling, the smearing is not nearly as bad as a lot of the IBM PC–style monitors that I have seen.

Like most IBM PC clones, the display, although readable, is not really crisp. The characters in reverse-video mode are so hard to read that this mode isn't really usable. To me it looks like excessive diffusion causes the bright areas to bleed into the dark areas. When, however, I replaced the Sperry monochrome controller card with an Everex Edge card, the diffusion problem disappeared.

One other available card designed specifically for the Sperry IT is a serial port card with four asynchronous ports for terminals or modems. Two of these cards may be installed for use with the XENIX System V operating system, allowing up to eight

(continued)

Sperry PC/IT

Company
Sperry Corporation
P.O. Box 500
Blue Bell, PA 19424
(800) 547-8362

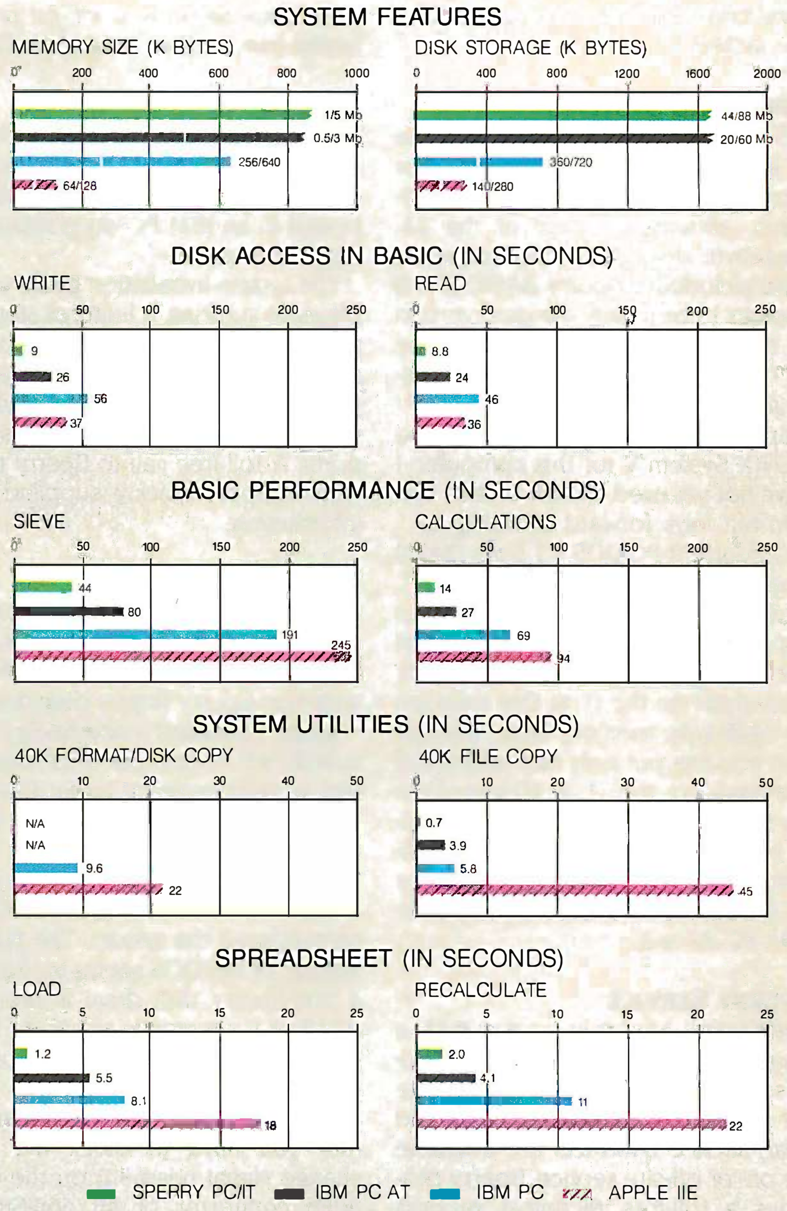
Size
System unit: 22¾ by 17 by 6¾ inches
Monitor: 12 by 11¾ by 11 inches
PC/IT keyboard: 17¾ by 7½ by 1½ inches

Components
Processor: 80286, 16-/16-bit processor; variable clock speed (6, 7.16, or 8 MHz); optional 80287
Memory: 512K bytes or 1 megabyte on main board; 5 megabytes maximum
Mass storage: 1200K-byte 5¼-inch floppy disk drive; 44.6-megabyte hard disk (30-millisecond average seek time)
Display: Choice of IBM PC–style monochrome, medium-resolution RGB, or high-resolution RGB
Keyboard: Choice of IBM PC style, PC/IT (IBM PC AT style), or Professional
Expansion: Additional 1200K-byte ($650) or 360K-byte ($425) floppy disk drive; additional 44.6-megabyte hard disk drive ($1725); 60-megabyte tape drive ($1995); up to eight more serial ports (for XENIX V)
Interfaces: Two serial ports and one parallel port standard

Software
MS-DOS 3.1, Sperry BASIC 3.0

Documentation
BASIC user's guide (469 pages), MS-DOS user's guide (475 pages), system installation guide (186 pages)

Price
Basic system with one 360K-byte floppy disk drive, one 1200K-byte floppy disk drive, one 44-megabyte hard disk drive, monochrome monitor and adapter, color adapter, two serial ports, one parallel port, and system software: $6044



The Memory Size graph shows the standard and optional memory available for the computers under comparison. The Disk Storage graph for the IBM PC AT and the Sperry PC/IT shows the standard hard-disk capacity and the highest disk capacity offered by the manufacturer. For the IBM PC and the Apple IIe, the Disk Storage graph shows floppy disk capacities. The graphs for Disk Access in BASIC show long it takes to write and then read a 64K-byte sequential file to a disk. In the Disk Access tests, a hard disk was used for the Sperry PC/IT and the IBM PC AT; a floppy disk drive was used for the IBM PC and the Apple IIe. (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 File Copy portion of the System Utilities graphs shows how long it takes to copy a 40K-byte file from one part of the hard disk to another, or from one floppy disk to another (for the IBM PC and the Apple IIe). No Disk Copy tests are done on hard disk systems. The Spreadsheet graphs show how long it takes to load and recalculate a 25- by 25-cell spreadsheet where each cell equals 1.001 times the cell to its left. The spreadsheet used was Microsoft's Multiplan. Tests for the Sperry were done with Sperry DOS 3.1 at 7.16 MHz, and tests for the PC AT were done with PC-DOS 3.0 at 6 MHz. The IBM PC used BASICA running under PC-DOS 2.0. The Apple IIe used ProDOS for all tests except the Spreadsheet tests, which were done with Apple DOS 3.3.

additional terminals to be attached to the system.

OPERATING SYSTEMS

MS-DOS version 3.1 comes with the IT. Included is the XDISK program for formatting a second logical DOS partition, allowing full use of the 44-megabyte drive. It has no surprises. Also included is Sperry BASIC 3.0. It appears to be a fairly standard version of Microsoft BASIC 3.0. All of the BYTE benchmarks ran without modification.

Sperry has also chosen to release XENIX System V for this computer. I have not yet used XENIX on this system but look forward to doing so.

Concurrent PC-DOS 4.1 from Digital Research runs quite nicely on the IT, and the machine is fast enough to support several processes running at the same time. Concurrent's major limitations on the IT at this time are its 640K-byte memory limit, the fact that you can put only two additional terminals on the IT, a 40-megabyte hard disk capacity limit, and an inability to access the tape drive. In addition, the IT will not boot Concurrent PC-DOS from the hard disk, while the IBM PC AT will.

SPERRY SERVICE

The Sperry hardware comes with a one-year warranty for carry-in or ship-in service. You can get on-site service for a small additional fee. After one year, service contracts are available for on- or off-site service. Sperry provides a toll-free technical support number. The people with whom I spoke seemed knowledgeable and willing to dispense information.

One slight problem with Sperry's service policy concerns non-Sperry parts. According to a warning in the manual, all non-Sperry parts in computers sent in for service "will be deemed by Sperry to have been discarded by the customer." This implied confiscation policy for non-Sperry parts is not realistic in a market where hundreds of makers and marketers of the same or similar hardware exist. Perhaps it needs only to be reworded to come across with a more benign intent. [*Editor's note: A spokesperson for Sperry stated that despite the warning in the manual, non-Sperry parts will not be confiscated from machines being serviced.*]

DOCUMENTATION

Three manuals are included with the system—BASIC, MS-DOS, and the system installation guide. All manuals are bound in an IBM PC–style slipcased three-ring binder.

The system installation guide was a pleasant surprise. It features step-by-step instructions for setting up the system and installing options. The major omission in this manual was the pin-out diagram of the 9-pin serial ports. A toll-free call to Sperry technical support quickly supplied this information.

COMPATIBILITY

All of the IBM PC software that I tried with the system seemed to work, but I did notice a curious incompatibility with non-Sperry floppy disk drives.

When I installed a non-Sperry Mitsubishi 501 floppy disk drive, the system worked perfectly under Concurrent PC-DOS. Under MS-DOS, however, both the Sperry and the non-Sperry drives became inaccessible and remained so until I rebooted and reconfigured the system. The Sperry version of MS-DOS seems to check if a non-Sperry disk drive is present, and if so, it apparently erases the floppy disk drive configuration information stored in CMOS memory.

From Sperry distributors, I learned that you have to block the disk change signal (lead 34) on the card edge connector of all non-Sperry drives. I did so with a small piece of tape, and my Mitsubishi drive worked perfectly. Unfortunately, the disk change signal is used occasionally by the Concurrent PC-DOS operating system. I find it most curious that Sperry's version of MS-DOS seems to go to such lengths to discourage the use of non-Sperry disk drives.

I experienced a couple of minor problems with the high-density floppy disk drive. Most of the time it was able to read a 360K-byte formatted disk. However, several 360K-byte disks formatted on an Eagle and written by a CompuPro could not be read on the high-density drive under either operating system, although they were readable with the 360K-byte drive on the Sperry IT. I also experienced several disk read/write errors on brand new high-density floppy disks that had formatted without error on two different ITs.

COMMENTS

Even at the system's fastest speed (7.16 MHz with no wait states), I found the keyboard auto-repeat to be too slow. (Fortunately, as with the IBM PC AT, there are short public domain programs to speed this up.)

As a whole, the benchmarks were fast. From BYTE's benchmarks and some benchmarks of my own, I found that both system- and disk-intensive tasks run significantly (460 percent) faster compared to a standard IBM PC XT–type machine.

Some factors of perceived speed don't show up in BYTE's benchmarks, however. For example, when I use WordStar on most systems, I find the wait for the overlays to be annoying. On the IT's hard disk, there was no perceptible delay. Another factor is how fast the screens come up. The IT has the fastest screens I have ever seen, even with screens completely full of text.

One minor annoyance concerns the system enclosure. It sometimes tends to resonate noisily with the hard disk drive. I had to use a small amount of padding to tighten up the fit.

CONCLUSIONS

I enjoyed working with the Sperry IT. Its drawbacks are primarily those shared by most IBM PC compatibles. Its benefits, however, far outweigh its weaknesses. It is a very fast computer for one person to use, and if half a dozen average processes were running on it concurrently, each task would have at least the performance level present on the IBM PC.

In the past, users had to buy the more expensive high-performance micros to adequately run multiuser programs for the MP/M-86 and Concurrent DOS environments. In many cases, the Sperry IT with Concurrent PC-DOS can now fill the bill. It's nice to find a machine designed with the multiuser environment in mind at a reasonable price. ■

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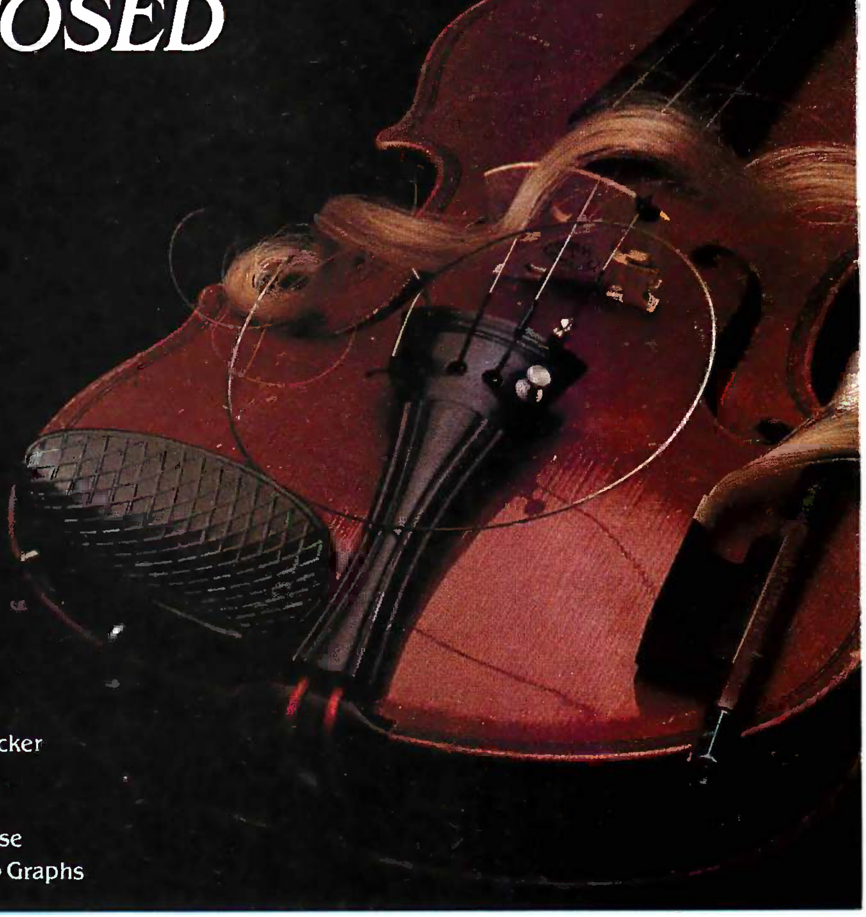

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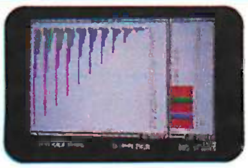

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Inquiry 326

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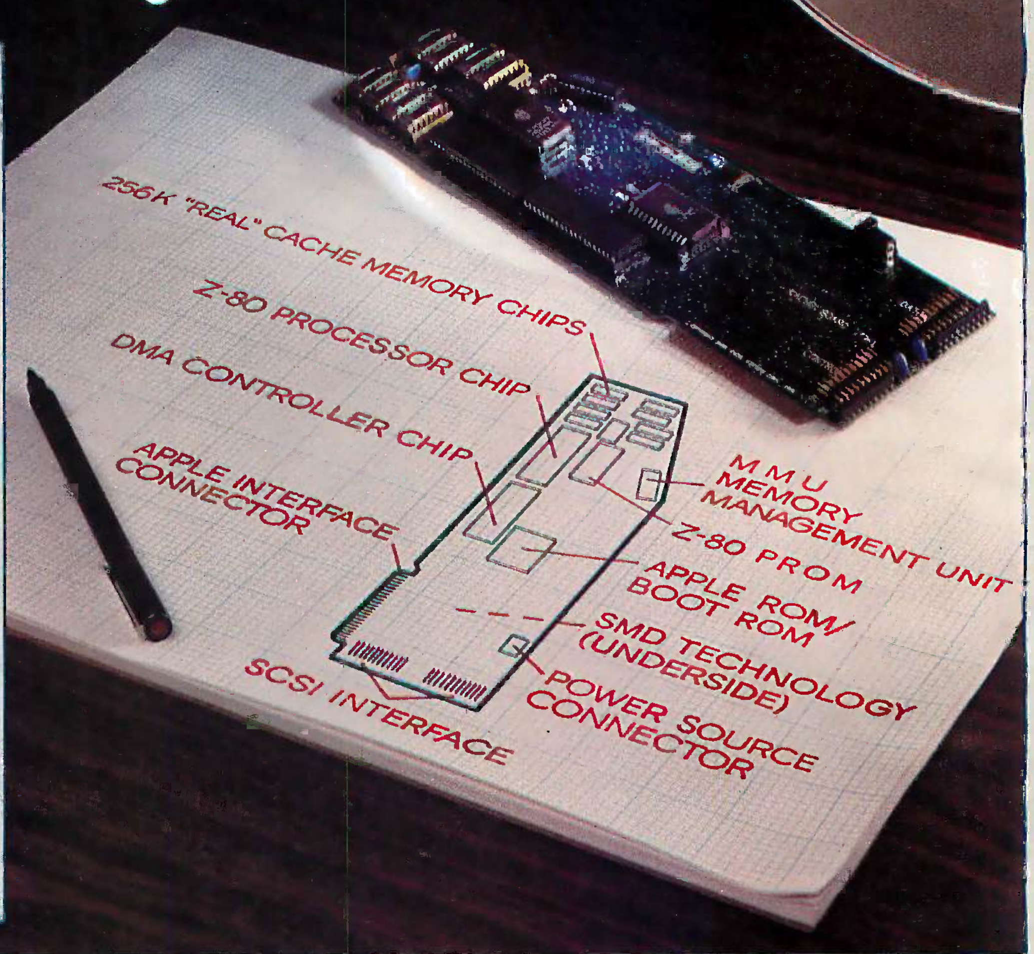

FEATURES

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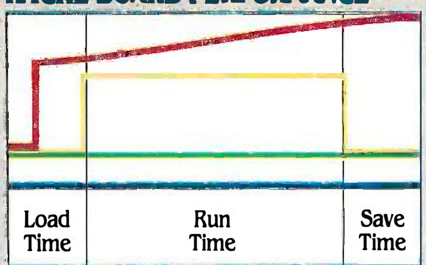

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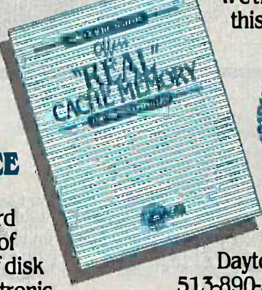

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Inquiry 210

DeSmet C Development Package for the Macintosh

BY JONATHAN ROBIE

A fast, low-cost C compiler with several strengths and a few significant flaws

The DeSmet C Development Package for the Macintosh, a compiler that costs only $150, produces faster and more compact code than most C compilers for the Macintosh. It also compiles faster, has a good programming environment, and gives good support for the ROM Toolbox. Although this compiler by C Ware Corporation has many strengths, it also has a few significant flaws, which I will examine.

USING DESMET C

DeSmet C operates with a UNIX-like shell that makes program development on the Macintosh similar to working in UNIX or on an IBM PC. There are no windows, no desk accessories, and no icons. The mouse is not even active. The shell is not flashy or fancy, but it is fast and responsive and eliminates the long waits that you would normally expect from the Macintosh. The text editor is similar to UNIX's vi and nearly identical to DeSmet's editor for the IBM PC.

The DeSmet C compiler also comes with a RAM disk. This RAM disk works only on a Macintosh with at least 512K bytes of RAM. It is installed by typing the command ramdisk in the shell or by clicking the RAM disk icon from the Finder. This opens a window that allows you to specify the disk drive number, unit number, and capacity. A set of files can automatically be loaded into the RAM disk at boot-up, and the RAM disk can be selected as the boot disk. This eliminates most of the disk swapping that is so common on the Macintosh and makes it feasible to use the compiler with only one disk drive if you have at least 512K bytes of RAM. Since the disk drives and the Finder are both very slow, you will find that the combination of the DeSmet shell and the RAM disk speeds up work on the Macintosh immensely.

BENCHMARKS

I used the same benchmarks that were used by Tim Field in "Five C Compilers for the Macintosh" (November 1985 BYTE). These benchmarks are described and justified in that article. Table 1 gives the benchmark results and code sizes found by Tim Field, along with those for the DeSmet C compiler. [*Editor's note: New benchmark sizes and times are also provided for Consulair's Mac C, version 4.0.*]

When no register variables are used, DeSmet C is the fastest (or one of the fastest) in the benchmarks that measure loop overhead (FRAME), efficiency of pointers (POINTER), function calls with passed parameters (QSORT), and integer arithmetic (INTMATH). DeSmet C was also the fastest for the SIEVE benchmark, which primarily tests array and integer math operations. Aztec C was slightly faster for the FIB and INTERFACE benchmarks, which measure function calls and the speed of calls to Macintosh ROM. For the benchmark that tests floating-point arithmetic (FLOAT), the Aztec C and Mac C compilers were significantly faster than DeSmet C, which came in third place. DeSmet C produced the smallest programs in every case except the QSORT benchmark. In this case, the program is significantly larger than that produced by Megamax C, but it is still smaller than the programs produced by the other compilers.

I used two additional benchmarks to test the speed of file I/O and to further explore performance on floating-point operations. Since I did not have the other compilers, I ran these benchmarks only on DeSmet C and Aztec C. The FILEIO benchmark tests the speed of file I/O by creating a 65,000-byte file and performing various reading and writing operations at random locations in the file. There was not much difference between the two compilers for this benchmark. The Savage benchmark (*Dr. Dobb's Journal*, September 1983, page 120) tests both speed and accuracy of transcendental floating-point functions. DeSmet C was significantly faster than Aztec C for this test, but it performed with slightly less accuracy. The correct output should be 250.00, and neither compiler was off by more than one part in 10 million. [*Editor's note: Mac C was quicker and more accurate than either of the other compilers. See table 1.*]

Overall, the DeSmet C compiler is clearly one of the fastest, and it generally has the most compact code. DeSmet C does not have register variables, however, and the Megamax C

(continued)

Jonathan Robie (P.O. Box 26121, Lansing, MI 48909) is finishing his master's degree in computer science and beginning doctoral work in cognitive psychology at Michigan State University.

and Aztec C compilers generally outperform DeSmet C when register variables are used (the register keyword is accepted, but a technician at C Ware informed me that it has no effect on register allocation). I wonder how fast these programs would run if DeSmet C supported register variables.

Compiling and linking are painfully slow with most Macintosh C compilers, but Tim Field found that these operations were much faster with Aztec C. I compared DeSmet C to Aztec C by compiling the SIEVE program with each. I used the RAM disk that comes with each compiler to hold the compiler, assembler, linker, and libraries, and all temporary files were processed on the RAM disk. The object file was written to the internal drive. Compile time was 11.79 seconds for the DeSmet C compiler and 12.56 seconds for Aztec C. Link time was 15.18 seconds for DeSmet C and 17.47 seconds for Aztec C. The total time required to compile and link was 30.03 seconds for Aztec C and 26.97 for DeSmet C, which means that DeSmet C is roughly 10 percent faster for this program.

Table 1: *The results of the benchmark tests and the sizes of the execution files produced.*

Execution Times
(in seconds)

	DeSmet C	Aztec C*	Megamax C*	Mac C	Softworks C*	Hippo-C*
FRAME						
Normal	0.10	0.10	0.10	0.13	0.13	0.25
Register	n.a.	0.05	0.05	n.a.	0.08	n.a.
POINTER						
Normal	20.40	25.50	30.02	31.71	24.33	33.23
Register	n.a.	13.15	18.93	n.a.	11.15	n.a.
INTMATH						
Normal	4.66	5.03	5.05	15.06	30.05	15.93
Register	n.a.	2.70	2.78	n.a.	26.73	n.a.
SIEVE						
Normal	6.08	6.20	6.20	7.80	8.83	12.65
Register	n.a.	3.88	4.17	n.a.	4.73	n.a.
QSORT						
Normal	11.46	68.43	93.38	13.28	157.08	test failed
Register	n.a.	50.87	70.80	n.a.	93.72	n.a.
FLOAT						
Normal	330.55	268.22	334.32	268.90	332.77	n.a.
FIB						
Normal	24.78	24.72	25.97	32.68	28.60	47.22
INTERFACE						
Normal	58.50	56.22	72.00	71.41	59.18	78.47

File Sizes
(in bytes for "normal" [non-register] runs)

	DeSmet C	Aztec C*	Megamax C*	Mac C	Softworks C*	Hippo-C*
FRAME	5792	8537	6544	12,800	32,000	20,992
POINTER	5860	8571	6586	12,800	32,000	21,044
INTMATH	6312	9109	7128	13,312	32,512	21,948
SIEVE	5866	16,897	6768	12,800	40,448	21,318
QSORT	10,356	13,113	7226	13,312	36,608	test failed
FLOAT	6208	9205	7256	13,312	32,256	n.a.
FIB	6016	8751	6810	12,800	32,256	21,304
INTERFACE	5976	8697	6700	12,800	32,256	21,230

Additional Benchmarks
(execution times in minutes:seconds)

	DeSmet C	Aztec C	Mac C
FILEIO	7:46	7:53	9:29
SAVAGE			
Speed	4:04	5:53	3:41
Result	249.999949691499	249.999999968363	250.000000000000

*These times are from Tim Field's November 1985 BYTE article.

FEATURES

The ROM Toolbox interface is well designed and makes calls to the Toolbox quite simple. Since C and Pascal have slightly different data structures and pass their parameters differently, you normally have to use different arguments when calling Toolbox routines from C. Since the documentation for the Toolbox is written with Pascal examples, this can be rather inconvenient. In DeSmet C, all conversions are done automatically before the ROM routine is accessed. Because the Toolbox calls are the same as in Pascal, you can use the formats found in *Inside Macintosh* without changing them. These routines are stored in a file called maclib.s, which you must link with your object code to produce a stand-alone application.

The compiler accepts variable names composed of up to 31 letters, making it easy to write readable code. It also allows in-line assembly code. This lets you rewrite time-critical sections of code in assembly language, perhaps retaining the original C source as comments.

DeSmet C uses a small memory model that limits you to 32K bytes of static data. Up to 32K bytes of additional data may be allocated by each called procedure. If you need larger blocks of data, you must allocate them on the heap. Each code segment is also limited to 32K bytes, but you can have up to 32 code segments in your program by using a flag at link time. Segments can be unloaded at run time with a function called unloadseg( ). This can be very helpful for writing code to run on the 128K Macintosh.

BUGS AND SHORTCOMINGS

The main problem with the DeSmet C compiler is its failure to support

(continued)


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logical devices or I/O redirection. Logical devices are reserved filenames that actually refer to devices. This allows you, for example, to access the printer as though it were an output file. Because this compiler does not support logical devices, there is no straightforward way to send output directly to the printer. There is a program called PR included with the package, which prints a text file so you can spool output to a file on disk and then chain to PR to print the file. You could also write your own printer output routines from the PR source code, which is included. A second, minor shortcoming of DeSmet C is that macro substitution does not occur within quoted strings.

I found three bugs in the libraries—two in the Macintosh library and one in a math routine. I was surprised to find that OpenPicture returned an integer rather than a pointer, an error flagged by the compiler. I found that this function was correctly declared in Quickdraw.h, but this declaration and 16 others were removed using #if 0/#endif statements. A call to C Ware tech support revealed that a prerelease version of the compiler did not have an intelligent linker, and these definitions were removed to keep program size down. You can correct this problem by deleting the #if 0/#endif lines from Quickdraw.h. The second bug is more obscure: When I ran the INTERFACE benchmark under the shell, the system crashed. The same program ran flawlessly under the Finder. I was unable to find the source of this bug. The third bug is in the pow( ) routine. There is a global variable called errno, which is used to flag errors in math routines. When an overflow occurs in pow( ), this variable is not flagged. Dividing by zero also fails to set this flag.

THE SHELL

The shell is a command interpreter that is similar to both the UNIX shell and the shell provided with the Aztec C compiler. Using the shell is much like using the operating systems on most computers—if you type the name of a program, then the program runs; if you type a command, then the command is carried out. If you are familiar with UNIX or MS-DOS, you will probably learn the shell's commands without much effort. However, you will most likely be annoyed by the fact that the shell, like the compiler, does not support logical device names or I/O redirection. PR is used to print files. Files are typed to the screen using the command more, which operates like the more command in UNIX; the first screen of the file is displayed, and the file scrolls up one line every time you hit the Return key. I find this less convenient than the more command in MS-DOS. The shell does not support subdirectories.

The DeSmet shell completely replaces the Finder and speeds up file access considerably. The Finder was not designed to make programming efficient, but to make the Macintosh easier to use. Since the shell is fast, flexible, and designed for programming, it is a much more suitable development environment than the Finder.

A series of shell commands can be put in a file (called a "script") and executed by typing the name of the file (like a .BAT file in MS-DOS). If a script is named .profile, then it will be executed whenever the shell is first booted. Scripts can take up to nine parameters, and the script can be aborted if errors occur on any command. The mod operator determines when a file was last modified and allows the programmer to write a make script, which will compile only those source files that have been modified since the last compilation.

The DeSmet shell also allows command logging, a feature found in many UNIX shells, but not in the Aztec shell. When you are logging commands, they are saved in a log file. To execute one of these commands again, you merely type enough characters to distinguish it from all the other commands. This is extremely convenient. When a C program is compiled or linked, several files may be specified, and several flags may be set. Since the development cycle typically involves compiling the same files repeatedly with the same files and flags, command logging greatly reduces the amount of typing needed. For instance, if you link a file using the command b68 foo.o 1:local.o 2:maclib.s, then you can repeat that command by simply typing the command !b6.

The Macintosh desk accessories are not available from the shell, and I wish some of them were there. When I program, I like to keep notes and error logs, and I find the Notepad and Scrapbook useful. I also miss the Alarm Clock. These capabilities have

(continued)

made programs like SideKick very popular, and they could easily have been included. Version 1.06F of the Aztec C compiler lets you add desk accessories to the shell by using a resource mover, but it is almost impossible to put all of the necessary files on the default drive and still have room on the disk for the Notepad and Scrapbook. I don't miss the Macintosh Calculator much; simple computations can be done from the shell using the eval statement. This statement, when followed by an arithmetic expression, gives the result in decimal, hexadecimal, and character formats. This is much more useful than the Calculator for programming. The eval statement does not support floating-point operations, however.

THE EDITOR

DeSmet C's editor, See, is a modal editor that is similar to the vi editor found on UNIX systems. The commands of See are much easier to remember than those of vi, however, because of well-chosen names. To make it even easier, a list of the commands is always displayed on the top line of the screen while you are in the text editor.

The Macintosh implementation of See is extremely similar to the IBM PC version (both of which were written by Michael Ouye). It uses the mouse for cursor positioning but also recognizes WordStar-like key combinations for moving the cursor (command-E moves the cursor up, command-X moves it down, etc.). I found See to be simple, graceful, fast, and powerful.

DOCUMENTATION

The manual for the DeSmet C compiler is brief, clear, and extremely helpful. It comes in one IBM-style notebook binder. There is no index, but the table of contents is very detailed and the documentation is well organized, so I was usually able to find specific sections of the manual quickly. An index would have made the documentation easier to use.

The manual describes important technical details that are often left unexplained in other manuals. For instance, the rules for extern declarations are described clearly and thoroughly, and the memory-model and calling conventions are carefully explained. All error messages are listed in an appendix at the end of the manual, with separate sections of messages for shell, editor, compiler, assembler, binder (linker), library, and CLIST. I like this arrangement; with *all* the error messages listed near the end of the manual, it is always easy to find them.

The "Macintosh interface" section of the manual is particularly valuable. Each part describes one portion of the Macintosh interface (e.g., QuickDraw, the Event Manager, and the Resource Manager) and contains a "getting started" section that tells the basics of how to use it and gives the code for a simple example. If you are new to programming the Macintosh, you will find these "getting started" sections a good way to learn. Nowhere in *Inside Macintosh* do you find such clear explanations. As I flipped through this section of the manual, I had vivid memories of the large amounts of time I had to spend learning how to program my Macintosh. This documentation probably would have saved me a great deal of time. C Ware claims that over 450 functions are supported by DeSmet C, but only a portion of these are documented in the manual. The manual suggests that you refer to *Inside Macintosh* for documentation on the remaining functions.

CONCLUSIONS

The DeSmet C Development Package for the Macintosh is a useful product with some major flaws and omissions. If future versions correct these problems, this could become the best C compiler available for the Macintosh. The UNIX-like shell is very responsive, the editor is powerful and easy to use, and the compiler produces code that is fast and compact. The Toolbox library makes access to the Macintosh ROM routines straightforward. The manual is clear and readable. In addition to these other features, it is the most inexpensive C compiler available for the Macintosh. Unfortunately, logical devices and I/O redirection have not been implemented, and there is no straightforward support for the printer. ■

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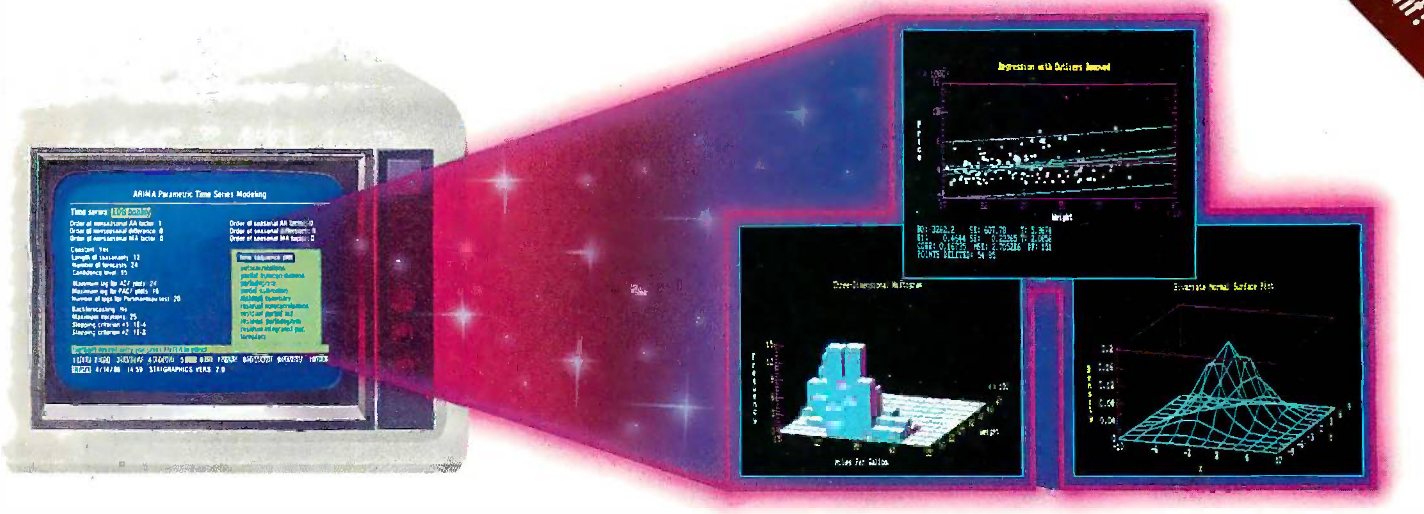

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TOPSI 2.0

BY LEONARD MOSKOWITZ

An implementation of OPS5 written in Turbo Pascal for MS-DOS computers

TOPSI 2.0, from Dynamic Master Systems (DMS), is an MS-DOS version of the OPS5 production system language. OPS5 is often used to write rule-based expert systems. Until recently, OPS5 was available only on large, expensive computers. However, TOPSI is written in Turbo Pascal for the IBM PC and compatibles and is a faithful implementation of OPS5, but with some critical differences.

USING TOPSI

When booting TOPSI, your system-configuration file, CONFIG.SYS, must contain the line device = ANSI.SYS to make your IBM PC act like an ANSI terminal. DMS doesn't tell you this in the documentation, however. After I added this line to my configuration file and booted, TOPSI came up clean. DMS does supply a terminal installation program that lets you define a new terminal if yours is not standard ANSI.

When you enter the command TOPSI, you get a right-arrow prompt meaning that you are at the top, or command, level. You can enter productions directly at the top level, which lets you edit your production systems from within the interpreter—a very useful capability. The alternative is to exit to an editor, modify the system, and then reenter OPS5.

At the top-level prompt, TOPSI expects a command in the form of a list, that is, enclosed in parentheses. TOPSI accepts a free-form entry format, so if you type an open parenthesis and press Return, it knows that the command hasn't been properly terminated. However, if you type an unrecognizable command, TOPSI accepts it, ignores it, and gives no error indication. TOPSI will give short, informative error messages, however, if you enter a known command with incorrect syntax.

You can load a production system directly from the MS-DOS command line. If you enter TOPSI *filename* (where *filename* is the name of a TOPSI production system file), TOPSI loads and runs the desired file, bypassing the top level. Since the productions are evaluated as they are read in, any comments in the source file are ignored.

TOPSI can also save a production system to a file. You can save just the productions, the productions and the contents of the working memory, or a memory image of both (which speeds up the loading process).

Typing (help) at the top level accesses TOPSI's Help file. The entire file is displayed screen by screen, and you can stop the display when you find the information you need. Although you can't ask for help on a particular topic, it's still a helpful feature.

TOPSI doesn't expand horizontal tabs when entering productions from the top level. This makes formatting the productions a little tedious. Normally, however, you would write the productions using a text editor and then load them into TOPSI via the (load) command, bypassing this difficulty. TOPSI formats your productions when you view them via the (pm) command.

BENCHMARKS

OPS5 is not a normal procedural language; therefore, the standard benchmarks don't apply, because it's unlikely that you would ever use OPS5 for numerical computation and because OPS5 programs are not expected to run in any particular order. A better procedure might be to measure TOPSI's performance under conditions known to stress it. I regularly use OPS5 on a Symbolics 3670 LISP workstation, and OPS5 for VAX version 1.0 on a VAX-11/785. Since these are strong OPS5 implementations, I have used them as comparisons for TOPSI. A good measure of OPS5's execution speed is the average number of productions it fires, or allows to act, per second.

One of OPS5's best features is its efficient pattern matcher, called the Rete algorithm. Because of it, OPS5's execution speed is relatively insensitive to the number of productions in a system. However, TOPSI doesn't use the Rete algorithm. DMS thought that the IBM PC didn't support enough memory to implement a full Rete network and so traded speed (which the Rete network would have provided) and memory to get a workable version of OPS5 on the IBM PC.

The first benchmark I ran (see figure 1) tested execution speed for a one-production system that matches one working-memory element and modifies it. Since both working memory and production memory remain small (one element each), there is only one instantiation—a production matched with a working-memory element that

(continued)

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TOPSI 2.0

Type
Programming language

Company
Dynamic Master Systems Inc.
P.O. Box 566456
Atlanta, GA 30356
(404) 565-0771

Format
5¼-inch MS-DOS floppy disk

Computer
MS-DOS or compatible (128K bytes of RAM minimum); CP/M-80; UNIX/C

Necessary Software
MS-DOS; source code and Turbo Pascal required to implement external procedures

Languages
Executable code; source code available in Turbo Pascal

Documentation
72-page user's manual; 48-page *Technical Reference Manual* included with purchase of source code

Price
$175; source code version is $400 complete

Audience
Those with an interest in artificial intelligence application programming

Comments
Three sample programs, a short tutorial, and a debug example are included; a Lattice C version for MS-DOS is also available

satisfies it—in the conflict set. Since there are only constants in the production and working memory, this could be considered a "best-case" test.

The second benchmark (see figure 2) was also a one-production system. It, too, matched a single working-memory element, but instead of modifying the element, it made a new one. As long as the number of productions stays low (benchmark 2 has only one), and you use only constants in the productions and working memory, this should also be a best-case test. It checks how fast the conflict set is built and resolved.

These two benchmarks provide a measure of efficiency for two of OPS5's fundamental operations—manipulating the working memory and building or resolving the conflict set. For versions that implement the Rete algorithm, both benchmarks should execute at speeds much higher than a typical expert system. All the versions had the trace mechanisms shut down (watch was set to zero and no breakpoints were active). The number of rule firings was controlled by the (run *x*) command, where *x* was the desired number of iterations.

I ran the TOPSI benchmark tests on two IBM PCs running PC-DOS 2.1. One had a full complement of memory (640K bytes). The other had only 192K bytes of memory. The results were identical. TOPSI uses the additional memory only to accommodate more productions. DMS estimates that a 256K-byte IBM PC can support close to 1000 productions. The VAX tests were run using OPS5 for VAX version 1.0 with a single user on an 11/785 in a 2000-block working set. The Symbolics tests were run on a Symbolics 3670 with 4 megabytes of memory. I used the OPS5 supplied with Verac Inc.'s OPS5e package running under version 5.2 of the Symbolics LISP system. OPS5 was run directly from a LISP Listener, avoiding the OPS5e user-interface enhancements. The garbage collector was disabled.

The results of the benchmarks are shown in table 1. Since the first benchmark is essentially a best-case test, the execution speeds are very high—much higher than you would normally see. TOPSI ran approximately 40 to 50 firings per second. The VAX ran between 300 and 400 firings per second, and the Symbolics ran approximately 400 to 500 firings per second.

In the second benchmark, the speed ratio maintained its roughly two- or three-to-one comparison between the Symbolics and the VAX, but TOPSI's performance dropped off dramatically. TOPSI started well, running about 5 firings per second for the first 50 working elements. After I added 100 elements to working memory, however, TOPSI was down to about 3 firings per second. By 200 elements, it was down to little more than 1 firing per second, and by 400, TOPSI took roughly 3 seconds for every 2 firings. Each time I doubled the number of working-memory elements, the execution time went up by a factor of four.

Since TOPSI does not use the Rete algorithm, the second benchmark is close to a "worst-case" example. TOPSI builds the conflict set dynamically, and in this benchmark every working-memory element is in the conflict set. This means that TOPSI would do only about 1 firing every 2 seconds when under a heavy load. I've tried some medium-size production systems of about 100 productions each, and this seems to be correct.

```
Enter this production into production memory:

(p one-wme
    (yes)                    ;match a "yes" in working memory
-->
    (modify 1 yes))          ;modify it to "yes"

From the top level, enter these commands:

(make yes)
(run x)

where "x" is the number of firings you desire.
```

Figure 1: *Benchmark 1: production and top-level commands. This benchmark tests execution speed for a one-production system that matches and modifies one working-memory element.*

Extensions

By far, TOPSI's most useful extension to OPS5 is that the compute action, normally available only on the right-hand side, can be used within a left-hand-side condition element. This extends the range of elements that you can match against.

Another new feature is the (find *variable term*) clause. It returns a variable bound to the position within a working-memory element where a particular term is found. You can then test this variable with the logical operators.

The top-level (print *argument*) lets you copy program output that goes to the console screen to a printer or other logical device. This is useful during program debugging and for documentation purposes.

DMS provides some debugging commands that let you examine locations in memory and display certain key addresses within the TOPSI system.

NONSTANDARD FEATURES

TOPSI has one major difference from OPS5 that you must take into consideration if you plan to port programs between dissimilar machines. In OPS5, the two conflict-resolution strategies keep a history of each rule that has been fired and the working-memory elements that satisfied it (an instantiation). The history ensures that no instantiation fires more than once. OPS5 keeps a history that goes back to the first firing. TOPSI, on the other hand, keeps a history that is only one firing deep. Therefore, you must explicitly account for the removal of instantiations from the conflict set if you don't want them to fire unexpectedly. This incompatibility means that you can move TOPSI production systems to OPS5 and they will run as is; however, you can't port OPS5 to TOPSI as easily.

Second, TOPSI doesn't like nil as a class name or as an atomic working-memory element. If you use nil this way, you will confuse the conflict resolver, and the production that matches the nil will stay in the conflict set forever. In general, you shouldn't use keywords as production or variable names. The rest of TOPSI's differences from standard OPS5 syntax are minor. For comparison, on the VAX, medium-size production systems run between 5 and 12 firings per second.

TOPSI lets you delete single elements from working memory via the (remove *argument*) command, where *argument* is the time tag of the element. There is no way to delete multiple working-memory elements from the top level, although you may delete multiple elements from the right-hand side of productions. TOPSI does not have the equivalent of the OPS5 (remove *) command, which removes all elements from working memory.

TOPSI also lacks two functions that standard OPS5 requires: (rjust), which right-justifies output, and (literal), which lets you assign a particular index to an attribute. TOPSI does have a command called (literal), but that's TOPSI's version of the (literalize) command. (TOPSI lets you rename keywords, so this is not really an incompatibility.)

You can move TOPSI production systems to OPS5 and they will run as is, but you can't port OPS5 to TOPSI as easily.

TOPSI's interface to external func-

(continued)

Table 1: *The benchmark results. Both benchmarks are best-case tests for implementations using the Rete algorithm. Benchmark 2 turns out to be nearly a worst-case test for TOPSI. (The – symbol means "too small to measure.")*

Benchmark 1 (in seconds)

Number of firings	TOPSI (IBM PC)	OPS5 for VAX version 1.0 (VAX-11/785)	OPS5 (Symbolics 3670)
1000	21	3	2 to 3
10000	208	29	20

Benchmark 2 (in seconds)

Number of firings	TOPSI (IBM PC)	OPS5 for VAX version 1.0 (VAX-11/785)	OPS5 (Symbolics 3670)
50	9	–	–
100	36	–	–
200	146	–	–
400	581	1	<1
1000	not measured	4	1 to 2
2000	not measured	11	3
4000	not measured	38	6

Enter this production into production memory:

```
(p many-wme
    (yes)                 ;match a "yes" in working memory
-->
    (make yes))           ;make a new wme
```

From the top level, enter these commands:

```
(make yes)
(run x)
```

where "*x*" is the number of firings you desire.

Figure 2: *Benchmark 2: production and top-level commands. This benchmark tests execution speed for a one-production system that matches one working-memory element and then makes a new one.*

If you plan to use external procedures, familiarity with Turbo Pascal would be a definite plus.

tions and procedures is generally nonstandard. The (call) function passes arguments directly, while standard OPS5 does not. The $ functions, which OPS5 provides to interface with external functions and procedures, are included when you buy TOPSI source code.

The file-access functions are also nonstandard. The TOPSI (openfile) action opens files for both input and output. The OPS5 version of these commands requires that you specify the allowable file operations.

In TOPSI, you must use the (default) action to map a file to an input or output action. OPS5 allows its file input and output functions—(accept), (acceptline), and (write)—either to access the default file (set via the (default) command) or to directly specify a file. TOPSI uses the default file for input and output. This means that you must reassign input and output via a (default) command if you want to switch files.

Documentation and Support

The TOPSI package includes the executable code on a floppy disk and in the user's manual. The manual includes a review of OPS5 fundamentals, a short step-by-step tutorial to get you started, a concise description of all the commands, and an example of the development and debugging of a short TOPSI program. All the basic functions of the tutorial worked well; it is a good learning aid. The manual is complete and well written in a pleasant conversational style, but it's no substitute for a textbook. If you haven't used OPS5 before, I recommend *Programming Expert Systems in OPS5* by Lee Brownston et al. (Addison-Wesley, 1985).

Since TOPSI is written in Turbo Pascal, you'll need to buy the TOPSI source code if you want to reference external functions or procedures from within your TOPSI programs. Turbo Pascal doesn't compile to linkable modules but instead compiles directly to executable code. Therefore, you must have all source code available at compilation time.

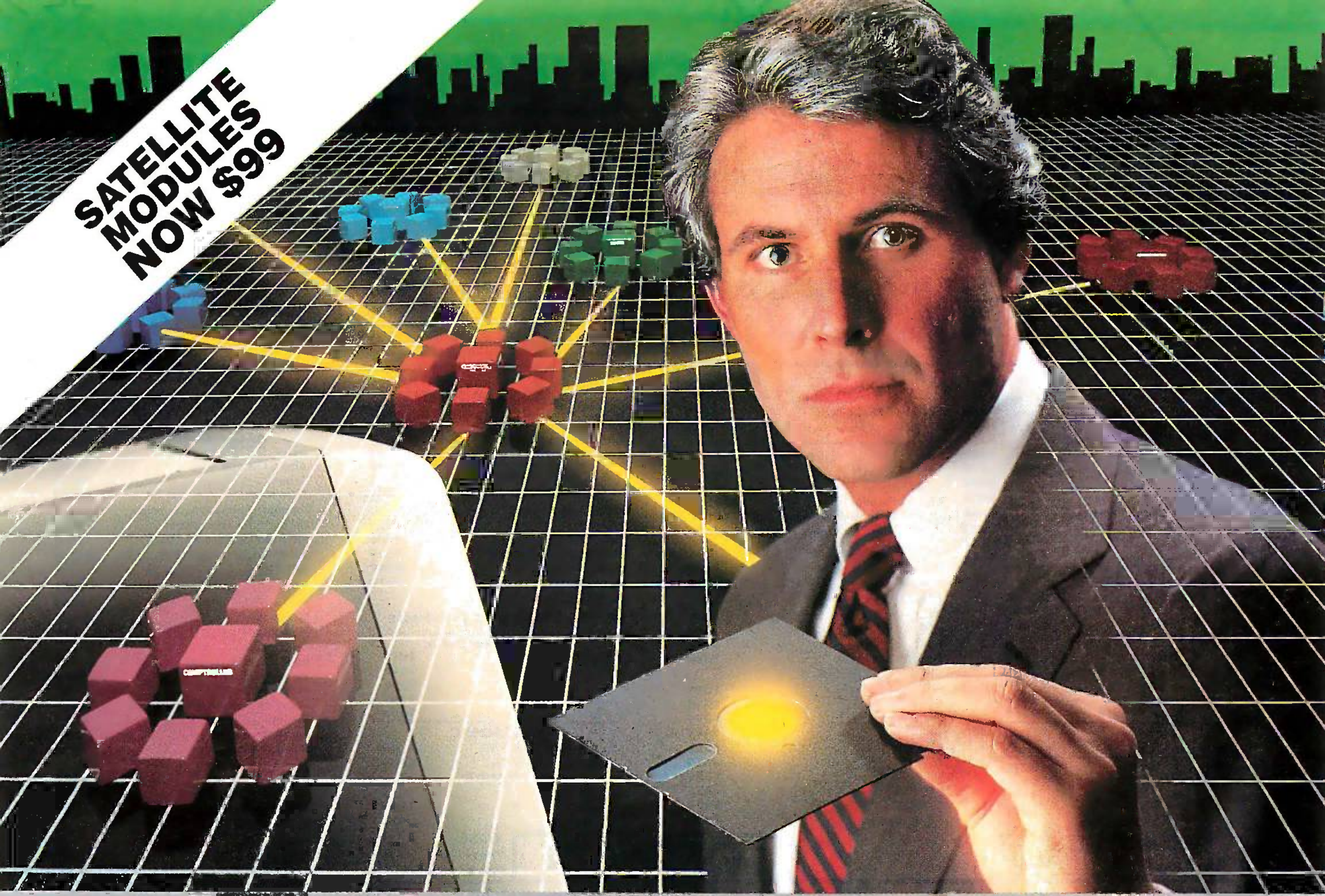
The TOPSI source code package includes a copy of DMS's *Technical Reference Manual* and a second disk containing the source code and some interface procedures. The *Technical Reference Manual* explains in detail how to modify TOPSI's source code to add user-defined subroutines and functions. It also describes the major program modules and data structures and has listings of the interface and floating-point math functions that DMS provides. Like the user's guide, it is well written, but a bit more technical. If you plan to use external procedures, some familiarity with Turbo Pascal would be a definite plus.

DMS is a two-person operation, consisting of David M. Smith and his wife, Julie. Their responses to my questions and problems were quick and courteous. If you should find a problem with TOPSI, DMS will provide the first update free of charge if you are a registered user. Subsequent updates will be provided at a nominal fee. For $10, DMS also offers a TOPSI user library.

Conclusions

TOPSI is a real implementation of OPS5 for microcomputers. All the core functions are there. Its incompatibilities with standard OPS5, once known, can be dealt with. While it is slow compared to the versions of OPS5 that run on more powerful computers, it should be adequate for many applications. Interfacing TOPSI to external procedures requires that you buy source code. The interfacing is not simple and requires familiarity with Turbo Pascal.

TOPSI is very reasonably priced. It can be used both as a serious programming tool and as a learning aid to introduce programmers to expert systems and artificial intelligence techniques. ■



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LET'S C AND CSD

BY WILLIAM G. WONG

An inexpensive C development package and a symbolic debugger

Let's C is a $75 package of development programs from the Mark Williams Company that includes a screen editor, a full-blown C compiler, an 8086/88 assembler, and a linker. A powerful C symbolic debugger, csd, is available for an additional $75. This is quite a collection for such a low price.

DOCUMENTATION

Let's C comes with two manuals: one covering the compiler and all the associated utilities, and the other dedicated to the text editor, MicroEMACS. Both are well organized with a good table of contents and index. Examples are quite sparse, however, especially in the description of the support library functions. The compiler manual is written with typical UNIX-style terseness.

The MicroEMACS manual layout is totally different. It is designed as a tutorial rather than a reference manual. Examples are plentiful, and sections are grouped by function. Unfortunately, there is no associated reference section except for an alphabetical listing of functions at the end; a simple functional list would have sufficed. Overall, the documentation is good, and most information is easily accessible. Sometimes, however, it takes a bit of digging through the manuals to answer a question or to see if an option exists.

MICROEMACS

You could use another line- or screen-oriented text editor in place of MicroEMACS, but since MicroEMACS is such a nice program you will probably decide that you want to use it. Because MicroEMACS is a memory-based editor, there is a limit to the file size it can handle. Fortunately, C's modularity keeps this from becoming much of a problem.

MicroEMACS is written in C and the source code for it is provided in the Let's C package, which makes it possible to modify and enhance the editor. The source code contains useful comments.

MicroEMACS supports windowed screen operation and multiple files. Windows provide views of different portions of the same file or views of different files altogether. Text can be moved between files. Command repetition and limited macro capabilities are supported. The limited number of functions makes it relatively easy to memorize most of the commands. (MicroEMACS's ancestor, EMACS, cannot make the same claim; it has significantly more options and operating modes.)

You enter commands with Control or Escape sequences. Multikey sequences are preceded by the Escape key or a Control-X (in the EMACS tradition). Commands tend to be mnemonic: Control-F moves forward one character, and Control-B moves backward one character.

MicroEMACS does have some quirks, but fortunately they can be fixed by using the ANSI.SYS driver file. This file is supplied with many MS-DOS systems and is usually included with PC-DOS. The source code for MicroEMACS comes in very handy, since you may have to make minor modifications if it does not work properly with your system.

I found that reading MicroEMACS source code uncovers some features of the editor that are not described in the manual. For example, I discovered that I could use the Escape sequence in place of Control-@ (which made my keyboard generate something else) to set the "mark," which is a point to start a block operation like copy or delete.

While recompiling the editor, I was disconcerted to find that certain functions used in the editor do not follow strict C procedures. Although the compiler flagged the offending functions, the resulting code still worked. (The reason for this is that the compiler generates only 16-bit pointers due to the small memory model.) Don't try to use another compiler or memory model without checking all flagged errors, or the program may not run at all.

Rebuilding the editor on a hard disk takes less than half an hour if you start from scratch. It is possible to rebuild it on a floppy disk system, but it is much more time-consuming.

LET'S C COMPILER

The Let's C compiler is very complete; it includes standard C function libraries as well as a math library with floating-point support for trigonometric functions. It is a four-pass compiler (including the preprocessor) and you can automatically invoke the linker.

The most striking feature is the large number of options supported by the compiler and various utilities. The compiler itself has over 30 command-line options, including various ways to customize the compiler and redirect-

(continued)

William G. Wong (Logic Fusion Inc., 1333 Moon Dr., Yardley, PA 19067) is president of Logic Fusion Inc. and a developer of systems and applications software.

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able I/O, which is also available to application programs created with Let's C. For example, you can use DOS commands to put control text into the DOS environment. You can also set which drive will be used for work files or #include files so that this information does not have to be repeated on the command line.

The command-line options are very powerful and are designed to make creation of multiple modules easy. For example, cc -o all *.c compiles all the C source code in the current directory (all files with a .C extension) and links them into the file ALL.EXE, including the standard C library. You can use multiple source files and wild cards to generate complex systems.

In addition to supporting the language as defined by Kernighan and Ritchie, the Let's C compiler also supports a number of extensions, including enumerated data types. Floating-point numbers may be single or double precision, but since floating-point numbers are stored in the DEC/VAX format, Let's C provides no 8087 support. (The more expensive version of the Let's C compiler allows you to select the IEEE format for storing floating-point numbers.)

Let's C also supports structure assignment, parameters, and return values. This feature can be turned off using the appropriate compiler option.

Dedicated registers are available for one or two variables by using the C "register" specification. These register variables can hold 8- or 16-bit integers and pointers. Let's C uses the SI and DI registers to manipulate register variables. It may be appropriate to use the register specification often, as the compiler always saves and restores the SI and DI registers even if no register variables are specified. The overhead is four instructions and four bytes of code per function. A more sophisticated compiler would save and restore these registers only if they were used.

The library of C functions is very complete with support of stream files (files using the fopen( ) function) and system-level files (files using the open( ) function). Standard DOS functions such as file rename and execution of another DOS program are supported, but these are nonstandard and usually nonportable functions. There are a few missing items from the Let's C libraries, the major one being the lack of access to the DOS routines for setting and reading the current time and date. Functions for accessing these routines are described in the manual but are not in the library, and the appropriate #include files are missing.

Let's C supports direct access to I/O ports, 8086 interrupts, and memory via peek and poke functions. Options in the peek and poke functions allow you to access the full 8086 address space. This provides a way to address memory beyond the 64K-byte limit set on small memory model programs (without having to purchase the more expensive version of the compiler), but it is not as efficient as access via the large memory model. This also makes Let's C appropriate for generating memory-resident programs.

The linker supports only the Mark Williams Company's object code and library formats. This restricts your ability to use object modules generated by another assembler or C compiler, but since Let's C comes with its own assembler, this may not be a problem for many users.

UTILITIES

The utilities that come with Let's C can be divided into two sets: compiler support utilities and general utilities for text-file manipulation. Each is described individually in the documentation. The compiler support utilities include

as	the assembler
cpp	the C preprocessor
lb	a library utility program
ld	the linker
nm	prints an object module's symbol table
size	prints sizes of program segments
strip	removes the symbol table from an object module

The general support utilities include

cmp	compares two files, character by character, for equality
egrep	searches a file for a specific pattern (string)
pr	paginates and prints files
tail	prints a selected number of bytes at the end of a file
wc	counts the occurrences of specific words in a file

The Let's C assembler supports the 8086 instruction set, while the more advanced version adds 8087 support. Macros are not supported by the assembler, but since the C preprocessor, cpp, can be used independently of the compiler, you can simulate a macro assembler by using C-style macros in your source code and executing cpp to expand the macros prior to assembly. Batch files make this a snap. Simulating a macro assembler also allows you to use a single macro syntax with both the compiler and the assembler.

The library utility can create and update library files that are compatible with the linker. Although the Let's C compiler can generate only small memory model programs, the linker and the assembler can also handle larger programs. Consequently, you can create assembler support modules that allow Let's C programs

(continued)

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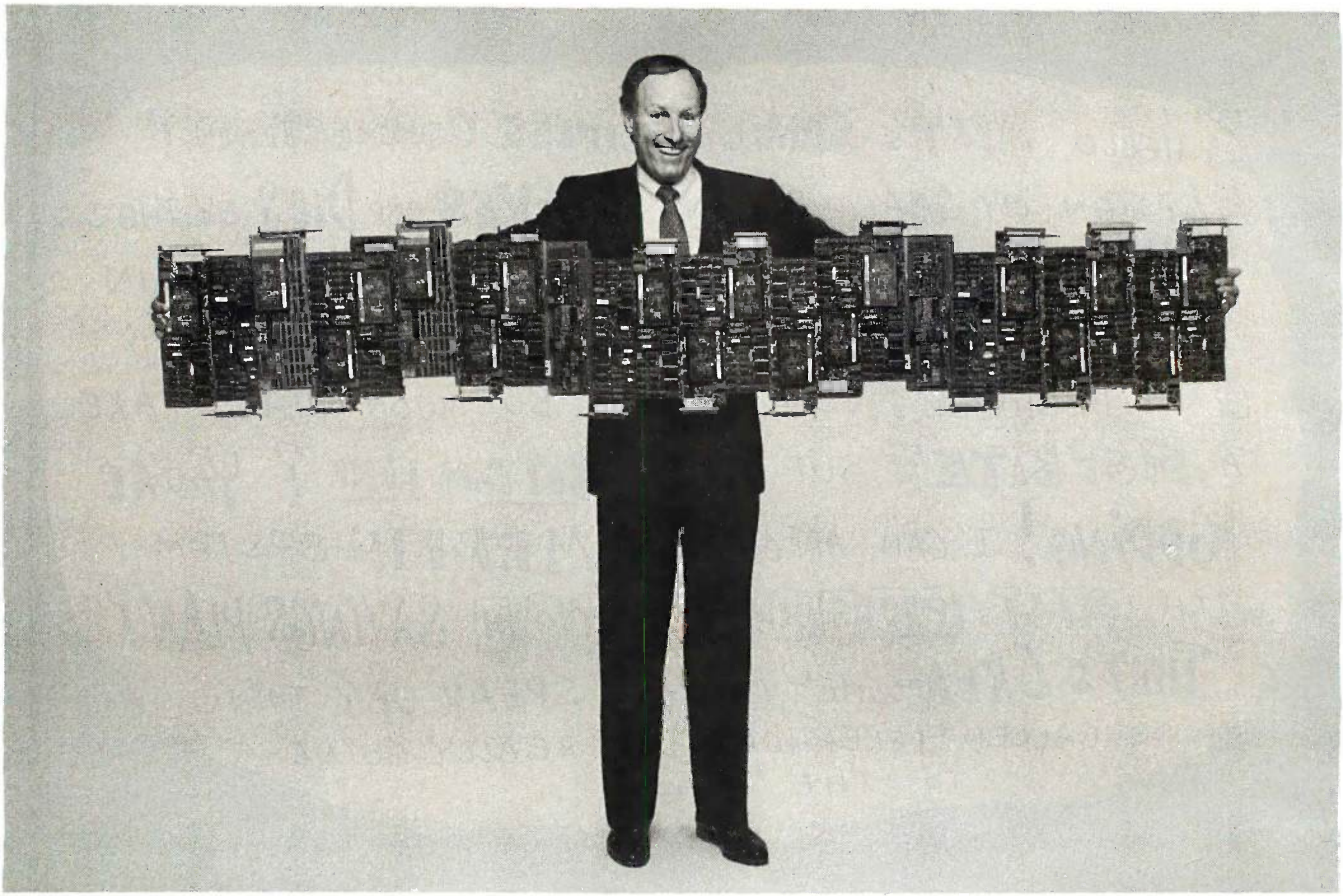

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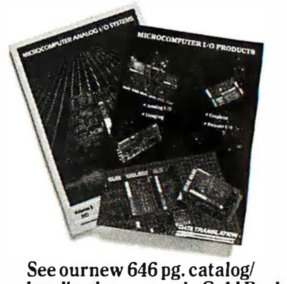

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to access memory areas beyond the 64K-byte small memory model limit.

The linker generates executable .EXE files using object modules from the compiler or the assembler. The linker supports a large number of options for segment placement, size, and program construction. Overlays are not supported. The linker does allow for command files, which makes the process of invoking the linker much easier, but there are no command-file parameters like those provided by the DOS batch facility. Hence, a link command file is required for each program being linked.

The list of symbols contained in an object module is obtained using the nm utility. You can generate modules without symbols, or you can remove an object module's symbol table using the strip utility.

CSD

The csd symbolic debugging tool is customized for the IBM PC. It provides multiple windows for viewing source code, debugging history, interactive evaluation, and program output. You can set breakpoints and perform single-stepping at the C statement level instead of at the machine instruction level. You can also examine or modify variables during the debugging process, referencing them by name rather than by address. Even strings and floating-point values are accessible in their "human-readable" form instead of as clumps of hexadecimal digits.

To set a breakpoint (referred to as a "tracepoint" in the manual), you simply move the cursor using the arrow keys and select the line of C code using the F3 function key.

You can also move up and down the stack, discovering which function called which other function. When you are at a particular "level" (or stack frame), csd displays the source code for that particular function and you can examine and change variables and breakpoints unique to the function.

Interaction is very quick, with most operations requiring only one or two keystrokes. The evaluation window allows you to enter and execute most C expressions, including calling user- and library-defined functions. It does not allow evaluation of expressions with C keywords (except sizeof), braces (compound statements), labels, or semicolons (multiple statements). Nor will it evaluate expressions containing such control constructs as case, for, if, and break.

The evaluation window also performs another useful function. Each statement left in the evaluation window is executed when a traced C statement is evaluated. This allows complex debugging information to be presented. However, leaving improper statements in the window can be a problem. For example, leaving an assignment statement to a loop's control variable in the window while tracing the loop can cause the loop to repeat indefinitely. Accidental setup

(continued)

The symbolic debugger is a definite aid to learning C and an indispensable tool for program development.

of such a situation can require some debugging of the debugger state, but it might be useful if the best way to test the loop is to keep it going until a problem is solved.

With a few exceptions, csd is close to the ideal debugging environment. Dealing with a program at the source level is a definite plus, and being able to display and alter the status of the program alleviates the need to put explicit debugging code into the program. However, csd does have some drawbacks, especially for more sophisticated users. For example, csd only works with programs compiled by the Mark Williams C compiler, or with programs that use the small memory model (the only kind available in the Let's C package). In addition, csd works only with PC-DOS or MS-DOS on strict IBM PC compatibles, and keyboard compatibility is especially important.

Although working at the source level is very useful, it is occasionally desirable to see things at the machine-code level. This is especially true when the program interacts with the operating system or hardware. You can access memory locations and hardware ports using csd, but the process is often tedious. (You can, however, write C functions to make this easier.) Dumping areas such as the stack or data structures is often useful when debugging.

Note that csd keeps most information resident in memory, which speeds up overall operation. An exception is the Help text for the program. This may be a limitation for large programs on small systems, but I did not encounter any such problems while using the system.

SYSTEM PERFORMANCE

As expected, the benchmarks show Let's C to be faster than interpretive BASIC in all categories, with integer- and character-based operations showing the largest speed differential and disk operations showing the smallest (see table 1).

Compile and link times compare favorably with other C compilers, and the size of the executable files is typically smaller. Of course, one big reason for their small size is the fact that only small memory model programs can be generated with Let's C.

The Sieve benchmark was done using various data types and specifications for the flag array used by the algorithm. This results in a significant difference in the execution time, but it is negligible in terms of program size. [*Editor's note: The source code for the benchmark programs used is available for downloading from* BYTEnet Listings *at* (617) 861-9764. *All the programs have been combined into a single file,* LETS.SRC.]

Note that the default stack size, 2K bytes, was altered for the Sieve test when the flag array was local to the function, since automatic structures are allocated from the stack. Placement of the flag array at the end of the variable definitions makes a difference, since the size of the offsets changes for the other variables if they occur after the array.

SUMMARY

Let's C is an inexpensive, high-quality programming package. It comes with all the tools you will need to create applications; there is no need to purchase an editor or other development software. Let's C also provides a good environment for learning the C programming language.

The drawbacks include the lack of 8087 and IEEE floating-point support, which would have provided a better interface to data files generated by other programs. The lack of overlay support can also restrict applications, but the ability to execute other DOS programs from a C program alleviates some problems. Probably the biggest flaw of Let's C is the lack of time and date support.

The symbolic debugger, csd, is a definite aid to learning C and an indispensable tool for program development. It would be nice to be able to run csd on non–IBM PC compatibles, however. Also, low-level access similar to other debugging programs would help. The use of function keys and windows greatly enhances the development process.

The growth path to the more advanced Mark Williams C compiler is a real plus, because it allows generation of large applications. This upward compatibility means that programs developed with Let's C can grow. It also adds an extra degree of transportability, as Mark Williams C compilers are available for processors such as the 68000 and the Z8000.

In general, Let's C and csd are appropriate for developing small memory model programs or for learning C. For the price, they are hard to beat. ■

Table 1: *Benchmark results. The benchmark programs were run on a dual-floppy* IBM PC XT *with* 640K *bytes of* RAM. *Times are in seconds.*

Program	Compile and Link (hard disk/floppy disk)	Execution	Size (bytes)
SIEVE.C	50/95		7336
LOCAL int	—	7.3	
LOCAL char	—	6.2	
GLOBAL int	—	6.7	
GLOBAL char	—	5.1	
CALC.C	51/110	20	10860
Write Test	45/94	31	7336
Read Test	45/94	30	7288

NEWWORD 3

BY JOHN HEILBORN AND NANCI REEL

An impressive word processor that is notably faster than any of its previous versions

When we reviewed NewWord 1.43 (February 1985 BYTE), we found it to be an affordable and versatile word-processing program. Compatible with WordStar, the earlier version of NewWord operated very much like WordStar while eliminating many of its drawbacks and adding a number of useful features, including an "unerase" buffer and several column-mode functions.

A quick look at NewStar Software's latest version of NewWord, called NewWord 3, shows that it retains all of its predecessor's strengths. In addition, it has an in-text math calculator, enhanced customization menus, both an integrated and a stand-alone spelling checker, programmable key macros, and computer-aided index and table of contents generation. It is accompanied by a hefty but well-organized and clearly written manual.

INSTALLATION

NewWord 3 comes with two installation programs, NWINSTAL and NW-CHANGE. NWINSTAL is a simple program that allows you to select a minimum of features, such as your printer type, video-display type, and whether you want to have on-screen underlining or not. For more in-depth customization, you'll need to use NW-CHANGE, which gives you access to some of the more advanced customizing features of NewWord 3 under a menu called Patches.

KEYBOARD MACROS

The shorthand (keyboard macros) function allows you to create and save custom character strings. These are then invoked with a two-character string, consisting of the Escape key and one other key. NewWord 3 comes with six preprogrammed shorthand macros: display/change a macro definition, display shorthand help menu, display result of last math calculation, display result of last math calculation formatted in dollars and cents, display last mathematical equation, and display today's date (from system clock).

In addition to the preprogrammed macros, NewWord can store 36 custom macros. These are initially limited to a total of 512K bytes (435K bytes without the preprogrammed macros). If you need more space, you can modify the size of the macro buffer with NWCHANGE.

ON-SCREEN CALCULATOR

NewWord features an on-screen calculator, which is called the Math Menu. The Math Menu allows you to perform arithmetic, logarithmic, and trigonometric calculations. For users who already have a memory-resident calculator, this may not seem like a very important feature. However, NewWord 3 lets you "drop" the equation and its result into your text with only a couple of keystrokes. Additionally, NewWord can total rows, columns, or arrays of numbers that have been entered into documents, in much the same way that you would mark and move a block of text.

SPELLING CHECKERS

NewWord 3 has two ways to check spelling: a built-in spelling checker and an external spell-checking utility called The Word Plus. Both spelling checkers use the same dictionaries and can therefore be expected to find the same types of errors, but for longer documents The Word Plus is faster.

NewWord 3's built-in spelling checker goes through your document and presents you with any misspelled or unfamiliar words, along with enough of the surrounding text to place the words in context. It also makes suggestions about possible replacement words. A real timesaving feature included in the spelling checker is its auto-alignment feature. Instead of requiring you to go back through the document after checking for spelling errors to ensure that paragraphs remain formatted properly, text is automatically re-aligned after each replacement. If you don't like this feature, you can easily turn it off. The built-in spelling checker can also be used to check the spelling of a single word.

The on-line spelling checker can look up a word that is not in a document. In this case, you can manually type either all or part of a word. If you enter only part of a word, you may use wild-card characters within the word. Once a match has been found in one of the dictionaries, you can enter the match into the document at the cursor.

NewWord 3 uses three dictionaries—the Quick Dictionary, the Main Dictionary, and the Update Dictionary. The Quick Dictionary contains a list of the most commonly used words. This dictionary is loaded into memory when the program starts, and NewWord looks here first to find a word.

(continued)

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If it finds a match, it does not check the longer Main Dictionary, which contains about 45,000 words. If your computer has enough memory and you use the spelling checker on a regular basis, you can load the Main Dictionary into RAM. The program will start up a bit more slowly, but checking spelling during the rest of your work session will be considerably faster, since accessing RAM is less time-consuming than accessing a disk.

NewWord's Update Dictionary stores words that you add to the dictionary yourself. They aren't added directly to the Main Dictionary, since this dictionary is compressed to get as many words as possible into the smallest amount of disk space.

INDEXING

NewWord 3's Index routine has three ways of constructing an index: it can index all words in a document, all words in a document except those words on an exclusion list, or just the words and phrases that you specify.

The exclusion-list method uses a standard list that is included with NewWord, which eliminates common words such as articles, pronouns, prepositions, conjunctions, and so on. You can also build your own custom exclusion list if you want to exclude additional words.

TABLE OF CONTENTS

With its computer-aided table of contents generation, NewWord can build a table of contents for a document. To use this feature, you go through the document and insert special dot commands in the appropriate places within the text. For example, the command .tc Introduction ..... # will replace the # with the correct page number in the table of contents after the page number is found in the document. You can also create subentries to be indented under a major heading, such as the title of a chapter:

.tc Introduction .... #
.tc   About This Book .... #

The .tc dot commands can also include print control commands. It is also possible to build several tables of contents for one document. If, for example, your document consists of several chapters of a book, you can create a table of contents for the entire book and separate figure and illustration tables all at once.

NEW EDITING COMMANDS

In addition to the global commands covered thus far, NewWord 3 has a number of new editing commands that aid in the process of entering text. Some are WordStar commands that NewWord 1.43 lacked, such as setting and finding block markers and continuous downward and upward scrolling. Other commands add features that WordStar doesn't offer, such as running DOS commands while editing a document, converting all characters in a block to uppercase or lowercase, calculating the number of characters that precede the cursor in a document, and previewing the document as it will print.

MERGE PRINTING

The merge-printing functions included in NewWord 3 may be its most powerful new features. These functions allow you to manipulate text automatically using conditional commands, variables, and numeric controls. To give you an idea of what could be done, let's examine a situation in which you have created a number of individual statements for each sale made to several different customers. By using the appropriate merge-printing commands, you could combine all of the individual statements and produce a single billing statement for each customer. NewWord would create the forms, fill in the names and addresses, and total all of the figures, including taxes and service charges, automatically.

SUMMARY

NewWord 3 is noticeably faster than any of its previous versions, which were all quite fast (see table 1). With its speed, its ability to be customized, and its variety of new editing features, NewWord 3 is a very impressive word processor that is definitely worth consideration. ■

Table 1: *The results of performing various functions using a 4000-word text file. Document Load shows the time required to load the file from disk to memory. Document Save shows how long it takes to save the file to disk. Search shows the time it takes to find the last word in the file, starting at the beginning. Scroll shows how long it takes to scroll through the file manually. Note that Document Save takes 14 seconds with the cursor at the top of the document, but only 3 seconds with the cursor at the bottom of the document.*

Comparison of benchmark results on the IBM PC (in seconds)

Test	NewWord 3	NewWord 1.43	WordStar 3.3
Document Load	3.4	19.8	9.9
Document Save			
cursor at top of document	14.0	23.2	24.9
cursor at bottom of document	3.4	n.a.	n.a.
Search	9.3	10.8	10.5
Scroll	48.0	81.5	41.2

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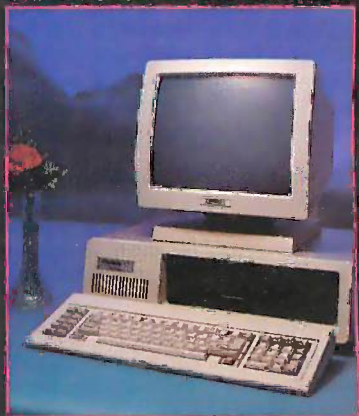

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REFLEX

BY RUSEL DEMARIA

An analytical database that has many unique features for interpreting data

Reflex, from Borland International, is a database that gives you five different "views" of your information—Form View, List View, Graph View, Crosstab View, and Report View. To let you control these views, Reflex employs elements of both the Lotus 1-2-3 and the Apple Macintosh user interfaces. It lets you use the slash (/) key to open the top line of a menu, and then it opens Mac-like windows from the top line choices. Reflex can be controlled by either the keyboard or a mouse, and the commands are consistent throughout the program.

FORM VIEW

The Form View, the most standard aspect of Reflex, is where you begin. To define a field, you simply type its name on the Form design screen. After you exit the design phase, the first data entered into that field automatically defines the data type, or "field"—Text, Numeric, or Date. You can move fields within a form at any time, and you can add or delete fields, or even change the field type.

Reflex has a total of six different fields: the three noted above (Text, Numeric, and Date) and the Repeating Text, Integer, and Calculated fields. The Repeating Text field is much like a normal Text field, except that it conserves memory by saving each repeating value only once. By redefining one field in a test database to Repeating Text, I was able to save 31K bytes of memory in a file.

The Integer field is a memory-saving device. You can define any whole number that falls between −32,766 and 32,767 as an Integer field instead of a Numeric field. By doing this, I was able to save 6K bytes of memory in my test database.

The Calculated field lets you enter formulas that manipulate data in other fields. When Reflex comes across a Calculated field, it goes to the fields designated by the formula, retrieves the data necessary to perform the calculation, and enters the result in the Calulated field.

Reflex offers several data input shortcuts. By far the most useful is the context-sensitive Choices key (the F10 key). You can use it whenever you need to select a field name (even while defining a formula), a filename from the disk, or one of the summary and analytical formula options. After pressing F10, you select your choice by highlighting it with the cursor keys or with the mouse, or by typing the first letter of its name.

Reflex also lets you perform sophisticated "what if" analysis. The Vary tool lets you create a set of records by varying the values in a field. For instance, if you wanted to test a product's pricing, you could create a series of records that varied the price from $50 to $100 in $5 increments. You can also use Vary for break-even analysis. If you vary a text field using a list of choices, the program will create a record for each choice. You can vary a single record or all the records in the current filter. You can even use Vary when you first set up a database, for instance, to create a record for each month of the year or for each division of a company.

LIST VIEW

The List View is a tabular listing of your records, with a column for each field and a row for each record. In the List View, you can set column widths, move or delete entire rows or columns, and add or modify records.

Like the other Reflex views, the List View lets you sort your records to any level and change the sort precedence at any time. You can also filter a database using AND, OR, NOT, or any standard mathematical operator, such as <, >, or > =.

GRAPH VIEW

Reflex offers the standard graph types (bar, pie, line, and scatter graphs) and makes them incredibly easy to create. The graphs can have both titles and legends, and the program generates legends automatically. The Summary and For Each options add exceptional power to the Graph View. Summary options include Sum, Count, Minimum, Maximum, Average, Standard Deviation, and Variance. You can change your graph to show one of these calculations with the touch of a key.

Because Reflex can split the screen into two or three windows, the Graph View can share a screen with the Form View or the List View. The live connection between the windows is remarkable. For instance, if you change data in one window, it immediately changes in the other windows, including the Graph View. In addition, if you move along the points of a graph, the records associated with those points appear in the Form View and are highlighted in the List View. Thus, if you see an especially low or high spot on a graph, it is easy to move the cursor to that spot and

(continued)

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Reflex

Type
Analytical database

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Borland International Inc.
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Comments
Can hold up to 32,500 records in memory. New version supports up to 250 fields per record (254 characters per field).

simultaneously view the record that caused it.

The For Each option brings information into sharp focus. Suppose you have invoices for five salespeople, and there are ten products in your product line. You could easily graph each salesperson's total sales using the Sum option. Using For Each, you could show separate information for each product or for each month. If a graph is much larger than the screen or the current window, it will scroll.

CROSSTAB VIEW

The Crosstab View is, in some ways, the heart of the Reflex system. It lets you create an overall view of your data the same way that a graph does, but in a numeric rather than a graphical summary. Reflex will calculate totals, averages, counts, variances, standard deviations, minimums, or maximums on whatever portion of the data you choose. It then displays the results in a chart that you can use to find any hidden relationships and significant figures.

In the earlier example, we looked at a graphical representation of each salesperson's total sales for each product. The Crosstab View can show us the same data in figures. To set up this example, you would summarize total sales for each salesperson and for each product. The result would be a grid with the salespeople's names on one axis and the product names on the other. At a glance, you would see total and individual sales statistics by salesperson and by product.

REPORT VIEW

The Report View is a separate program that performs several functions. You can convert Lotus 1-2-3, Symphony, dBASE II or III, DIF, PFS, or ASCII text files to Reflex's format. You can convert entire files or parts of files, or take a random sampling from any of these files. You can merge two separate Reflex databases into one, provided that both files contain the same field definitions. You can print graphs previously saved on the main Reflex program. You can also design sophisticated reports of all kinds, from mailing labels to complex data analyses containing up to five break conditions.

One drawback to the Report View is that you can't run it from within Reflex; you must exit to DOS and run the Report View separately. Nevertheless, it is a useful utility that is worth the extra effort.

Designing reports is easy and powerful. It uses the same commands and menus used in other parts of Reflex. The design form is very flexible and versatile. You can sort your file within the Report View and use up to five sorted fields as special break fields. You can move entire fields, define variable widths, and set summaries and percentages. You can also define new calculated fields and use logical operators such as IF. . .THEN, CASE, and CHOOSE. In addition, you can format and align data easily by copying, inserting, and deleting separate entries or entire lines.

OTHER FEATURES

The Preview feature lets you view your report on screen at any time. Because some reports might contain extensive and complex break conditions and summarizations, the Preview feature is a valuable one. A very helpful feature of the Report View lets you display actual data from the file in place of the filenames. You can actually scroll through your data this way, looking at what will appear in the report.

You can also design reports and print them out to a file. Reflex offers several different delimiters that allow you to export files back to other programs, such as Lotus 1-2-3 or Symphony. Unfortunately, Reflex lacks the ability to export directly to these files, so you will have to retranslate the files from within the target application.

The most recent version of Reflex requires a high-resolution graphics, EGA, or Hercules-type monochrome screen. With the EGA screen, you get roughly twice as many usable lines per screen. For example, with the List View I got 26 lines of data, as opposed to 13 lines with a standard color card. Reflex does not support color. [*Editor's note: You can add color to the program by using a public domain program called* GCOLOR.COM, *which is available in a variety of formats. See page* 405 *for details.*]

Reflex keeps its working file in memory. By merging files, you can create a larger file than the available memory can hold. You can work on parts of files by using the Partial Retrieve feature and by specifying a range, conditional formula, or random sample. Reflex also supports expanded-memory cards that use the Lotus/Intel/Microsoft standard. When you check the status of the program, in addition to total versus available conventional memory and number of records in the database and in the current filter, you will get a total versus available memory reading for any acceptable expanded memory.

SUMMARY

Reflex has a few weaknesses—its inability to export directly back to other programs, its lack of a direct link to the Report View, and its lack of macros. However, Relfex is loaded with unique features that you can use to cut, slice, and dissect data to bring out the hidden meanings within it. ■

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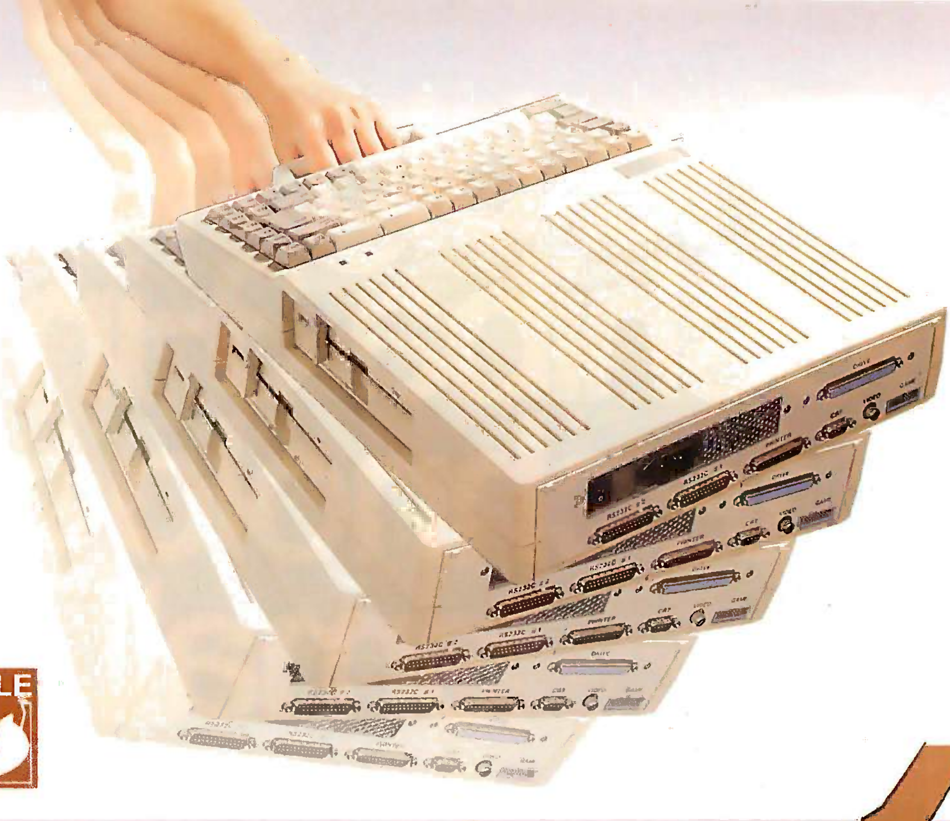

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GURU

BY ERNEST R. TELLO

A complete, integrated software package that includes an expert-system shell

Guru, from Micro Data Base Systems (MDBS), is an integrated software package that includes a spreadsheet, a database, and other business applications, as well as an expert system and a natural-language interface. The expert system offers both a forward and a backward chainer, reasoning with uncertainty, full interaction with the spreadsheet and database, and the ability to execute any command or program. There is also an SQL-like query language (like the one included with KnowledgeMan, another product from MDBS), as well as graphics, communications, and a text processor. Written partly in C and partly in assembly language, Guru runs exceptionally fast for a system that does so much.

PROGRAMMING LANGUAGE

In many respects, the procedural programming language in the Guru environment surpasses those available in dBASE III, Symphony, and Framework. The Guru language has a full range of control and conditional keywords for programming conditional branches and iterative loops, and it supports arrays in two dimensions. There is a macro command that allows you to extend the language interactively to add new commands to the system, as with LISP and FORTH. Guru also has a release command that allows you to free memory by selectively "undefining" macros.

The macro command is greatly limited in comparison to those of FORTH and LISP, since it is unable to write macros that take arguments. It can only be used to write subroutines that operate on named variables, and values have to be assigned to the variables before calling the macro command. In spite of this limitation, however, the macros are very useful and powerful.

The root command in Guru is a surprisingly powerful equation solver. It assigns the root of a given equation in one variable as a value to whatever variable name you specify, with a tolerance range for possible root values. Tolerance ranges are essential for equations that have more than one root. If several roots exist within the specified range, root only supplies one of them. The tighter the range specified, the less work root has to do, and the less time it takes. A particularly good use of this function is solving problems where there is a formula for finding the coefficients of a more complex set of equations, such as in the quadratic formula, or in the characteristic equation for third-order differential equations. Generally, root is capable of handling N-degree polynomials in a single variable, as well as equations involving trigonometric functions.

The perform . . . return combination lets you execute any Guru program in the current directory as a subroutine and then return to the program or macro that called it to continue processing instructions. Programmers will find Guru's ability to declare local variables, macros, forms, and arrays an attractive feature. The run command lets you run external programs in the current directory.

However, the programming environment in this (first) release of Guru is not completely robust and forgiving. If you make a programming error or forget to initialize a variable that you call, Guru may crash or become unusable and need rebooting. Because the macros, which are dedicated to certain variable names, cannot take arguments, user-defined macro functions are typically special-purpose routines. However, there are ways of overcoming this limitation. For example, a dedicated array can be set up as a vector that holds values of named variables, much as a stack would. Various functions could then be devised for loading and unloading the array with the desired values.

RULESETS

There are two ways to prepare a knowledge base in Guru. You can use the powerful full-screen text processor, or, until you become familiar with the rulebase syntax, you can use the window-oriented Ruleset Manager.

A ruleset in the expert-system facility consists of various sections or clauses. All rulesets must have an initialization section, a name section, a goal section, a rule section with at least one rule clause, a variables section, and a completion section. In the initialization section, the knowledge base may set the values of any variables it chooses and specify other variables to be input by requesting them from the user. Typically, the environment variables are set, and the variables to be used by the expert system are set to "unknown." Also, any statements in the Guru programming language may be made in this section

(continued)

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The goal section contains the declaration of the name of the goal variable, which marks the conclusion of reasoning when it is assigned a value. The completion section contains the directives that are carried out when the evaluation of the goal is completed. Usually this completion section will contain conditionals and cases, which produce different results depending on the state of the variables when the system's goal has been reached. In this way, many types of results are possible for the outcome of an expert system besides bare textual advice.

RULES

Both the premises and conclusions of rules can interact with the spreadsheet using various built-in functions. For example, the premises can look up values in a spreadsheet model and perform various operations on them for the test, including math, logical, and fuzzy operators. Even text-string functions and wild-card and character class matches can be used in rule premises.

One of the most powerful aspects of the Guru expert system is the availability of the Guru programming language for use in the conclusions of rules. Almost any operation that the integrated environment can do may occur as the result of the firing of a rule. This includes inserting new records in a database, assigning new definitions to spreadsheet cells, and the recalculation of a spreadsheet. It also includes generating graphics displays, communicating with remote computers, executing entire Guru programs, and calling up and searching other rulebases.

The Guru inference engine can be controlled, and various defaults can be modified. The rule language lets you assign cost and priority values to

(continued)

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rules. Rule priorities may be set with integers from 1 to 100. The priority of a rule is used to modify the order in which rules are chosen for testing, according to the assignment of the e.sord environment variable, which is described below. The range of values for the cost of a rule are similar, but opposite in effect to that of the priority value.

The ready option lets you specify a Guru command to be executed as soon as a particular rule has been selected for evaluation, but before any of its conditions have been tested. This is useful for customizing the environment to test specific rules. One interesting application for this would be the recording of statistical information each time certain rules come up for evaluation.

The needs clause applies when a rule's premise contains a macro or a reference to the element of an array. It is a streamlining feature, making all the information necessary for such rule evaluation immediately available to the inference engine. If this clause is omitted, Guru will still be able to process the rules, but often far more slowly.

The changes clause is similar, but it applies to the conclusions, or actions, of rules. It provides a list of all the variables that will be changed either directly or indirectly when the rule fires. This is particularly useful for backward-chaining consultations, where the system will chain backward from a goal to those rules that can establish the conditions needed for that goal. As with the needs clause, Guru can function without a changes declaration, but it considerably speeds up the search.

Environmental Variables

One way of controlling the operation of the inference engine is to set the value of various environment variables. These are the most important variables in the Guru environment.

The e.sord variable has six possible values to which it can be set. Assignment is done, as with any other variable, with the let command. If the command let e.sord = "C" is used in a program or a knowledge base, then Guru will pursue a least-cost strategy, meaning that all the rules with the lowest cost value will be processed first. If the "F" option is chosen, the rules will be processed in the order in which they appear in the knowledge base. With the "H" option, the highest possible action certainty for the present goal must be achieved. The "P" option specifies that the highest-priority rules will be considered first. If the "U" option is chosen, the rules that have the fewest unknown variables are tested first.

The e.tryp variable also has a number of options. Setting its value to "S" imposes a strict strategy for evaluating any premise whose value is unknown. This means that its evaluation will be abandoned if any variable's value cannot be determined. If the "P" option is chosen, Guru will try to determine the values for all unknown variables and attempt to evaluate the expression. The "E" option causes Guru to continue to evaluate conditions after each variable becomes known, and it will stop only when the entire premise becomes known.

The Consult Command

Another important way of controlling the operating of the inference engine is by the various options of the consult command. The consult . . . to test . . . option activates forward chaining, a reasoning strategy driven by the facts that are already known to test as many rules as possible to prove additional facts. The consult . . . to execute . . . option lets you supply Guru with the name of a rulebase and a particular agenda of rules to test. This command could be used as part of a loop to periodically test the conditions of rules to see if they are ready to fire.

Uncertainty

As with many expert-system shells, Guru can associate numbers with each expression that records the degree to which such an expression is known by the system. These indexes are called certainty factors. When conclusions are drawn from premises that have certainty factors associated with them, a formula must be used to compute the certainty factors of conclusions. Guru offers an entire catalog of possible options for computing these certainty factors.

Guru also has an interesting implementation of fuzzy sets, which it calls set variables. Set variables may have several values, each with its own certainty factor. This is helpful for problems with no definitive answer, but it is useful to choose the best from some strong candidates. Set variables help to solve the problem of rules that contradict one another, or rules whose values need to change. For example, if two or more rules that fire indicate conflicting values for a given variable, a set variable can record both results, though possibly with different certainty factors.

Set variables may have up to 255 values. The notation for representing the set of values for a given variable is a bracketed list with the elements separated by commas. The set may also mix values of different data types.

Explanations

You can generate explanations of how the Guru expert system arrived at its results or why it is asking a question in various ways. If a consultation has already concluded, you use the how and why commands. If the consultation is still under way and you want to know why a particular question is being asked, the Control-Y key combination will generate the result. The explanation facility allows inference tracing so that entire sequences of rule chains may be reviewed. This is a valuable and useful feature.

Database Management and Statistics

One feature that distinguishes Guru's integrated business software from programs like Symphony and Framework is its powerful relational random access data-file system. Index files can be created for these databases to allow fast random access and retrieval of records. The select command can automatically generate an output table based on query conditions supplied either by the user or by rules in an expert system, and it can do so for several data-file tables simultaneously. The stat command can be used to compute various statistics from the values in records, such as sum, minimum, maximum, average, and standard deviation. As with the select command, statistical functions can be done with several files simultaneously.

By using the redefine, browse, change, mark, and compress commands, you can design knowledge bases to alter the contents of databases, depending on which rules fire. Some interesting and complex systems can be built using this capability.

SPREADSHEETS

Guru's full-featured spreadsheet has all the features of a current generation spreadsheet, and more. Two of its special features are the ability to look up cell values from other parts of the Guru environment and the ability to enter them in spreadsheet cells.

In a few ways, the Guru spreadsheet has advanced the state of the art beyond Lotus 1-2-3 and Symphony. For example, when copying complex cell formulas over a range of cells, a prompt will appear, asking if you want the formula adjusted for each of the terms of the formula. Thus, you can devise a complex formula composed of both absolute references and relative references.

The real power of the Guru spreadsheet is that the whole command language with macros is at your disposal for defining the value of cells. This means that you can save an enormous amount of typing by using macros and editing existing programs for the cell formula you need.

Another useful feature of the Guru spreadsheet is its ability to determine the value of a spreadsheet cell by consulting a ruleset. In other words, when the worksheet is recalculated, knowledge bases can be executed. On the basis of such consultations, the value of the spreadsheet cells will be determined and the values placed in the cells.

CUSTOM REPORTING

Custom reports are generated in Guru with predesigned templates, which can be created interactively and stored on disk. When designing a template, you simply position the cursor where you want text to appear and type. Any "special effects" desired, such as highlighting, blinking, or color attributes, may then be specified.

In addition, header and footer patterns may be designed as part of the template. There are three basic header and footer configurations: report, page, and group setups. The report configuration is a formatted template that shows how information is to be presented. The page configuration, which is for printed reports, specifies how each page will be laid out and what headers and footers will be used. The group configuration presents the information in separate groupings, such as by department or by company.

COMMUNICATIONS

The communications facility in Guru allows the exchange of information between computers through a direct serial connection or via modem. A variety of communication modes are possible, including terminal emulation mode, automatic dialing, log-in, and log-out. Raw communications processing can be done on a character, line, or block basis.

Guru lets you embed commands that trigger data retrieval at transmission time. With information that will change over time, the communication routines can be written so that the most up-to-date information will be retrieved automatically and included in the message at sending time.

BUSINESS GRAPHICS

Guru can graph data using bar graphs, exploded pie charts, area graphs, line plots, and scatter graphs. It also has free-form graphics, so maps and other illustrations can be presented on graphics screens or combined with text. Using the free-form graphics facility, a single command will send Guru to retrieve data stored in array blocks and then produce a drawing to represent the data.

Mirror images can be plotted simply by resetting the range command from high to low, or vice versa. Since these arrays can be created and modified by the firing of rules in a knowledge base, the form of a free-form picture may be determined by an expert-system consultation. This

Custom reports are generated with predesigned templates.

could produce both a report and an illustration.

A graph can be based not only on the data stored in database files and spreadsheets but also on query specifications, statistics, and information stored by the Guru command language in variables and arrays. It is possible to display more than one such graph simultaneously, with the display characteristics of each controlled separately. Different regions of a graphics screen may also be cleared separately and new graphs can be drawn on them. This makes possible the comparison of charts for different sets of data values.

CONCLUSIONS

Even if it did not have a built-in expert-system shell, Guru would still be an extremely powerful integrated software system. Yet, in spite of all its power, Guru does have limitations. One is memory—with only half a megabyte, or even 640K bytes, there are real limits on what you can do. Another drawback is Guru's knowledge representation. Because the effect of rule firing in Guru is to set the value or values of a variable, more complex representation schemes, such as the familiar Object-Attribute-Value scheme, are not directly supported.

Since the expert-system facility in Guru is capable of calling on any function or command in the system or activating separate procedural programs, there is really nothing in the entire integrated software system that cannot be accessed from an expert-system application. This total integration of programming language, rule-based reasoning, and integrated business software facilities lets the user develop hybrid systems in which either the expert system or procedural programming has the upper hand. Guru's concept of total integration is not only very useful, it is very powerful. ■

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HOW TO LOG ON TO BIX:

Step 1: Set your computer's telecommunications program for full duplex using 8-bit words, no parity, and 1 stop bit, or 7-bit words, even parity, and 1 stop bit. You may call at either 300 or 1200 baud.

Step 2: To reach BIX via Tymnet.*

* BIX *is accessible from anywhere in the country through local Tymnet numbers. If you don't know the Tymnet numbers for your area, contact the* BIX *Customer Service* Line *(see below)*. At *other times, numbers can be obtained by calling Tymnet at* 800-336-0149.

- Call your local Tymnet number and log on.
- Depending on your baud rate, Tymnet will respond with "garble" or request a terminal identifier. Enter the letter "a". (Ignore quotation marks in this and succeeding entries.)
- Tymnet will ask you to log on. Enter "byteneti" and a carriage return (CR).
- Tymnet will ask you for a password. Enter "mgh" and (CR). You will then be at the door to the BIX computer.

Step 3: (If there is no prompt requesting a login at this point, hit a (CR) which should produce it.) When you see a phrase ending in "login:", enter "bix". (Echoing of this response is normal.)

You should now see the BIX logo scroll onto the screen and a prompt asking you to enter your name. Since this will be your first time on the system, enter "new" and a carriage return. This will take you to a special section where you enter the information we need to register you as a BIX user. Follow the on-line prompts and supply the information requested. BIX lets you re-enter data if you make a mistake.

When you've completed your registration, BIX will automatically take you to a special "Learn" conference where you'll get a quick tutorial on how to use the system. (Typing "help" or "?" at any prompt while you are on BIX will give you an immediate review of available commands.)

ACCESSING BIX FROM FOREIGN COUNTRIES

To reach BIX from other countries, you need an account with your local Postal Telephone & Telegraph (PTT) company. From your PTT, enter 310600157878. Then follow instructions starting at Step 3. A list of PTT addresses and contacts for most foreign countries is available by calling or writing BIX.

CUSTOMER SERVICE

If you follow these instructions but still are unable to log on to BIX, call the BIX Customer Service Line for assistance at 800-227-2983, 8:30 a.m.–11 p.m. eastern time weekdays. In New Hampshire and outside the U.S., call (603) 924-7681.

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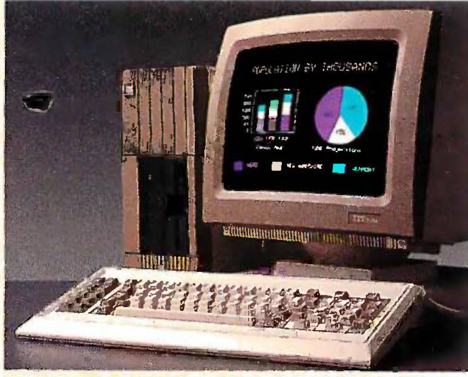

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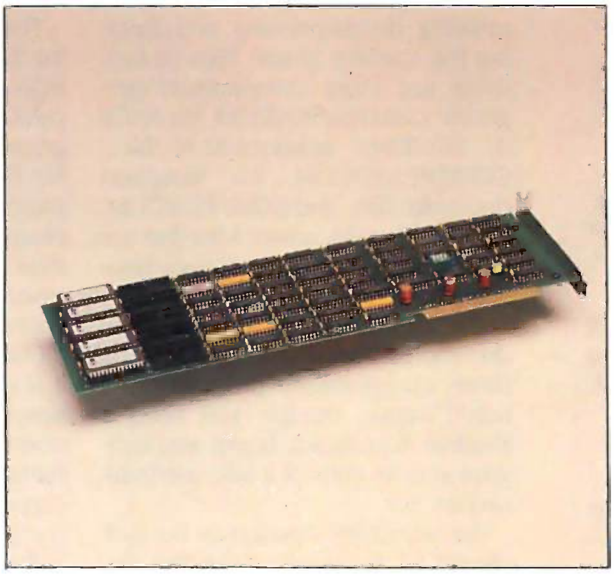
The Datran Modem Accelerator

By Barry Nance

A special-purpose time, space, and money saver for transmitting text files

The Datran Modem Accelerator is an add-on board plus software that shortens the time required to transmit prestored textual material over telephone lines. The Modem Accelerator's printed circuit board fits into a full-length slot of an IBM PC, XT, AT, or compatible. You need two Modem Accelerator boards for normal use—one at either end of the telecommunications link. The accompanying software includes a spelling checker. In addition to lessening telecommunications time, the Modem Accelerator conserves disk space by storing files in compressed form.



How It Works

Version 1.1 of the Modem Accelerator board, which is reviewed here, contains a 28,000-word dictionary in ROM and produces compressed files by substituting a "token" for each word or phrase in the source file that it finds in the dictionary. (Datran calls this concept the "Symbolic Tokenizer.") The board transfers words that it doesn't find in the dictionary into the compressed file untouched. Datran claims that files compressed with this product are about one-third the size of the original file and that the time and cost of on-line telecommunications are reduced accordingly.

Datran has designed the board with customization in mind; it plans to release legal and medical dictionaries on ROM chips in 1986 and is considering foreign-language dictionaries. It also makes special ROM dictionaries for corporations that use specialized nomenclature or that have special security requirements. The board that was delivered to BYTE for review had five ROM chips installed and five empty sockets for future additions.

Installation of the Board

I easily installed the Modem Accelerator hardware as the fourth board in my IBM PC. Since I have the standard 63.5-watt power supply (which feeds a graphics adapter, a 384K-byte multifunction board, a combination hard/floppy disk controller, a 20-megabyte hard disk drive, and a floppy disk drive), I wondered if adding the fourth board would cause power problems. However, the PC powered up cleanly after installation and has shown no sign of hardware trouble since.

When you're not compressing, decompressing, or checking the spelling of files, the Modem Accelerator is completely transparent to the operation of your PC. I ran the IBM Advanced Diagnostics program after installing the board (a good practice after installing any hardware in your PC) and found no diagnostic errors. The list of installed devices shown by the Diagnostics program did not include the Datran board.

The Modem Accelerator has switches that you can set to address the board at different I/O addresses and to accommodate faster microprocessors, such as the AT's 80286. My installation did not require changes in the switch settings. Datran says it doesn't know of any other board whose presence would require the I/O port addresses to be different, but it provides the switches just in case. Datran also says that if error messages appear or if the board seems to malfunction, you should reset the switches (and run an installation program to notify the software of the change) to determine if the prob-

(continued)

Barry Nance (17 Pease St., Wilbraham, MA 01095) is president and chief programmer for Business Software Services. He moderates several conferences on BIX.

Datran Modem Accelerator, version 1.1

Type
Text-file compression/decompression for telecommunications purposes

Company
Datran Inc.
10519 Lauriston Ave.
Los Angeles, CA 90064
(213) 474-3684

Hardware Needed
IBM PC, XT, AT, or compatible with at least 128K bytes of RAM, serial port, and modem

Software Needed
Text editor or word processor that places the Control-Z EOF marker at the end of its files

Dimensions
Full-length board for IBM PC, XT, or AT (4.2 inches high and 13.2 inches long)

Software
File-compression programs, decompression program, line editor for spelling dictionary, spelling checker (one 5¼-inch double-sided 360K-byte disk)

Documentation
17 photocopied, stapled pages with table of contents and appendix showing error-message definitions; 3-page short manual for "impatient experienced users"

Price
$495 each; normally purchased in pairs

lem is caused by duplicate I/O port usage.

Software Installation

Instead of putting both the dictionary and the compression software in ROM, Datran chose to distribute the software on disk. Thus, the "data" (a table of words and their tokens) is in ROM chips, while the software is in the form of an easily upgradable disk. The first program disk I received from Datran contained a "hard error," and I could not execute or copy the compress programs. I was able to copy the replacement disk's files to my hard disk drive with no problem—the disk is not copy-protected.

The Modem Accelerator's disk contains separate programs for compressing, decompressing, and checking the spelling of text files. In fact, there are three compression programs: COMPRESSN.COM, for ASCII or WordStar nondocument files; COMPRESSD.COM, for WordStar document files; and COMPRESJ.COM, for WordStar document files that are to be printed using microspace justification.

The DECOMP.COM program can decompress files written by any of the three compression programs. As noted above, though, you need a Modem Accelerator board and software at both ends of a telecommunications link.

The other files supplied on the disk consist of the spelling checker, the special installation program (for any boards whose I/O port addresses conflict with the Modem Accelerator board), some data files, and a program that you can use to create your own dictionary of words (up to 500). This personal dictionary works with the spelling checker but does not take part in the compression/decompression process.

Testing the Compress/Decompress Feature

The main feature of the Modem Accelerator is its ability to shrink a text file to a very small size and expand the shrunken file back to its original state. You can send a shrunken disk file across a telecommunications link in much less time than the full-size version of that same file, saving time and phone charges. Balanced against the phone bill is the cost of the time it takes to perform the compression and decompression.

Shrunken disk files take up less space on the disk, and you can use the Modem Accelerator board and software to produce shrunken disk files merely to conserve disk space. However, if you're using a hard disk drive to hold shrunken files, you should note that the smallest unit of allocation on a hard disk, the cluster, is usually 4K or 8K bytes. Thus, files that are fairly small to begin with are not good candidates for shrinkage, since they will always take up a minimum of 4K to 8K bytes of disk space.

The three programs for compressing files work in conjunction with the ROM dictionary on the Modem Accelerator board. The decompress program can operate on a compressed file from any of the three compress programs. The Datran board only processes text files; program files and data files are not supported (logical, since they would contain no correspondence with the ROM dictionary).

Compressing a file prior to sending it across a telecommunications link is simple: You give, for example, the command COMPRESN <*filename.ext*>. The software does not support path names. The result of the compression is a new file named <*filename*.CMP>, which you can send across the phone lines as a binary-type file.

Once the file is received at the other end of the link, the command DECOMP <*filename*> will produce a file named <*filename*.RSN> that is an expanded image of the original file. As you can see, it's important to distinguish filenames by using the first eight characters of the name, since the software uses the last three characters to indicate the compression status (and spell-checked status) of a file.

For both the compress and decompress operations, you can use a /D option that deletes the original file after compression or decompression—an

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BASTOC
A BASIC to C translator for the BASIC programmer who wants to upgrade to C.

EDITORS

Brief This programmer's editor has several outstanding features. Brief's macro language compiler allows the programmer to create new commands and assign them to any key. Brief's unique "undo" facility will even let you recover from accidentally entered commands. Create as many windows as will fit on a screen, containing the same or different portions of one or several files. Compile programs without ever having to leave Brief.

FirsTime Speed-up program development with an easy-to-use C and Pascal syntax checking editor. Detects syntax errors, undefined variables and mismatched type assignments. Use function key menus to generate statements or enter your code directly. On-line help available.

VEDIT Plus A full-screen text editor for program development and word processing. It contains powerful features including use of macros, on-line help facility, paragraph formatting, and file comparison.

EMACS Customizable editor including windowing, multi-tasking and special modes for C and Pascal.

FUNCTIONS

The Greenleaf Comm Library
A library of over 120 communication routines. Contains functions to create interrupt driven routines or perform direct I/O to multiple Comm Ports. Its strengths are in asynchronous communications, interrupt mode, modem control, XMODEM, XON/XOFF and flow control.

PforCe New A library of 400 plus functions for interrupt driven communications, background tasks, string/table parsing, data base manipulation, DOS and BIOS functions and more. Superbly written and documented software with complete source code included.

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BASIC_C Speed-up development time with this BASIC to C library, which acts as a bridge to C providing many of the capabilities of the BASIC language.

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option that you should use with care.

To test the shrink and expand programs, I used BIX (BYTE Information Exchange) as a "holding tank" for the compressed material. In other words, since I had only one Modem Accelerator board, I compressed each file, sent it to BIX, downloaded it back to my PC, and decompressed the downloaded file. I recorded the time required to transmit and receive each file and compared the result with the original file to ensure that no damage had been done to the text. (This article was one of the files that I sent and received. Other files included a 2-page report and a 45-page manual.)

Table 1 shows the results of the tests. Note that when I didn't use an error-checking protocol (such as XMODEM), the transfers took less time, but line noise caused the file to be unusable on every other transmission. With longer files, the probability of damage from line noise increases even more. I highly recommend that you use an error-checking protocol for telecommunications involving compressed files.

Also note that the material traveled through a packet-switched network (Tymnet) in all cases. This somewhat increased the transmission time over that required for direct PC-to-PC connections, but the effect was the same for all files and it did not affect the relationship between original file and compressed file timings.

For benchmark comparisons, I used two software-only (no hardware involved) compression programs that have been in use for some time—ARC.EXE and SQ.COM. ARC.EXE is a shareware program from System Enhancement Associates. I used version 4.31 for the benchmark. SQ.COM, another shareware program, was written by Richard Greenlaw and Vernon Buerg. I used version 1.28.

Table 2 compares the Modem Accelerator's compression of files with compressions performed by these other methods. Note that the Modem Accelerator produced the smallest files. In contrast, SQ.COM took a little less time to perform its compression but produced files that were significantly larger than those of the Modem Accelerator. The ARC.EXE program compressed files better than SQ.COM but took much longer to do it. The Modem Accelerator was both quick and effective.

The time required to perform text compression is almost as important as the size of the resulting file. In an environment of compressing, sending, receiving, and decompressing 20 to 50 files per day, the operator time adds up and must be considered in the overall cost savings.

In an environment of sending and receiving many files per day, the Modem Accelerator's speed should keep operating costs down and its degree of compression should reduce long-distance charges accordingly.

SPELLING CHECKER

The Modem Accelerator's spelling checker can check the spelling of words in a file automatically, going through an entire file without stopping, or on a word-by-word basis. If you choose the Automatic Sequencing option, the spelling checker inserts a special character (¦) before each word that it cannot find in the ROM dictionary. If you don't choose Auto-

(continued)

Table 1: *A comparison of three text files of various sizes, the time the Modem Accelerator took to compress them, their size after compression, and the length of time required to transmit the files, using straight ASCII and XMODEM transfers. Note that although the ASCII transfer (without error-checking protocol) was faster, it failed to transfer the file accurately in two out of three tests. Transmit times are based on 1200 bps (bits per second) transfer through Tymnet. File sizes are in bytes; times are in seconds.*

Original Size	Compressed Size	Compression Time	ASCII Transmit (original)	ASCII Transmit (compressed)	XMODEM Transmit (original)	XMODEM Transmit (compressed)
5553	2176	6	48	23	105	40
19825	7680	16	169	74	372	144
51154	21952	35	439	203	960	411

Table 2: *A comparison of the three test files as compressed and transmitted by the Datran Modem Accelerator and by two software-based data compression programs, ARC.EXE and SQ.COM. Transmit times are based on 1200-bps transfer through Tymnet using the XMODEM protocol. File sizes are in bytes; times are in seconds.*

Original Size	Compress Time			Compressed Size			Transmit Time		
	Datran	ARC	SQ	Datran	ARC	SQ	Datran	ARC	SQ
5553	6	16	4	2176	3181	3305	40	58	61
51154	35	117	30	21952	25480	30477	411	477	571
19825	16	51	14	7680	10301	12288	144	193	230

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PC Tech Journal

Inquiry 55

The spelling checker is not the reason to buy a Modem Accelerator.

matic Sequencing, the program stops at each unrecognized word and lets you mark the word with the ¦ character, ignore the word, save the word in the separate (disk-based) dictionary, or stop the program.

Since the ROM dictionary contains only 28,000 words (and only 500 additional words in the separate disk dictionary), the spelling checker will mark as errors a lot of words that are correctly spelled. The exact number, of course, depends on how closely your writing vocabulary matches that of the dictionary. In tests, I found that the program flagged roughly five percent of the words that were correctly spelled. This is a small portion of a file, but remember that the Automatic Sequencing mode inserts a ¦ character in front of each "error," and you have to remove the ¦ after confirming that the word is indeed spelled correctly.

Also, the spelling checker does not let you correct spelling errors on the spot. You must first exit from the spelling checker, use your word processor or editor to search for the ¦ characters, and then correct the spelling of the flagged words. For this reason, if I were going to use the spelling checker on a regular basis, I would not choose the Automatic Sequencing mode but instead review the words as they pop up as "errors" on the screen.

Some word-processing programs for the IBM PC put an end-of-file (EOF) marker character (Control-Z) at the end of each text file; some don't. The Modem Accelerator software absolutely requires that the marker be present. I tried to check the spelling of a file I created with PC-Write, which doesn't add Control-Z to the end of a file. The spelling checker went into a loop and reprocessed the file over and over—I had to reboot to recover from the error the first time. I tried it again and had to use an NMI push button to reset the computer. Ctrl-Alt-Del had no effect; the keyboard was locked up.

Datran mentions in its documentation that it is presently adding the capability to handle files from additional word-processing programs. If the documentation that came with your editor/word processor doesn't specify whether it uses the Control-Z convention, you should check with Datran to determine its compatibility with the Modem Accelerator.

CONCLUSION

The Modem Accelerator is a special-purpose tool, suited to certain environments. It works on prestored files—you can't use it in the midst of an interactive telecommunications link to compress keyboard input as it flows across the link. The Modem Accelerator does not work on program or data files, only text files. The text files it compresses must have the Control-Z EOF marker. Compressing a file takes time, as does decompressing the file at the receiving end. Since the resulting compressed file is an encoded version of the original, it may contain "characters" that could be interpreted as telecommunications control characters in some links. Finally, you'll have to establish procedures and conventions for using the boards at either end of the link to conserve connect time and to avoid human errors in the handling of the files.

The Modem Accelerator could be effectively used by corporations that are now sending medium to large files of text across long-distance phone lines. In this environment, the shrink/expand capability could be a time and money saver.

The spelling checker is not the reason for buying a Modem Accelerator board. There are software products that perform this function much better and that contain many more words (the one I regularly use, IBM's Word Proof, version 1.0, has a dictionary of 125,000 words). Keeping in mind that the spelling checker is a by-product of the ROM dictionary, you can use this feature instead of other software on an occasional basis—perhaps as a quick check of a text file that you're about to send over the phone lines. ■

GE'S 3-8100 PRINTER

The otherwise informative and useful review of General Electric's 3-8100 printer by Robert D. Swearengin (May) neglects to mention a factor of importance to potential consumers: cost and availability of essential supplies. Although 100,000 characters must seem like an inexhaustible amount of printing, calculations reveal otherwise. If a page contains 52 lines of 65 characters each, the 100,000 characters turns out to be approximately 30 pages. If double-spaced documents and programs are figured at half this number of pages, it means your ribbon costs, at six dollars each, will run 10 to 20 cents a page! This factor must be taken into account for anyone in the market for low-cost printing.

JOHN DEHAVEN
Ratchaburi, Thailand

ZBASIC

Several difficulties in using ZBasic are not emphasized in the review by TJ Byers (May). My ZBasic experience is with the version for the IBM PC and compatibles on a Panasonic Sr. Partner.

I prefer my high-precision answers to be correct, not crunched, so ZBasic's 6 to 54 internal binary-coded decimal double-precision accuracy appeals to me. There are some calculations that failed at double-precision 54 but worked very well at double-precision 52. Unfortunately, this achievement is marred by the absence of run-time arithmetic error messages.

Subtle and hard-to-find bugs can be introduced into ZBasic programs by their precision rules for complex arithmetic expressions, with mixed precision of the variables. The GW-BASIC and BASICA rules are simple and unambiguous: The expression has the precision of its highest-precision variable.

ZBasic references RESTORE for DATA statements by item number starting at 0 rather than by line number. The input formats for time and date hexadecimals use comma delimiters, and TIMER is not supported.

The requirement that all keywords be in uppercase and that no variable name contain an uppercase keyword is a burden when converting programs to ZBasic. Variable names are case-sensitive, so Temp, temp, and TEMP are three different variables. Because of this, I found I had to alternate between GW-BASIC and ZBasic. I also had to remember that ZBasic changed the meaning of the / and \ divides. The backslash must be used to force floating-point divide.

It took some effort for me to find the equivalence between the usual GW-BASIC screens 0, 1, and 2 and the 16 ZBasic modes. Some modes give surreal displays, and only modes 5 and 7 give correct graphics. Mode 5 is somewhat like screen 1, and mode 7 is somewhat like screen 2.

In brief, ZBasic has many pitfalls for the unwary. Programs must be well debugged before conversion to ZBasic. There are no run-time arithmetic messages, nor is breakpoint debugging possible.

GEORGE WM THOMSON
Detroit, MI

PANASONIC EXEC. PARTNER

I would like to provide additional information on the Panasonic Exec. Partner (reviewed by Rich Malloy in the April issue).

Panasonic has an excellent technical manual for the Exec. Partner. It costs $5 (plus $2.25 tax and shipping), and is available from MSC Service Literature, P.O. Box 848, Arlington Heights, IL 60005.

The warning sticker about the disk drive should not have been a disappointment for Mr. Malloy. If you burrow through the manuals for most computers, they have a similar warning. Panasonic seems to have been a little more forthright about the real problem of random flux changes in the heads during initial start-up of the floppy disk drives. It is true that data disks should not be left in place with the heads clamped down; you get media and head degradation as a result. I have Teac drives in my IBM PC, and they raise and lower the heads between uses, which is the way disk drives should work.

The expansion chassis that is available from Panasonic is very easy to attach. By using this box, you can add another monitor and a graphics card. The MODE command allows you to change how the screen (gas-plasma or external) behaves. I think that the proper use of MODE would probably answer many of your concerns about the gas-plasma screen. I have had both the gas-plasma screen and an external monitor working at once.

FRANCIS P. BOWLES
Woods Hole, MA

VME/10

I read the review of the Motorola VME/10 by Robert E. Robinson III (February). I have been using this machine for two years with the VERSAdos operating system. I would like to express my views on the VME/10, VERSAdos, and Motorola.

First of all, there is considerable doubt in my mind that the 384K bytes of memory is ported on the VMEbus.

Second, the capability for graphics exists, but there is no support software.

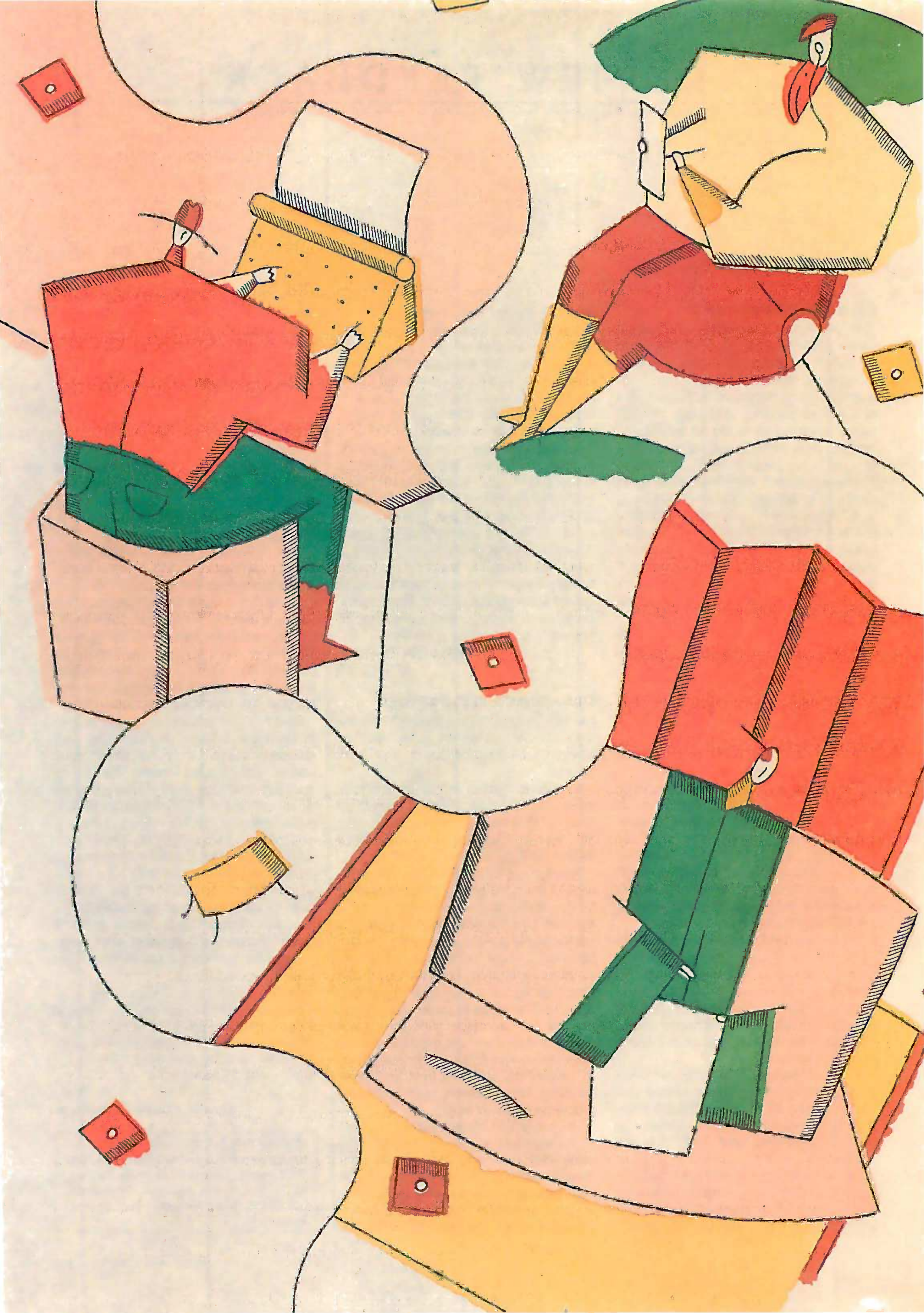
Third, between two VME/10s (one of which I've used for two years and the other for over a year), I have had problems with the reset switch, power switch, power supply, disk controller, and keyboard.

Fourth, Dr. Robinson has been luckier in dealing with Motorola than I have. Last October I asked if there was any simpler way of doing backups rather than doing transfers to floppy disks. Can backup be done onto half-inch tape using the 9-track tape controller (MVME435A)? There are no facilities under VERSAdos. There aren't any controllers for quarter-inch streaming tape. A month later, Motorola announced such a controller (MVME350). Subsequent calls to Motorola have produced many promises of data sheets for this device. I finally received a data sheet after three months but no information on what VERSAdos support it has.

Finally, although I disagree with Dr. Robinson's conclusions on the design, construction, and reliability of the VME/10, I am not entirely negative. My next project may be done with Motorola equipment using VERSAdos.

J. L. PAUL
Dorval, Quebec, Canada ■

REVIEW FEEDBACK *is a column of readers' letters. We welcome responses that support or challenge* BYTE *reviews. Send letters to Review Feedback,* BYTE, *One Phoenix Mill Lane, Peterborough,* NH 03458. *Name and address must be on all letters.*



Kernel

JERRY HAS BEEN DOING a great deal of traveling lately. This month he visited the United States Air Force Academy and the West Coast Computer Faire. He then had upcoming trips to Austin, Berkeley, and Atlanta. Although the travel began to grind him down, much of it was fun, and he learned a lot. Jerry is impressed with the use of computers at the Air Force Academy, especially in the area of computer-aided design. He is also pleased to report that the Faire is still his favorite computer show.

Ezra Shapiro thought he had seen the last of word processors for MS-DOS machines. No such luck. He does believe that he is near the bottom of the pile, though. The ones this month are called Mindreader (Ezra is impressed by its oddness), PC-Write 2.6, and Word 3.0.

Bruce Webster also visited the West Coast Computer Faire. While *he* believes that it has become more an exercise in nostalgia than a vital happening, he still sees value in such shows. They provide small, innovative companies direct exposure to users and to the press. Bruce did see some interesting products and plans to keep coming back to the Faire. While he was in the Bay Area, Bruce also visited Atari and Commodore.

UNIX-based systems have been scarce at the personal computer level in Japan. Recently, however, Fujitsu announced an upgrade that could make these systems more common. Bill Raike looks at the upgraded FM-16β. Changing his course, Bill then considers the lack of hardware and software to do Japanese-language word processing on an IBM PC.

This month's Mathematical Recreations column finds Bob Kurosaka looking at some number-sequence games: sum of cubes, factorial sums, palindromic sums, and delete and add. Computers make the job of exploring these games much easier than doing it manually. Thus, Bob provides BASIC programs to check them out.

Sharp-eyed Kernel readers will notice there is no BYTE U.K. this month. Dick Pountain was kept busy doing an article for the Theme section. BYTE U.K. will return in September with an Occam technique that boosts performance in parallel-computing systems.

OFF WE GO

BY JERRY POURNELLE

Jerry hits the road in many directions and learns a great deal

I think they're trying to kill me. When this month is over, I will have spent more time on the road than I did at home. All this travel is necessary, and some of it was fun, but it can sure grind you down. Fortunately I learned a lot, so there's much to report.

COMPUTERS FOR CADETS

One place I went was the United States Air Force Academy in Colorado Springs, where I was the guest of the department of civil engineering. I hadn't thought of it, but of course the U.S. Air Force is the largest owner of pavement in the world and operates one of the world's largest construction enterprises. Besides flying airplanes, the Air Force has to design, build, and operate bases for them, which often means they must set up small, self-contained cities and provide every service from grocery stores to mortuaries.

This fall USAFA is trying an experiment: every cadet will be required to buy a Zenith 248 IBM PC AT compatible. Cadets will be given an allowance for this, and the machines will be theirs when they graduate. Meanwhile, the Academy is stringing coax cable through the dormitories: the intent is to link up all those machines into a central conferencing network. As I write this, they have chosen neither the conferencing software nor the large machines to handle the networking. I've been encouraging them to license CoSy from the University of Guelph. CoSy is the system used by BIX. USAFA and BIX have much the same requirements: electronic mail, conferencing, ability to handle 500 to 1000 simultaneous users (BIX isn't that big yet, but I expect it to be in a year or so). I have no hesitation in recommending CoSy for any reasonable-size conferencing activity, and, after all, it was developed for academic use.

The Academy is an academic institution, but it's still owned by the U.S. government, meaning that nothing is very simple, and that particularly applies to computers. Example: if Academy professors see a piece of commercial software they think would be useful, they can't just go buy it by name, since that would be a sole-source procurement, and the government really frowns on noncompetitive purchases. You wouldn't *believe* the paperwork they have to go through just to get a compiler, or a math program, or a graphics package. Generally, one of the professors will just buy it out of his own pocket; but clearly there's a limit to how much can be acquired that way.

They do have one thing going for them. Like all the service academies, the Air Force Academy operates on an honor system, and a number of big software publishers have given site licenses to the institution: the cadets can use the software as long as they're at the Academy but can't take copies with them on graduation, and of course they don't let any copies leave the Academy grounds. It all makes sense to me. The practice doesn't cost publishers much, and it can't hurt future sales to have the U.S. Air Force officer corps familiar with a product—especially since in many cases the Zenith 248 the officer owns on graduation will be the most powerful computer at his new post. Of course, all those computers will need software. . .

AUTOCAD

One outfit that has donated its software to USAFA is Autodesk, who has not only given the Academy permission to use its CAD software packages but even sent some experts out to get it all properly installed on the Academy's dozen AT&T 6300s last fall. No one at the Academy had ever used a CAD system, but they decided to use it in their design course: meaning that students and professors had to learn together.

It was a raging success. The course not only covered more ground than ever before, but the cadets were able to produce really professional-quality work—and to show not only the professors, but also the AutoCAD designers, some new uses for the program. I'm clearly no expert in either civil engineering or CAD programs, but I heard nothing but glowing praise for AutoCAD.

AutoCAD has a number of nifty features. For example, you can create a shape—say a bathtub—and store it. If you change the scale of drawing, the size of that shape will change when you call it up. To install a bathtub of that style, you retrieve it from memory, drag it about the plan with the mouse, rotate it until it's oriented the way you like, and there it is.

You can also make arrays of shapes, which gave one of the cadets an idea. He drew a parked fighter plane, moved another next to it, set that up as an array, and presto! he had a template for drawing in off-runway park-

(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.

The West Coast Computer Faire is still my favorite computer show.

ing areas for F-15 fighters. Others added to the file so that most aircraft shapes are now in the civil engineering department's library.

This year AutoCAD could be used on only a dozen machines. Next year the cadets will be able to work on problems on their own machines. Printing their work will still be a bottleneck—the Academy has only three plotters that they can use—but even so they expect to be able to enrich their design course even more. Incidentally, if anyone out there has a couple of spare plotters they'd like to rent out for a dollar a year, you might write Colonel Swint at the Department of Civil Engineering, USAFA, Colorado Springs, CO 80840.

There's another fallout to this: the Academy is slowly accumulating computerized plans in AutoCAD format for a number of major U.S. Air Force bases, which means the cadets can have experience designing base changes, repairs after combat, and the like, working on real installations. This will cut down their postacademic training period when they leave the Academy and go out to do useful work. It probably won't hurt AutoCAD's sales, either...

COLLEGES AND COMPUTERS

The service academies are leading the way, but I suspect that by 1995—probably well before that—just about every college and university will require all students to own a personal computer. The advantages are just too great. Examinations can be turned in on disk rather than paper: not a big advantage in some academic disciplines, but in engineering design and other graphics-intensive course areas the savings in instructor time will be startling.

On the other hand, there may be some glitches. I'm writing this in April. USAFA expects to have its networking system in place by August. I don't think that will be easy—yet many of the academic departments are planning courses in ways that depend not only on the cadets having computers but on their being networked. I wish them well at it, but I'd sure hate to decide on a computer, buy it, decide on software, buy that, and get it all working to link 4000 PCompatibles in four months' time.

I'm sure USAFA will survive any early setbacks. Meanwhile, the engineering professors have developed some really spiffy instructional software for PCompatibles. One demonstrates pendular motion with springs of various resiliency stressed under different conditions. Another does Hardy cross-analyses. They have drainage models, soil-stress models, and a raft of other stuff to use in engineering classes. It's all in the public domain, too. They don't have a budget for publishing or providing copies to everyone who asks, but they are very interested in suggested improvements. I'm sure that anyone who wants to make a significant software swap will get sympathetic attention.

THE ELEVENTH FAIRE

Another place I went was the West Coast Computer Faire, and I'm pleased to report that the Faire is still my favorite computer show.

It didn't have to be. Early this year the Faire was bought by The Interface Group, the outfit that brings you COMDEX and many other computer shows; and while they do those shows very well indeed, the Interface people are after all involved in a commercial enterprise; while the Faire is something very special.

I needn't have worried. Sheldon Adelson, who is president of Interface, said not once but several times that he considers the Faire "the spawning grounds of the computer industry," and "you have to give something back." He even said it again when he came down to introduce me at the talk I gave. Incidentally, he introduced me as "the consummate hacker," which is flattering but alas not really true, and as "the voice of the computer users," which comes pretty close to what I attempt to be.

I don't suppose for a moment that start-up companies won't still have Faire troubles, but most will be due to a problem Shelly can't solve. It's expensive to put on shows in San Francisco, and made more so by the strict union contracts the city has signed. Lest someone think I'm automatically antiunion, my wife's father was a coal miner, and company cops once dynamited his house for trying to organize a union: but I do not think he would have approved of a situation in which a small entrepreneur is not allowed to move his own goods and is charged $450 to have someone do it in five minutes with a forklift. I sometimes wonder if San Francisco really wants conventions and shows.

The Interface Group says they want suggestions from everyone who loves the Faire. Clearly they can't do everything we'd like, and they certainly don't intend to lose money; but they have promised to be cooperative. They certainly paid enough attention to me.

I do believe that Shelly Adelson will try to keep the Faire what it has always been: a place for users, developers, hackers, writers, and enthusiasts to get together. The heart of the Faire has always been the tiny little booths along the walls. Adelson deserves a lot of credit for recognizing that and keeping their costs as low as he can.

I went to this year's Faire with the nagging thought that it might be my last. It won't be.

BACCHANALIA...

There's one major change in the Faire. For the past several years, there have been wild parties: one year *InfoWorld* held a press reception in the Coit Tower, and another year they rented the rotunda of San Francisco's City Hall. Microsoft used to throw humongous parties.

During the salad days everyone threw parties; I can recall one Osborne affair at which Lee Felsenstein solemnly informed me that Osborne would set new standards of adequacy in party giving. I wasn't quite sure how to take that. For a few years, though, every night during the

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> *Much of the excitement at this year's Faire was centered around the* Atari ST *machines.*

Faire there was at least one big blast.

This year there were almost none. The Interface Group held a traditional reception for press and exhibitors; nothing wrong with it, but it was a pretty tame affair. Of course, *anything* would seem a tame affair after Philippe Kahn's First (and, alas, apparently Last) Annual Bacchanalia last year. Indeed, I'm told, the reason no one, including Borland, threw any kind of big party this year was that no one could think of a way to top last year's toga party. After you've seen Philippe Kahn playing a saxophone while dressed as the Emperor Nero, what's left?

ATARI AGAIN

Much of the excitement at this year's Faire was centered around the Atari ST machines. Neither Atari nor Commodore actually had a booth at the Faire, but both were well represented by users groups. In addition, Atari president Sam Tramiel showed up with his software VP brother Leonard to hold a combination users group meeting and press conference.

According to the Tramiels, Atari is in excellent shape. Sales of 8-bit machines haven't grown, but they're holding steady, and that provides plenty of cash flow for development while the new Atari ST machine sales build up. They also insist that the ST machines are selling well. I believe that, although I think some of the early sales reports were exaggerated. Incidentally, they report that in Europe about half the STs sold are monochrome; in the U.S. only 20 percent are monochrome alone; there are also "substantial" sales of both, but no numbers were mentioned.

A number of users were concerned about math chips for the Atari ST. "We'll put in math chips when Motorola has a math chip," Leonard Tramiel said. "We won't do a kludge." They may have to reconsider that decision if they want serious penetration of the business market.

Throughout the press conference the Tramiel brothers seemed thoroughly confident. They admit that Atari had far worse financial problems than they knew before they took over the company from Warner. "It took some pretty ruthless actions," Sam Tramiel said. That's an understatement: at Spring COMDEX 1985, Atari had so few employees that even top executives were answering their own telephones. It's still a no-frills company.

As I write this, there still isn't enough software for the Atari, but there's a lot; and perhaps more important, the tools to generate software are showing up. New compilers, debuggers, documents and tip sheets, and especially new users groups make the Atari ST series the machines to watch.

HACKING YOUR ST

A lot of Atari 520 ST owners are improving the machines on their own. The original 520 didn't have the operating system in ROM; this added appreciably to boot-up time. While Atari dealers would install the ROMs for a reasonable price, I didn't have a local dealer since my 520 came directly from Atari. Friends sent me a ROM set, and following instructions given on BIX I sat down one night to do it myself.

It took about 10 minutes, and everything worked fine. A very few programs want the old operating system that boots off disk; thoughtfully, Atari has set things up so you can do that.

I also have instructions for increasing the 520's memory to a full megabyte; the same directions are available on BIX. This is a modification that Atari won't support, and since it involves soldering chips there is significant risk of doing permanent damage to your machine; but provided that you're careful it's not difficult, the parts are cheap, it adds nothing to the complexity of using the machine, and

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The 2400I Internal Modem Card fits into any expansion slot, as it is a compact half-card modem. It's designed specifically to operate in the IBM Personal Computer PC/XT/AT family and compatible computers. The rear panel has two RJ-11C modular telephone jacks for the telephone line and the telephone set. The modem can be set for COM1 or COM2. The 2400I modem allows asynchronous communications with remote computers and other data terminal equipment over standard voice grade telephone lines. The 2400E External Modem offers the user asynchronous or synchronous communications. The 2400E is enclosed in a slimline plastic enclosure. The front panel displays the eight modem status indicator lights. It works on any computer or terminal with an RS-232C serial port.

Siblings

Not to be forgotten are our 300/1200 baud modems. The Internal Modem Card is designed for the PC, PC/XT and most compatibles; it occupies one full length slot and the internal speaker lets you know the call progress. An RS-232 serial port is standard, COM1 or COM2; you can use the port for other peripherals when the modem is not being used. Our External stand alone modem can be used with any computer or terminal which utilizes an RS-232C serial port. It also comes with 8 status indicator lamps and a snap off front panel that allows for quick setting of the switches for all types of communication packages. At $139 and $149, these are the best price/performance modems for most communications.

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Hours: M - F 8 am - 5 pm PTZ   Sat 8 am - 12 am PTZ   Inquiry 248 having a 700K-byte RAM disk sure cuts down on compile times. Anyone interested in hacking an ST should get into the Atari ST (atari.st) conference on BIX. However, fair warning, if you muck up your machine, don't blame me.

MACCARTRIDGE

Probably the most interesting thing demonstrated at the Faire was MacCartridge from David Small and Joel Rosenblum of Data Pacific (P.O. Box 10805, Marina Del Rey, CA 90295). This is a device that turns an Atari ST into a fast Macintosh.

Actually none of that's exactly true; that is, they had the MacCartridge, but they didn't exactly demonstrate it because they didn't have a booth, and even if they had they were afraid of Apple's lawyers; and an Atari ST with MacCartridge won't run all the software you can run on a Mac.

It runs an awful lot of it, including Microsoft's Excel. (As a bonus, Excel runs 20 percent faster, too.) One secret of MacCartridge's success is that it has sockets on board for Apple's (older 64K-byte) Macintosh ROMs. Small and Rosenblum bought their ROM set from Apple; but they can't sell MacCartridge unless Apple will either sell them the ROMs at a reasonable cost or license them to reproduce them. As I write this, Apple hasn't made up its mind what to do about this.

If that weren't enough for Apple to worry about, the MacCartridge will work just fine with RAM chips in those slots, provided that you upload the Apple operating system from disk. While I was at the Faire, at least three people offered me not only disk copies of the ROMs but commented source code to the Macintosh OS, so it's pretty safe to assume that it's widespread among the hacker community. It's also safe to assume that while MacCartridge is a neat hack, Rosenblum and Small aren't the only ones who can think up a way to make the Atari run Macintosh programs right out of the box. Macintosh software developers aren't likely to be unhappy selling to this new market, either.

I don't know what's going to happen, but I think I'm in no danger predicting that by the time you read this there will be a number of ways of making an Atari pretend to be a Macintosh. The Atari may never run some Macintosh software without modification—stuff like Wizardry with really serious copy protection, for example—but much of that will eventually be ported over to the Atari anyway; and meanwhile here's yet another way to expand the Atari ST's software base.

MACNOSY

MacNosy is a serious Macintosh disassembler from Steve Jasik. I first saw it last year at the MacFaire. It has since been improved, and I've yet to meet anyone who didn't think it was worth the money.

One letter from a satisfied MacNosy

user says that it lets you find out what the Macintosh ROM routines really do, as opposed to the hints given in *Inside Macintosh*. That appears to be true; I guess you aren't supposed to wonder why Apple charges a lot of money for a book of hints. After all, Infocom sells hints for its adventure games.

Do understand, a disassembler is a hacker's tool. If 68000 assembly language means nothing to you, MacNosy won't be worth anything at all; but if you're out to hack your Mac, you need MacNosy bad.

AT LIGHTSPEED

I have a problem with language reviews. Readers tell me they appreciate being told about new developments in languages, so I try to say something about them; but it's very difficult (read "impossible") for me really to work with every new compiler long enough to determine its strengths and weaknesses. Of course, in a show report that doesn't matter a lot anyway, since show reports are impressions, not full reviews.

With that said, I can talk about Lightspeed C. This thing compiles code at a demonic rate. It comes with a whole bunch of routines to interface it with the Macintosh, as well as a 68000 assembly language debugger. You can use Lightspeed on a single-drive 512K-byte Mac, but you're much better off with two drives.

The Lightspeed documents are very clear and well written, provided, of course, that you are familiar with the C programming language; Lightspeed doesn't pretend to give you a language introduction manual. There's ample instruction on interfacing with Macintosh ROM routines, including QuickDraw, and an excellent index.

I am extremely unlikely to do any C programming for the Macintosh, but if I decided to try, I'm pretty sure I'd start with the Lightspeed C compiler. C hackers I respect tell me there are some bugs in the present version of Lightspeed C, but Think Technologies has a good list of them and is working hard to correct them; by the time this is in print, most should be fixed.

(continued)

I tried to persuade Think Technologies to port the system over to the Atari ST. I think I heard them say they were working on it. It should be worth watching for.

A New Magazine

The last couple of years haven't been particularly good ones for computer magazines. Several major ones folded up, and others began to look pretty sick. However, hope springs eternal, and new ones do appear.

Tony Bove and Cheryl Rhodes have been in the micro revolution for a long time. Their strong point has been clear writing, generally but not invariably for beginners; they have the ability to make complex notions understandable. Their *Users Guide* magazine was about the best CP/M publication around, and one of their books was in the "Pournelle Users Guide" series by Baen Books. In 1985 they founded a new magazine, *Desktop Publishing*. It was, of course, rather specialized, so much so that I didn't even hear about it until they were doing the third issue. Just about then they were acquired by CW Communications, the outfit that publishes the *PC World* series. The name will be changed to *Publish!*

Tony and Cheryl were excited about all this when I saw them at the Faire. I hope it works out well for them. I found their three issues of *Desktop Publishing* quite well done, and I'd have been happy to subscribe. I'm not likely to go into the publishing business for myself, but I make my living as a writer; it's important to keep track of all new developments in publishing, and the trend to more and more author control, right up to finished typesetting, is getting stronger all the time. I suppose now I'll still subscribe, but I can't say I find the name change as thrilling as Cheryl and Tony seem to think it is.

Publish! is likely to remain pretty specialized, but the niche it fits in may be expanding more rapidly than most people think. As the niche expands, they'll get competition. As it is, though, they're moving into an area that has largely been left to the Seybold family, and the Seybold

(continued)

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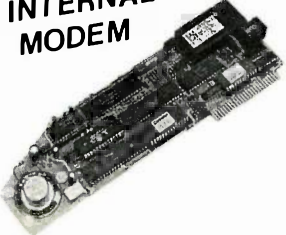

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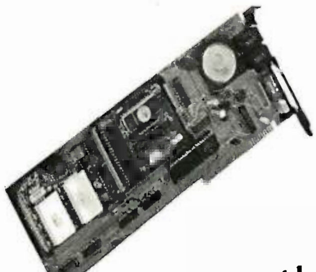

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reports aren't competition for *Publish!* because Seybold publications are expensive and don't take advertising.

Incidentally, the Seybold reports are almost indispensable for those serious about keeping up with the absolutely latest developments in the fields of publishing and serious use of microcomputers.

DESKTOPS

"Desktop" publishing isn't an unforeseen phenomenon. A number of writers, including me, predicted that small computers would have an impact on the publishing industry; that impact is just beginning. The effect isn't as great as some predicted because printing is really the smallest part of publishing. The real job publishers do is marketing and distribution. After all, if you had enough money, you always could get a rather handsome book printed by one of the vanity presses—the official name is "author-subsidized publishing"—but because the bookstores know all about those, the typical self-published book is lucky to sell a hundred copies, including to the author's relatives. There are exceptions, but in general, getting your book competently printed isn't the real barrier to effective publication and it never has been.

On the other hand, every author has horror stories. Ogden Nash did a wonderful poem about an author "who took a gun and shot that printer who printed 'not' instead of 'now'," and in the poem the judge lets him off on the grounds of justifiable homicide. During the height of the Napoleonic wars, an authors' convention in England toasted Napoleon who was "if you will, the enemy of all mankind, but who once shot a publisher." The enmity between authors and publishers has quite a lot to do with murdering one's text: editors who substitute their phrasing for yours (that doesn't happen to me often); lousy proofreading; and suchlike.

Small computers, and programs like the excellent Print Shop series and accessories by Brøderbund for the IBM PC, are making it possible for authors to have real control over what their text looks like when it gets into print.

Of course, that means that if it's really fouled up there's no publisher to blame . . .

MIDI

MIDI (musical instrument digital interface) is a standard; it's a bit like ASCII, only it's a way to represent music rather than text in a computer. It's also a hardware standard that specifies a 5-pin DIN connector—sort of as if the ASCII standard also mandated using RS-232C ports.

MIDI is going to change the world. I saw only a little of this at the Faire, and I don't expect to see much at COMDEX Atlanta next week; but MIDI and small computers are bringing about a revolution in music.

For instance: whole movie scores, with what sounds like a full orchestra, are being written and performed by a single composer equipped with a keyboard and a computer. People who have never practiced, can't play an instrument, and don't know how to read or write music are now recording and performing. Most are hobbyists, but some are doing well commercially. New ideas abound. New products are announced weekly. There's a ferment in the music scene that reminds me of the early enthusiasm among computer hobbyists.

Interestingly enough, most of this is happening unbeknownst to computer people. There is some overlap. The man who brought all this to my attention is Bill Burns, a computer hobbyist I met at the Hacker Convention in the fall of 1984 and again at the Faire this year. Bill was an early member of the Homebrew Computer Club.

He tells me that if you've got an IBM PC or a Macintosh, you can get into the computer music revolution with a pretty small investment. His recommendation is for a PCompatible; the Roland DG MPU-401 MIDI adapter, which is a PC card and a small box; one of the MIDI-compatible Casio music synthesizers; and a program called Personal Composer. With those items, you can write symphonies even if you've never played a note in your life.

It works this way. You get an idea for a tune and get it into the machine, if necessary by playing it in one finger at a time on the keyboard. You can then edit the result: change notes; change their duration; change the "attack" or compression; add notes; put in new simultaneous sounds; blend in new instrument voices like horns; and keep fooling around with that until you have what you think sounds right. After that you can do another melody, or an expansion of the old one, and blend it into the original. The result will likely be bloody awful, but it might not be, and anyway you can edit that, too.

When it's all done, Personal Composer will print out what you've written, in standard musical notation, on an Epson MX-80 printer. It's slow,

(continued)

since it does it a dot at a time, but it does the job.

So far the musical revolution has been dominated by musicians who have discovered computers and are teaching themselves how to use them. A good part of the ferment centers about *Keyboard* magazine, which used to be a publication for performers but has become something like the BYTE of the computer music hobbyist. *Keyboard* is filled with advertisements for electronics, computer stuff, and programs: you can buy a thousand musical voices for a few dollars. Join users groups. Things like that.

When the old master computer hackers discover this new scene—and some are beginning to—the cross-fertilization ought to be something wonderful to see. Oops. To hear. I can hardly wait to try it. I've some notions for variations on a theme by Mozart . . .

GENERIC CADD

Computers change everything. Architects are among the last resisters to CAD, which is a pity; but that won't last. One reason it won't is because so many of their customers *will* have a CAD system.

AutoCAD holds a commanding lock on the top end of professional CAD systems for microcomputers; but it's pretty expensive for those who just want to learn what CAD is all about and maybe want to design a new room, or a toolshed, or just see how they might rearrange their furniture. For people like that, comes now Generic CADD by Generic Software. This is a PCompatible program that does quite a lot and sells for less than a hundred bucks.

It doesn't pretend to do everything. In particular, Generic CADD doesn't handle overlays as well as AutoCAD; but it does do layers and overlays.

I saw the program demonstrated at the Faire, and I've had a copy to play with for a couple of weeks. It runs just fine on Big Kat, the Kaypro 286i PC AT work-alike with Logitech's Logimouse, and while you had better be determined to learn it—there are some puzzling concepts to get used to—I haven't had much problem. I'm putting the new office additions into it. It's as easy a way to learn to use a CAD system as any.

I wish I'd done that before we did the office. Not that I'm not pleased with my office and library; but here and there, changes of a few inches would have made some odd-size cabinets and desks fit better, and I'd have discovered that if I'd done a CAD model before construction began.

Next time I'll have all that. Meanwhile: if you're serious about design work, you probably need AutoCAD; but if you're just interested in CAD and want to know more, you might find Generic CADD more than good enough.

MACINTAX

In the cold light of the next morning this *may* not be the all-time best ever

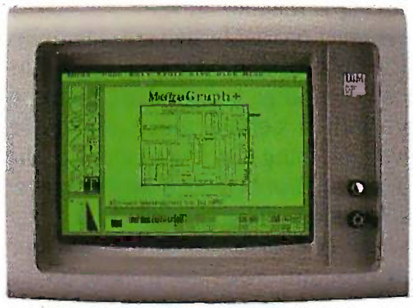
(continued)

640 x 350 16 COLOR

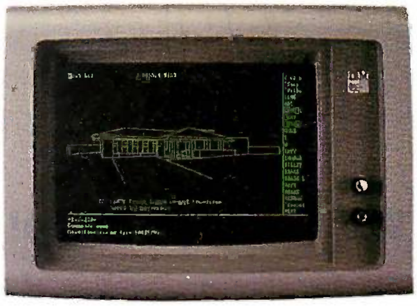
EGA PAINT

GEM

FLIGHT SIMULATOR



PAINT BRUSH



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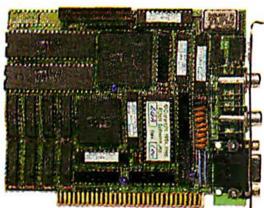

IBM sets the standards for Monochrome, Color/Graphics and the Enhanced Graphics Adapter. Hercules sets the Monochrome Graphics standard. And the MegraGraph-Plus simply redefines the standard for what the Graphics Adapter is supposed to be: Monochrome text, Hercules graphics, color graphics, enhanced graphics. And most importantly . . . No software driver patches required.

Fully Compatible

You can run almost all software from your early investment. Including Flight Simulator, Pin Ball, Jet and Lotus 1-2-3 Version 1A.

And it will still run all the business software packages written for IBM Enhanced Graphics Adapter (EGA). Examples include Auto CAD, IBM Drawing Assistant, Gem Draw, Microsoft Window, Word & Chart, Lotus 1-2-3 and Symphony, Dr. Halo, PC Paint Brush, EGA-Paint and many, many more.

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CGA compatible	✓	(1)	(2)	(2)
MDA compatible	✓	✓	✓	✓
Chip count	24	29	86	40
Hercules compatible 720 x 348 graphics	✓	✓		
No Software Patches required	✓		✓	✓
Boot from:				
— Flight Simulator	✓			
— Pin Ball	✓			
— Jet	✓			
Runs Lotus 1-2-3 version 1A:				
— Hercules mode	✓	(1)		
— Color mode	✓	(1)		
Two Video Jacks	✓	✓	✓	
Display Memory	256K	256K	64K	256K
Light Pen connector	✓	✓	✓	✓

(1) Needs software driver patches.
(2) Compatible only to the BIOS level, but not the hardware level. Will not be compatible with most games software.

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Inquiry 31

most wonderful program I've used, but it's a candidate; and about 10 p.m. on April 15 I was absolutely certain of it. People, Softview's MacInTax is wonderful. This is a program worth buying a Macintosh for.

As you probably suspect, MacInTax does your income taxes on a Macintosh computer. It does them painlessly. With a certain grace and style, even. Nothing is going to make doing taxes fun, but by gum if anything ever would, this program will do it.

Now, of course, this isn't an accounting program. You have to have all the information demanded ready at hand. For me that's no problem. My life is pretty complicated, and most of it is deductible—provided, of course, that I can prove it. Naturally one of the first things I did when I got a microcomputer was to write an accounting system that would handle all my sources of income and the myriad deductible ways I spend it. Later I added a check-writing system, so that each month I enter my bills and credit-card purchases, poke a couple of buttons, and watch the checks roll out. All those entries are then stored until tax time. Even so, my family has always said they'd rather visit the Inferno than be around me during tax time.

Not any more.

MacInTax is like—well, it's like having a personal tax preparer who *listens*. With MacInTax you never enter information more than once. You never do any calculations at all. Once MacInTax knows enough, it fills in everything it can, and if you change something, it recalculates.

Technically, MacInTax is a series of linked, formatted spreadsheets; but that's a bit like saying that one of Monsieur Andre Lion's medallions of beef with wild forest mushrooms is partly oxidized muscle tissue covered with fungus. What happens with MacInTax is that you start with the basic 1040 form on screen. You go through, adding information where possible. When you can't go any further, pull down new schedules. Schedule B for interest. Schedule E for rents and royalty income. The husband and wife form. Each time you enter something on one of those forms, everything affected changes.

Want to experiment with income averaging? Save your previous work and try it; see what it does for you. Ever get everything all done and suddenly remember another deduction? Sure you have. With MacInTax it's simple. Just go in and add it.

When you're all finished, MacInTax checks things. Does the law require that you explicitly enter -0- somewhere? MacInTax will tell you. Have you made a mistake somewhere else? In general, MacInTax won't let you do that, but if you did, it may find that, too. Eventually, when all is ready, send it to the printer. Laser printer or Imagewriter: MacInTax will generate completely filled-in forms, ready for signing.

As a bonus, it will do your state tax if you live in California, and Softview will be adding other states for next year.

If you do your own taxes or if you're *thinking* of doing your own taxes, get this program, even if you have to borrow a Macintosh to run it on. It's that good.

Boy, is it ever recommended.

TEKMAR GRAPHICS LIBRARY

This is a preliminary report: preliminary because just at the moment the Tekmar Graphics Library is tied to the Tecmar Graphics Master Board for the IBM PC. The Advanced Systems Consultants people are rewriting their science/engineering curve-fitting and plotting programs to work on a standard EGA, and they tell me they'll have all that done about the time you read this.

What they have now is pretty slick. For less than $200 you get eight disks, a thick and well-written manual, source code to much of what's supplied, subroutines to let you build your own stuff or modify theirs, and as good a scientific plotting/curve-generation program as I've ever seen. The output of the program is totally under user control, and it can be as flashy as you like: multiple colors, labels, windows with detail inserted in dead parts of the graphs; you name it, and you can do it.

The documents are *complete*. They tend to be hacker-oriented, but gen-

(continued)

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What's more, at high data rates, the modem's built-in error detection-correction protocol ensures error-free transmission when phone lines get too "noisy." Constantly monitoring the line, FASTCOMM 2496 quickly bounces you back to top speed when the lines clear. Your data remains intact and error-free! You get optimum performance without the worry!

#3 ...you can choose the flexibility of an internal modem.

The FASTCOMM 2496B may be the version for you! Ideal for PC applications, this half card inserts into any full or short expansion slot in your IBM PC, XT, AT or compatible, leaving you more room for other expansion uses.

#4 ...or choose the portability of an external modem.

Our external version—the compact FASTCOMM 2496—is a superb choice for PC terminal to mainframe applications. Its LED status indicators and speaker control make for easy monitoring during operation.

#5 ...or choose only the speed you need, now.

Start with either our FASTCOMM 9600 or 2400, at even lower prices. Later, snap in additional speeds by purchasing our FASTSNAP boards, available for both the external or half card modem.

#6 ...customize your modem to suit your needs.

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The FASTCOMM 2496 runs with virtually any asynchronous communications software that can support 9600 baud, including *Crosstalk XVI, Carbon* Copy, *Respond, Relay Gold, Q Modem, Blast and SimPC 3278.*

#8 ...and you get top to bottom service.

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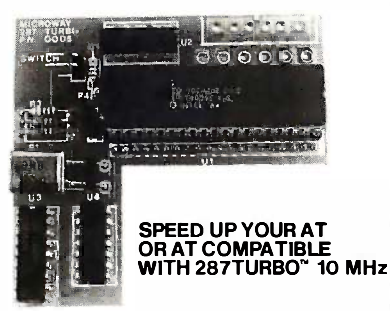

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erally any engineer or scientist who understands his own data would be able to use this program, given a bit of patience and determination. If you've got curves to fit and plots to make and access to a machine with a Tecmar Graphics Master Board, this is probably the program for you. If you've got everything but the hardware, it might be worth finding out how far they've got in the rewrite. There are easier programs to use, but I haven't seen any that beat this for value.

Winding Down

As usual, there's a huge pot full of stuff I can't get at. As part of this mad month, I was up to Bellingham, Washington, a town that Larry and I pretty well flattened in our novel *Footfall*. Bob Wallace, who invented shareware with his PC-Write, came up; he's entirely redone the manual, as well as added new features. PC-Write is one heck of a value for the money.

Spruce Technology has renamed their intelligent programming editor that understands quite a lot about the C language. They call it First Time, and anyone who hacks Microsoft or Lattice C on PCompatibles would be well advised to look it over. A number of programmers I respect swear it saves them quite a lot of time and frustration. First Time has syntax checking, "place holder" markers, ways to edit include files, and a whole bunch of other conveniences, as well as more standard program editor features like search and replace. It isn't copy-protected. Good value. There are Pascal versions as well.

The book of the month is *Price Theory: An Intermediate Text* by David Friedman (South-Western Publishing Company of Cincinnati, OH, 1986). I wouldn't normally read an economics textbook for fun, but this isn't a normal economics text. I've known David for some years, and I wouldn't expect *anything* he wrote to be normal. This book tries to explain darned near everything people do in economic terms, and whether or not it succeeds, it sure ain't dull. I wish they'd used it as a text when I studied the subject.

The game of the month is Star Raiders II for the Atari ST, which is like the old 8-bit Star Raiders had died and gone to heaven. The action is fast, the graphics are gorgeous, and I've spent entirely too much time with it.

Tomorrow morning I'm off to Austin, Texas, for a meeting with the chancellor; from there to Berkeley, California, for the science fiction Nebula Awards banquet; and from there direct to Atlanta for COMDEX. My new office is finally finished and it's wonderful. Now I have to figure out a way to be in it for a while. Every now and then someone asks me why I do all this. Sometimes I wonder too, but not for long. The truth is, I love it.

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE *Publications, 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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MORE WORDS

BY EZRA SHAPIRO

Word processors: Mindreader, PC-Write 2.6, and Word 3.0

Enough already. I'm getting sick of word processors for MS-DOS machines. You'd think the flood of these products would die down, but no, here are three more of the beasts. At least I've just about made it to the bottom of the pile, and I'll be able to avoid them for a month. Maybe two months. Maybe . . . no, I'll just have to see what wanders in. But next month, I promise, I'll have something different. Maybe graphics. Anything but another word processor.

STRANGE BREW

Mindreader (Businessoft, $189) has got to be the oddest product I've used in a long, long time. Before I go any further, I ought to state flatly that Mindreader is a failure as a full-featured word processor, which is what it's supposed to be. If you're only going to be writing small documents—memos and short form letters and the like—you probably could live with the program, but if you have a big writing project, Mindreader just won't cut it. The basic word-processing engine it employs is underpowered, clumsy, and poorly organized.

However, parts of the program are absolutely brilliant, and I'd pay far more money than Mindreader's price for a word processor that had them. Mindreader is a peculiar mixture of the astonishing and the irritating. So I wind up straddling the fence on this one; I simultaneously hate it and love it. My long-term hope is that Mindreader will be improved in future versions, or that other software publishers adopt its innovations in their products. And there are lots of innovations at which to marvel.

The program is certainly fun to use. It loads with graphics and sound effects reminiscent of an action-oriented video game. Although you can shut off the beeps and trills and scales the program makes, they add an air of humor to what everyone else takes as deadly serious business. The configuration routines are also designed to be entertaining; rather than selecting from a standard palette, you get to choose from a list of color combinations with names like "Sahara" (white letters on a black screen) and "Hawaii" (yellow on blue). Mindreader even contains an anagram game that you can play when you want to take a break. I like all this stuff; why should business software always be tedious?

But Mindreader's greatest strengths lie in the area of what could best be called auxiliary text-handling features, by which I mean features peripheral to the actual entering and editing of copy. Tops on my list is Mindreader's glossary, in which you can store as many as 260 boilerplate text items. Each item can be inserted anywhere in your document with three keystrokes, or you can enter keyword labels and locate the right boilerplate by performing a keyword search. An entry can contain up to 700 characters, including carriage returns and prompts for user input, so you can create phrases, paragraphs, signature blocks, even data-entry forms.

Next is what Mindreader calls WordComplete, and it's what gives the program its name. Here's how it works: Type a couple of characters. If the characters match anything in Mindreader's extensive dictionary, the program pops up a window that offers you the five most likely choices for completing the word. You can type a semicolon for the most common choice, or a number from 2 to 5 for the others. This sounds like it would be more trouble than it's worth, but in practice it's a major boon for slow typists, resulting in massive reduction in keystrokes and a commensurate increase in effective typing speed. If you set the program to its "AI Learn" mode, it will monitor your choices, remember what you're most likely to type, and upgrade that item to the number one spot. You can also force the program to offer specific options; I configured the program to make the phrase "Ezra Shapiro" the primary completion every time I typed an E. Faster typists can either turn this feature off or set it to standby mode for use when needed.

Mindreader also gives you keyboard macros, as-you-type spelling checking (although it doesn't suggest alternatives), a built-in calendar and appointment book, a pop-up calculator, both vertical and horizontal computation in text, and a name/address database that makes for easy merging into form letters. A status command displays file space used; counts of words, lines, characters, and keystrokes; a keystroke reduction factor; and typing speed. And there's TurboCursor—after passing seven characters at normal speed, the cursor accelerates to double time.

So what's wrong? Plenty. Mindreader can only handle files up to 44K bytes. Block moves and copies can only be of single lines or groups of

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I can sum up what makes me like Quicksoft's PC-Write in one word: attitude.

lines—no phrases or sentences that start or end in the middle of a line. Block deletes aren't allowed. There is no true insert mode; pressing the Ins key splits the line, you enter your additional copy, then press Ins again to close things up. There's no command to move the cursor to either edge of the screen. You have no way to reassign function keys or eliminate the function-key map that fills both the top and bottom margins of the display. Page numbers can't be used in headers; they appear centered at the bottom of the page or not at all. No footers. You have only two printer choices, laser or standard. Both the game and the name/address index can be accessed only from the main menu, but exiting from either drops you out to the DOS prompt.

Also, Mindreader is so insistent on being helpful that it adds the appropriate spacing after every punctuation mark. I couldn't figure out a way to defeat this; as a result, I wound up with two spaces after every comma (one from the program and one that I typed instinctively), three or four spaces at the end of every sentence, and so on. For a real laugh, try typing DOS filenames with their embedded periods and watch what happens.

My conclusion is that anyone out there who's trying to write the Great American Word Processor should buy a copy of Mindreader and study it very carefully. Hunt-and-peck typists with light word-processing needs will enjoy the nifty features without noticing the problems. But anybody who wants heavy-duty capabilities should look elsewhere.

A final note from the Harsh-Realities-of-Life Department: Version 1.0 of Mindreader came to me in a dark blue box with a funky drawing of a wizard and the slogan "writes like a charm." The manual was written with a light touch and stressed the friendlier aspects of the program; the software wasn't copy-protected. I based this column's evaluation on version 2.09, which arrived in a gray box with the slogan "Artificial Intelligence for Business Writing." The documentation had a much more sober tone, and—you guessed it—the product was copy-protected. Make of this what you will.

Shareware Classic

I can sum up what makes me like PC-Write (Quicksoft, $75) in one word: *attitude*. The program is one of the earliest shareware products for the PC-and-compatibles world, and shareware it is, perhaps more truly than other programs lumped into the category.

You can obtain a free copy of the program—a complete, legal, working copy—from a users group, a friend, or an electronic bulletin board. If you'd like a copy of the disk, Quicksoft will mail you one for a mere $10. You're encouraged to use it and to give copies to anyone else. When you decide you like the program (or when you can't live with the guilt), send Quicksoft $75. In return, you get a disk with an individual registration number, a bound manual, a tutorial, a summary pamphlet, a quick-reference card, a one-year subscription to Quicksoft's quarterly newsletter, two postcards to mail in when you want either a new version of the software or complete source code (Microsoft Pascal and assembler), and a year's worth of telephone support. If that isn't enough, any time someone else registers a copy of PC-Write and submits your number, Quicksoft will send you $25. (If you give three people copies of your PC-Write disk, and they all decide to register, you've made back your entire investment.) Whew! This is the best deal in software.

The attitude goes further, too. The newsletter publishes known bugs and fixes when possible. (Remember when Ashton-Tate did that with dBASE II and built its customer base into a loyal family?) And the PC-Write manual notes that even though the program comes with definition files for something like 200 printers, if you've got an obscure printer not covered, just send the company a copy of the printer manual and Quicksoft will write a custom configuration file for you. You know any other company that does that?

I believe in Quicksoft and what the company is doing. The product has been improving steadily, and the recent jump from version 2.55 to 2.6 is another significant step to make a good program better. However, as big a fan as I am, I do have some warnings to issue.

PC-Write is not for the fainthearted or the easily confused. It's powerful but idiosyncratic; it has grown slicker over the years, but the program is still the child of its author, Bob Wallace, and his mind doesn't work the way mine does. I've faulted other products for many of PC-Write's qualities, but somehow this program hangs together better than the rest.

It's a throwback in that it's a two-part word processor: editor and text formatter. The editor is fast and versatile and ranks with the best. The formatter is controlled by dot commands entered in text (a style I detest), but they do offer pinpoint precision.

What I dislike most about the editor is the way it uses nearly every available key combination, to the point where I get thoroughly lost. The Ins key, for example, inserts a space; to toggle insert mode you have to press the Scroll Lock key. The numeric keypad plus-sign key repeats a search, so you can't use it to enter the character. As a safety net, PC-Write accepts many of WordStar's commands, but they use up still more keyboard possibilities.

On the other hand, what I like about the program is its marvelous reconfigurability. You can reassign keys to functions or functions to keys (effectively the same thing) and set up format defaults best suited to your tastes. You can even use the reassignment system to hold macros and boilerplates, if you can find a trigger key that isn't already assigned. Figuring out how to do all this requires a bunch of head-scratching and manual-riffling, but it's worth the torture. Only drawback is that your reconfigured

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(MS-DOS)
Quicksoft
219 First N, #224
Seattle, WA 98109
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WORD 3.0 .... $450
(MS-DOS)
Microsoft Corp.
16011 NE 36th Way
Redmond, WA 98073
(206) 882-8080

command set will be out of whack with PC-Write's prompts. If you're that concerned, you *could* always get the source and recompile it, right?

New features with this version include automatic reformatting, embedded ruler lines, up to eight header/footer lines, orphan control, directory editing, footnotes broken over page breaks, automatic numbering of footnotes and headings, enhanced dot commands, support for more printers, and proportional spacing.

The new documentation, bound in a hard cover that makes it look like a high school literature textbook, is light-years ahead of what it once was, but it's still oddly structured and repetitive. Everything you want to know is there, but it's tough to find. However, the program itself is now actually informative. The four cramped help screens of earlier versions have given way to 40 well-designed screens, and the enigmatic command prompts have actually turned into decent menus.

On the whole, I like the program, and I'm continually amazed to discover the neat features that Wallace has tucked away in the cracks. It's a good package even if it represents a journey of exploration.

Oh yes, be sure to phone Quicksoft

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before ordering anything. The company was talking about price changes on July 1, but when I wrote this it hadn't yet made any final decisions.

WORD, BRIEFLY

More good news and bad news. The good news is that Word 3.0 (Microsoft, $450) is faster and sports a number of spiffy new features. The bad news is that it's still Microsoft Word.

Microsoft seems determined to make a run on the desktop publishing market, and to that end Word supports nearly every printer ever manufactured, particularly ones that include the word "laser" in their names. My hunch is that this release is a first step in that direction, and that Microsoft will continue to enhance the product to make it a winner in this arena. So I think it's a good bandwagon to ride on.

The hot feature is moderately powerful outlining capability. New commands allow you to expand and collapse blocks of text in outline form. The program is primarily a word processor, not an outliner, and I'm still not comfortable working with it. I'm accustomed to using Ready! to maintain small outlines that I pop into my documents. Word gives you the ability to really develop a text document as easily movable chunks. Barring the sudden appearance of a cheap monitor that can display several pages of text in sharp resolution, this may be the only method of zooming between structure and detail that we'll have for a while. I have to admit I'm tempted to spend a lot of time with this one.

So I'm giving the product an early plus rating, even though I loathe the Microsoft interface (the one with the useless box around the screen and the menu along the bottom). But it works great with a mouse, and overall it's a solid package. The documentation is thick and thorough, and not badly written. The disk tutorials are excellent.

Is this a recommendation? I'm not sure. I think I'll have to run the product head-to-head against PC-Outline, MaxThink, and whatever Living Videotext is cooking up and get back to this later. ■

GOING TO THE FAIRE

BY BRUCE WEBSTER

Bruce also debates product values with Commodore and Atari execs

It's late April as I write this, and a few weeks have passed since my trip to the 11th Annual West Coast Computer Faire. The Faire used to be an important trade show where new products made their debut and rival companies covertly (or overtly) scouted each other out. I attended my first Faire some years back as a representative of a software firm introducing a major revision of an existing product. I can still remember the worry about what our competitors might be bringing out and our delight in discovering that we had jumped ahead of all of them. Since all the major companies in that market segment were there, it was good news indeed.

Now the Faire has become more an exercise in nostalgia than a vital happening. As a computer industry event, it no longer matters. Press announcements, market research, and COMDEX have supplanted the Faire and reduced it to a local end-user computer show. In fact, plans are underway to hold Faires in different parts of the country.

At this point, you can insert standard sermon B-5 about How The Industry Has Matured. Sadly, all the clichés in the sermon are true: Things *have* changed irrevocably, and it ain't ever going to be as fun (or easy or cheap) as it once was to get in there and slug it out with everyone else. I don't see much evidence, though, that this maturity has improved the industry. A lot of turkeys still hit the shelves, only now many are kept alive longer than they deserve to be, thanks to fancy dressings and constant infusions of advertising money. Meanwhile, a lot of valuable, innovative products never get onto the shelves because the firms pushing them don't have the bucks to compete with the big boys.

Lest I sound too gloomy, let me hasten to add that I sense a shift of direction in the pendulum's swing. Many consumers have learned that slick packaging and gorgeous ads don't necessarily indicate a product's true worth, nor does a photocopied manual in a plastic bag mean a program is buggy or inadequate. Thanks to Turbo Pascal and similar products, buyers have learned that price and value are not necessarily related; an inexpensive product may be quite good and an expensive product quite bad. Indeed, a growing number of users are starting to suspect an inverse relationship between price and value.

A brief aside. The legend of Turbo Pascal has by now reached mythic proportions in the industry, as evidenced by the number of firms that, in marketing meetings, make plans to become "the next Borland." As with any legend, a few ironies stand out. First, Borland didn't achieve its success by imitating another firm; instead, the company found an empty niche and gambled that it could succeed by filling that slot. Second, Borland itself is in danger of being overwhelmed by its own success and becoming (if it hasn't already) just another one of the big boys, instead of the renegade innovator that it portrays itself to be. The company seems to be falling prey to some of the common sins of the industry: not offering enough technical support, introducing too many products (some of dubious value), preannouncing new software (a practice Borland used to shun), and even advertising vaporware (will Turbo Pascal for the Amiga ever be released?). On the other hand, given Borland's track record and market position, the company can probably do what it wants to—for now, at least.

Getting back to the original topic, there is still a lot of value in shows like the West Coast Faire, the Mac Exposition, and so on, because they provide small, innovative companies direct exposure to users and to the press. Of course, they also provide exposure for small, dull companies, for large, dull companies, and other distractions, so that users and the press have to try and sort one from another. But that's part of the fun. (The question asked most often at the Faire was, "What did you see that was interesting?")

In summary, I wish the Faire a long life. I, for one, plan to keep coming back.

FAIRE HIGHLIGHTS

What did *I* see that was interesting? Well, the most significant product was Lightspeed C from Think Technologies, the same folks who developed MacPascal and Instant Pascal for Apple.

Lightspeed C is an integrated C development environment for the Mac that looks as though it could really speed up program development. Not only does the compiler scream along, but the linker is also amazingly quick and intelligent, allowing quick turnaround time for program changes. It appears to be a full-featured C, with complete Macintosh Toolbox and operating system support. And

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it's cheap: $175, compared to $250 to $500 for most other Macintosh C compilers.

Lightspeed C was developed primarily by Michael Kahl, with help from Jon Hueras. Andrew Singer, president of Think Technologies, was involved in the product's conception and design. I just received a review copy; look for a more detailed report in the next month or two.

The most interesting product, and one which you've undoubtedly heard about, was MacCartridge from Data Pacific. This is a ROM cartridge for the Atari ST that contains—surprise!—the old 64K-byte Apple Macintosh ROMs. When used with a host program, it converts your ST into a quasi-Macintosh. There remain the small problem of disk formats (though Data Pacific offers Mac software transferred to ST disks) and the large problem of Apple legal action, which may well have killed the product by now.

David Small, who was exhibiting MacCartridge in one of the Atari users-group booths, said he was visited by a contingent from Apple, led by Guy Kawasaki (noted software evangelist) and "a lot of guys in T-shirts who talked like attorneys." Small evidently persuaded them that he had done nothing actionable and even tried to convince them that such a product would ultimately help Apple, though I suspect it would help Macintosh software developers far more than it would Apple. And since said product would also help Atari an awful lot, I see little chance of Apple giving its blessing to MacCartridge and a good chance of the company actively opposing it. Small says he has no funds to fight a legal battle and so would have to fold at the sign of any threat from Apple. It was a great hack, though . . .

One product that I walked by two or three times before noticing was Morgan Computing Company's Advanced Trace86, an upgrade of the firm's Trace86 debugging utility for IBM PCs and clones. Trace86 is already a good alternative to the MS-DOS Debug program, but the advanced version provides several enhancements and improvements. According to the flier, it has an assembly language interpreter that does incremental assembly of instructions as you type them in. It also allows you to create assembly language programs and save them as .COM files. The program runs on IBM PCs with at least 128K bytes of RAM. Since 8086 assembly language programming is not one of my strong points, I'm very interested in using this to help me make the plunge. Look for a follow-up here once I get a review copy.

There weren't too many finished (shippable) Amiga programs showing at the Faire, but I did see a beta-test version of Mimetics Corporation's Sound Scape, a program that turns your Amiga into a synthesizer and MIDI (musical instrument digital interface) sequencer. Adding a MIDI adapter to the serial port allows you to receive MIDI commands from other devices, or you can use the Amiga's keyboard as, er, a keyboard. Watching the demo, I got the feeling that I could really compose some interesting (and maybe even enjoyable) music with it, prompting BYTE's Ezra Shapiro to comment on the "triumph of technology over talent." A finished version of Sound Scape should show up here in a month or two; again, look for a more detailed report then.

One Amiga product that *is* being shipped is a version of Aztec C from Manx Software. You may recall from my May column that I ended up switching from Lattice C to a beta-test copy of Aztec C for most of my Amiga benchmarks, with a significant improvement in times. Not only that, but Aztec C has its own linker that works a lot faster than the standard Alink program that Lattice C uses. I'll be curious to see if this "finished" (is any compiler ever finished?) version is any better. Jim Goodnow, who worked heavily on the Amiga version, gave me some additional good news: Manx is porting Aztec C to the ST.

MEANWHILE, DOWN AT THE RANCH

My trip to San Francisco included visits to Atari and Commodore. At Atari, Neil Harris and Leonard Tramiel spent a fair amount of time with me, doing their best to answer some of my criticisms of the ST and to explain strong points I might have overlooked. In some respects, they were preaching to the converted—I think the 1040ST is a great machine and that Atari will probably sell as many as they can produce—but I appreciated their comments nevertheless.

Tramiel argued that GEM Desktop, the user interface on the ST, is just as powerful and easy to use as the Macintosh Finder. He made the valid point that "different" doesn't necessarily mean "better" or "worse" and that many users are so accustomed to the Macintosh Finder that they perceive GEM Desktop's differences as deficiencies. He also pointed out some of GEM Desktop's advantages, such as the ability to open a disk's window multiple times so that you can view different portions of a directory simultaneously.

Still, I think GEM Desktop is rigid and demanding compared to Finder. All windows have to be organized the same (names versus icons, as well as method of sorting). You can't rearrange icons within a window. Viewing by icons forces you either to open the window the full width of the screen or to do a lot of horizontal scrolling, since the icons are not adjusted to fit within the current window size. And those infernal drop-down menus are always getting in the way, requiring a lot of extra button pushing compared to Apple's patented pull-down menus. The irony is that GEM's developers at Digital Research designed the drop-down menu to avoid patent infringement and wound up having legal problems with Apple anyway.

Tramiel is right about one thing: I have been spoiled by the Macintosh, and I tend to resent GEM making decisions for me that I would rather make myself.

Tramiel and I agreed on another point, namely, the ease of low-level access within the ST. He showed me an animated three-dimensional Bessel wave function running through a 20-step cycle at an amazing rate of several cycles per second. The method was simple: All 20 steps were individual screen images that had been predrawn (at about 3 minutes each) and saved on disk. The demo program then loaded the 20 pictures into RAM, eating up 640K

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bytes (this was on a 1040ST). The program created an animation effect simply by changing the screen pointer successively to each of the 20 images. This simple technique would be impossible on the Macintosh and would be limited by the 512K bytes of "chip RAM" on the Amiga 1000.

The ST makes it easy to get down and mess with the "guts" of the machine; with the Macintosh and the Amiga, both the hardware and the system software tend to get in the way. I think that's very much the reason why ST software has come onto the market so quickly, while Amiga software has lagged behind.

The mood at Atari was upbeat and aggressive. The 1040ST and the new 520ST started shipping in March, relieving a lot of dealers who went through a lean period with few machines to sell. Atari even released an explanation for the delay in shipping: A plane loaded with 1040s was on its way to the U.S., stopped in the Philippines for refueling, then was unable to take off again for a few weeks due to the political upheavals caused by the then-pending presidential election. There *are* signs that the initial 1040STs were shipped in a hurry. For example, the initial models that dealers received did not have the promised RF modulator, though there was space for the circuitry on the motherboard and even a cutout on the internal shielding for the RF wiring to pass through. The customers don't really seem to care, though; reports are that the 1040ST is selling just fine.

GOOD SIGNS FROM COMMODORE

At Commodore, as well as at the local ComputerLand-Amiga show in San Jose, indications are that the company is finally getting its act together with regard to the Amiga machine.

First, Commodore planned a large exhibit at COMDEX/Spring. Commodore's absence at COMDEX/Fall and the Winter CES hurt them with developers and dealers.

Second, Commodore has a "limited time" offer of an Amiga 1000 plus an RGB monitor for just $1295; in effect, the monitor is free. That significantly shrinks the price gap between the Amiga 1000 and the ST models, a gap that had grown with the introduction of the 1040 and the unbundling of the 520.

Management changes are also encouraging. These include shifts in location (back to the West Coast) and changes in the people who handle third-party developers. Ever since Commodore moved third-party relations last year to West Chester, Pennsylvania, developers have been complaining about lack of cooperation from the company. Prior to that move, Caryn Mical (née Havis) had been doing an outstanding job in the West Coast office.

Finally, Commodore's new magazine ad campaign (touting the special bundled deal) appears to be better conceived and executed than previous efforts. It relies on understatement and simplicity rather than hoopla or bizarre imagery and makes the Amiga look like a business machine—something Commodore very much wants.

Even with all that, I still get a sense of carefully guarded frustration from some of the current employees at Commodore (and not-so-guarded frustration from those who have left). The frustration is not so much over current policies and directions; there is universal agreement that Commodore has finally committed itself to the Amiga and is heading in the right direction. The frustration is more in terms of lost time and opportunity.

MACINTOSH SHUFFLE

Hmm. Let me check my calendar here. Yes, it's time to pull out my gun and take some shots at Apple, rehashing old criticisms and relishing my being able to say "I told you so."

In April, Apple announced and released yet another Macintosh, the Mac 512K Enhanced. This represents the fourth (or, if you really want to get picky, the fifth) version of the Mac to appear in a little more than two years since the Mac was first announced. There was the original 128K Mac; purists may contend there were two versions here, the "original" original and the one with the same motherboard as the 512K Mac. Then came the 512K Mac, followed by the Mac Plus. Now we have the 512K Mac Enhanced, a machine with the new 128K-byte ROMs, an 800K-byte disk drive, and the same list price ($1999) as the old 512K Mac, which has been dropped (the second

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ITEMS DISCUSSED

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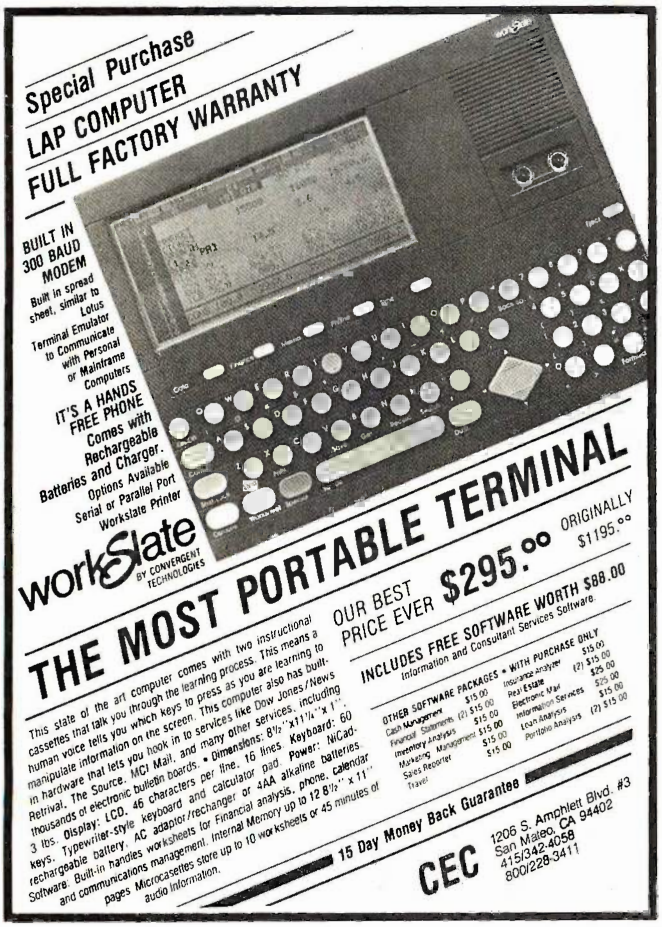

ACCORDING TO WEBSTER

Apple is apparently listening to what users want and doing its best to undo some of the unfortunate decisions made a few years back.

the old 512K Mac, which has been dropped (the second version of the Macintosh to die within the past two years).

Please don't get me wrong. I am not criticizing Apple for replacing the old 512K-byte Mac with the new one. On the contrary, I think it's a necessary move to make the new ROMs and disk drives the standard. And Apple is wisely providing upgrade paths from the old 512K-byte Mac to the new one and from the old and new 512K-byte Macs to the Mac Plus.

What makes me want to laugh (and sometimes cry) is the memory of the statements that came out of Apple a few years back, defending the machine's closed, limited architecture. The major claim was that programmers would not have to worry (as they supposedly do with, say, the IBM PC) about how much memory or what peripherals or ports the machine had. Instead, developers would always be assured of a fixed configuration.

Now, developers not only have to worry about four different models, they also have to deal with in-between versions caused by partial upgrades: two different keyboards, two different ROM sets (64K and 128K bytes), two different disk capacities (400K and 800K bytes), an optional SCSI port, whether or not HFS (hierarchical file system) is being used, if the +5-volt pin is available on the serial ports (it isn't on any Mac that's been upgraded to the new round serial connectors), and, of course, the amount of RAM available. This gives the Macintosh many of the disadvantages of an open architecture (with which Apple II and IBM PC developers seem to have somehow coped) and none of the advantages.

Again, I'm not really taking shots at the current Apple management, which now seems committed to open-architecture machines. The company is apparently listening to what the users want and doing its best to undo some of the unfortunate decisions made a few years back. I just hope Apple and other firms learn from those mistakes.

IN THE QUEUE

Lots of stuff is lined up for next month. Look for reports on Turbo Prolog from Borland, Lightspeed C, Multi-Forth for the Amiga, and the Supra 20-megabyte hard disk for the Atari ST. Until then, see you on the bit stream.

Thanks to James, Mike, and Mike at Lloyd's Computers for hardware repairs above and beyond the call of duty; to Neil Harris at Atari for his time and patience; and to Lynne Judd for tackling the stables of Augeas (or at least the modern equivalent). ■

FUJITSU PROCESSOR UPGRADE

BY WILLIAM M. RAIKE

UNIX *now runs on the* Fujitsu *with an* 80286 *chip on board*

The majority of personal computers sold in Japan are not designed to be IBM PC–compatible. That holds true for all of the computers in NEC's PC9800 series, as well as for the Fujitsu FM-16β. Fortunately, however, a considerable amount of U.S.-made software will run on these machines because they run under either MS-DOS or CP/M-86. Both operating systems are enhanced to support the extensive Japanese-language features built into these powerful computers. UNIX-based systems, though, have been scarce at the personal computer level; one exception has been the NEC PC98XA, for which a kanji (Japanese-language) version of Microsoft's XENIX operating system has been available for nearly a year. But recently Fujitsu announced an upgrade of its personal computer series that could make UNIX-based systems less scarce here in Japan.

FUJITSU'S 80286 BOARD

A major factor in my decision to buy the Fujitsu FM-16β last year was Fujitsu's announcement that an 80286 processor board would be available for the computer shortly. I had welcomed it as an opportunity to use the XENIX operating system. A prototype of the board was in operation at the same computer show where NEC introduced its top-of-the-line 80286-based PC98XA last spring; both ran Microsoft/ASCII's version of XENIX that supports the Japanese language. At long last, Fujitsu has released the new processor board, although its $500 list price doesn't exactly spur me to rush out and buy one. And the price of Fujitsu's version of XENIX, to be sold separately, hasn't been announced yet but may well be more than $1000. Having just switched from CP/M-86 to MS-DOS (see the May BYTE Japan), I'll wait before trying another operating system.

AN UPGRADE OF THE FM-16β

Fujitsu's introduction of its 80286 processor board is actually a side effect of the company's most recent steps to upgrade the FM-16β. This computer, based on the 80186 processor, is a powerful machine. I'm very satisfied with the one I bought last year. It can hold up to a full megabyte of RAM and uses an MBL68B09E coprocessor to relieve the main processor of the need to manage the screen and keyboard.

The upgraded Fujitsu FM-16β comes in four models: the FD I and HD I, and the FD II and HD II. The FD I and HD I are essentially the same as the original FM-16β models; the FD designation indicates two built-in floppy disk drives, while the HD models incorporate a built-in 10-megabyte hard disk drive. The main difference between the FD I and HD I models and the previous ones (FD and HD) is that the new versions come with a full megabyte of memory as standard, in addition to the standard 192K bytes of graphics video RAM; the older models came equipped with only 512K bytes.

The Japanese-language features of all the models are identical and extensive: They incorporate both the JIS (Japanese Industrial Standard) No. 1 and No. 2 kanji character sets in ROM, with a total of over 6000 characters, in addition to the normal alphanumeric character sets and the Japanese katakana phonetic alphabet. (The combination of alphanumeric characters and katakana is often abbreviated in Japanese brochures as the "ANK character set.") They can run either the CP/M-86 or MS-DOS (version 2.11 or 3.1) operating systems.

The core of the upgrade revolves around the central processor. The new FD II and HD II models incorporate an 80286 processor in place of the 80186 in the FD I and HD I. The 80286, the same processor used in IBM's top-of-the-line PC AT, runs at 8 MHz, the same clock speed as the 80186 in the FD I and HD I models, but it is a substantially more powerful chip. Among other things, its 24-bit addressing capability allows the processor to directly address 16 megabytes of memory. Contrast that with the 8088/8086/80186 chips used in most personal computers these days that can address a maximum of only 1 megabyte. The UNIX operating system and its variants generally perform best in an environment in which substantial amounts of fast disk storage (i.e., hard disk capacity) are available. UNIX can take especially effective advantage of large amounts of semiconductor memory (i.e., RAM disk), which is rapidly becoming inexpensive due to recent advances in large-scale integrated circuit memory technology.

Although the new Fujitsu models are not compatible with IBM's PC AT

(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 or its various clones, they can run under MS-DOS and XENIX. The amount of Japanese-language software you can buy is considerable, although it isn't much compared to the volume of software Americans can access if they own a PC AT or clone. Of course, Fujitsu FM-16β computers have no problems running U.S.-made generic MS-DOS software. And the price of this amount of computing power is low: At current yen/dollar exchange rates, the FM-16β HD II model with an 80286 processor, 1 megabyte of RAM, one 1.2-megabyte floppy disk drive, and one 10-megabyte hard disk drive sells for only about $3765. The dual floppy disk version costs only $2180. And for the FD I and HD I models the price reductions mean that the second ½-megabyte of memory is essentially free compared to the price of the older models. The dual floppy disk version sells for about $1895, while the hard disk model goes for about $3475. These prices are list prices—you can usually find discounts of around 20 percent in Tokyo's electronics district in Akihabara.

A FREQUENT QUESTION

The most frequent question I get from BYTE readers is, What software and/or hardware is available that will allow Japanese-language word processing on an IBM PC or PC clone? Unfortunately, my answer is always brief: To my knowledge, there is no such software and/or board available. The IBM "standard" is no standard at all in Japan, since Japanese personal computer hardware has generally been considerably more powerful and cost-effective than the IBM PC, PC XT, PC AT, or their many work-alikes. Japanese computers incorporate extensive Japanese-language features such as kanji-character ROM and operating system support for the Japanese language, together with some quite powerful graphics features.

Many letter writers asking that question are students and faculty members from American universities. Taking all things into consideration, it seems there would be a significant potential market for equipment (like a kanji ROM board in conjunction with something like the Hercules graphics board on the IBM PC and compatibles) that could work with at least one existing Japanese-language word-processing program for IBM PC owners. As far as I know, no one has approached this market, despite the thousands of boards you can buy for the IBM PC that perform various other specialized functions.

Another important potential market for a combined hardware/software solution to the problem of giving the IBM PC a Japanese-language capability is the growing number of foreign companies that market their products in Japan. For example, one American manufacturer of laboratory instrumentation equipment with a Japanese subsidiary produces a system based on an IBM PC clone. The company installs its proprietary circuit boards, which it then supplies along with its own special-purpose software. Company representatives asked my opinion about their plans to introduce the equipment to the Japanese market, with the idea that the computer could be performing useful tasks (such as word processing or other chores) when it isn't being used for taking laboratory measurements.

Since a computer that has no Japanese-language capabilities (such as the IBM PC) would have minimal usefulness outside the immediate (laboratory instrumentation) application, I felt the company's choices were limited. One might redesign the product around a Japanese personal computer like the NEC PC9801, but the potential market (perhaps one or two hundred systems per year) couldn't possibly justify it. Even for products with larger sales volumes, I can guess that with two separate versions of a product for home and export (i.e., Japanese) markets, the engineering improvements for the export model would take a back seat.

A CHALLENGE

I challenge BYTE readers with entrepreneurial inclinations to approach this problem. It'll take a knowledge of both hardware and software: Designing a kanji ROM board will require familiarity with the IBM PC (or PC XT or PC AT) and demand an awareness of the problems and issues involved in dealing with the Japanese language in computers, especially the state of the art of Japanese word processing. The goal should be to run at least one Japanese word-processing program currently in widespread use on, for example, the NEC PC-9801VM2 computer, substantially as is, on an IBM PC or PC clone that is equipped with a suitable kanji ROM board (and probably a Hercules or equivalent graphics board).

We all hear about the U.S./Japan trade imbalance. Consider that Japanese auto manufacturers can produce right-hand-drive models for their domestic market and left-hand-drive models for export. It would seem that American manufacturing companies make all too few efforts to tailor their products to the long-term Japanese market. Why not adapt personal computer products to the Japanese market?

The only analogous development I know of for a U.S.-made computer is the DynaMac version of Apple's Macintosh that I wrote about earlier (January BYTE Japan). That machine doesn't really do much to address either of the markets I've mentioned, since it's not sold in the U.S. and since there are far more third-party hardware/software products available for IBM personal computers than for the Macintosh.

NEXT MONTH

Bill discusses a new trend in Japanese culture that leads him into sharing some interesting highlights of the Microcomputer Show. ■

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Inquiry 93

NUMBER GAMES

BY ROBERT T. KUROSAKA

Bob teaches some familiar old tricks to a new machine

Here's an old number trick: Start with any four-digit number, say, 3917. Form a new number by arranging its digits in decreasing order, 9731, and another with the digits in increasing order, 1379. Find the difference of these numbers: 8352. Repeat the procedure with 8352: 8532 − 2358 = 6174. Another repetition produces 7641 − 1467 = 6174. We see that further repetitions will yield an endless sequence of 6174s.

Questions arise immediately: Will *all* four-digit numbers eventually arrive at this or some other self-replicating value? Which numbers require the most steps before they are repeated? It turns out that *all* four-digit numbers (except multiples of 1111) will reach 6174 in at most seven steps.

Many similar procedures exist for generating repeating sequences, and some of them produce startling results. Computers make the job of exploring them far easier than the manual method.

What's the purpose of this intellectual thumb-twiddling, you ask. Hardly ever a practical one, I admit, but after all, the name of this column is "Mathematical Recreations."

This month I'll look at several number-sequence games, providing BASIC programs that check them out. (Readers are also encouraged to seek ways of improving on my solutions.)

In all cases, the term *number* will mean *positive integer*.

SUM OF CUBES

Start with any number, say, 352. Find the sum of the *cubes* of its digits: $3^3 + 5^3 + 2^3 = 160$. Repeat the procedure with 160: $1^3 + 6^3 + 0^3 = 217$, which in turn gives $2^3 + 1^3 + 7^3 = 352$. We already find ourselves in a loop: (160, 217, 352).

Listing 1 is a program that performs the sum-of-cubes routine on any set of consecutive numbers. For a particular *n*, it prints the consecutive sums of cubes until a loop is found. Readers may wish to modify the program later, perhaps suppressing the actual terms and printing out only the number of steps taken and the type of loop.

It has been proved that all numbers will eventually reach one of several loops. I have seen the proof in a Mathematical Association of America journal, but I cannot find that article, nor do I remember the proof.

The following are a few of the known loops: three-step: (55, 250, 133); two-step: (136, 244) and (919, 1459); one-step: (153), (370), (371), and, of course, (1).

After exploring the sum-of-cubes procedure, readers may wish to investigate other powers or even other number bases.

FACTORIAL SUMS

Start with any number, say, 169. Find the sum of the *factorials* of its digits: 1! + 6! + 9! = 363601. Repeat the process: 3! + 6! + 3! + 6! + 0! + 1! = 1454. Then, 1! + 4! + 5! + 4! = 169, and we have already found a loop: (169, 363601, 1454).

I have examined all numbers less than 1000 and found that nearly all of them enter this particular loop. You will also find some one-step loops, since 1 = 1!, 2 = 2!, and 145 = 1! + 4! + 5!. Some two-step loops are (871, 45361) and (872, 45362).

Listing 2 calculates the sum of factorials for any range of numbers. When numbers are set for 10-digit precision, the program can handle starting values up to 9999999999. But even this giant yields 10 × 9! = 3628800. As long as we limit the argument to 10 digits at most, no result will exceed 7 digits. Of course, if double precision is available, the program can be adapted to work with even larger numbers.

PALINDROMIC SUMS

It has been said that the first man introduced himself to the first woman with a palindrome: "Madam, I'm Adam!" Not to be outdone, she replied in kind: "Eve."

Now we'll go searching for sequences that produce numeric palindromes, that is, numbers that read the same forward and backward.

Start with any number, say, 48. Reverse its digits and add the result to the original number: 48 + 84 = 132. Repeat the procedure: 132 + 231 = 363, a palindrome.

All numbers may eventually produce palindromes using this reverse-and-add routine—but that remains to be proved. Some numbers are known to require many steps; for example, 89 requires 24 steps.

Charles W. Trigg, presently book review editor for the *Journal of Recreational Mathematics* and a prolific contributor to numerous mathematics publications, found only 249 numbers less than 10,000 that require more than 100 steps to reach a palindrome. Among them is the dreaded 196, which has been taken to *hundreds of*

(continued)

Robert T. Kurosaka teaches mathematics in the Massachusetts State College system. He can be reached c/o BYTE, *One Phoenix Mill Lane, Peterborough,* NH 03458.

thousands of steps with no palindrome in sight. The same is true for its "cousins," 295 and 394.

Listing 3 investigates palindromic sums for any range of numbers. The lower limit for the sequence is 11, and there is no explicit upper limit. It does not have safeguards against dubious numbers like 196 that produce very long sequences. Improvements are left to the reader's ingenuity.

Delete and Add

One of my favorites is the delightful little marvel shown in the sample run of listing 4. Begin by listing the whole numbers 1 through *n*. You then delete

(continued)

Listing 1a: *The* BASIC *program to produce cube sums until a cycle is found.*

```
10 REM Sum of Cubes
20 REM by Bob Kurosaka
30 REM -------------------------------------------------
40 DIM A(10),B(100)  :REM A() holds digits, B() holds sums.
50 CLS
60 PRINT "Program generates sequences of cube sums."
70 PRINT
80 PRINT "Lower limit, upper limit ";
90 INPUT LL, UL
100 LL=ABS(INT(LL))
110 UL=ABS(INT(UL))
120 REM -------------------------------------------------
130 FOR N=LL TO UL   :REM Sequences for each no. LL to NN
140 SP=0             :REM SP counts the steps before a cycle
150 B(SP)=N          :REM Make the first term=N
160 PRINT B(SP);     :REM Print the current term
170 M=B(SP)          :REM Make a copy of latest term
180 REM -------------------------------------------------
190 REM Break up the term into its component digits
200 D=1              :REM D = no. of digits
210 T=INT(M/10)      :REM T = no. of "Tens" in M
220 A(D)=M-10*T      :REM Store rightmost digit in array A
230 IF T<>0 THEN D=D+1: M=T: GOTO 210
240 REM -------------------------------------------------
250 REM Calculate the sum of the cubes of the digits in A()
260 SUM=0
270 FOR I=1 TO D
280 SUM=SUM+A(I)*A(I)*A(I)
290 NEXT I
300 REM See if sum has occurred already.
310 I=0
320 WHILE B(I)<>SUM AND I<=SP
330 I=I+1
340 WEND
350 IF B(I)=SUM AND I<=SP THEN 400
360 SP=SP+1                 :REM one more step
370 B(SP)=SUM               :REM Store SUM in array B
380 GOTO 160
390 REM -------------------------------------------------
400 PRINT SUM; "* loops to step "; I
410 NEXT N
420 END
```

Listing 1b: A *sample run.*

```
Program generates sequences of cube sums.

Lower limit, upper limit ? 21, 25
 21   9  729  1080  513  153  153 * loops to step  5
 22  16  217  352  160  217 * loops to step  2
 23  35  152  134  92  737  713  371  371 * loops to step  7
 24  72  351  153  153 * loops to step  3
 25  133  55  250  133 * loops to step  1
Ok
```

Listing 2a: *The* BASIC *program to produce factorial sums until a cycle is found.*

```
10 REM Sum of Factorials
20 REM by Bob Kurosaka
30 REM -------------------------------------------------------
40 DIM A(10),B(100),F(10)
50 DATA 1,1,2,6,24,120,720,5040,40320,362880
60 FOR J=1 TO 10
70 READ F(J)
80 NEXT J
90 CLS
100 PRINT "Program generates factorial sum sequences."
110 PRINT
120 PRINT "Lower limit, upper limit ";
130 INPUT LL, UL
140 LL=ABS(INT(LL))
150 UL=ABS(INT(UL))
160 REM -------------------------------------------------------
170 FOR N=LL TO UL      :REM Sequences for each no. LL to NN
180 SP=0                :REM SP counts the steps before a cycle
190 B(SP)=N             :REM Make the first term=N
200 PRINT B(SP);        :REM Print the current term
210 M=B(SP)             :REM Make a copy of latest term
220 REM -------------------------------------------------------
230 REM Break up the term into its component digits
240 D=1                   :REM D = no. of digits
250 T=INT(M/10)           :REM T = no. of "Tens" in M
260 A(D)=M-10*T           :REM Store rightmost digit in array A
270 IF T<>0 THEN D=D+1: M=T: GOTO 250
280 REM -------------------------------------------------------
290 REM Calculate the sum of the factorials of digits in A()
300 SUM=0
310 FOR I=1 TO D
320 SUM=SUM+F(A(I)+1)
330 NEXT I
340 REM See if sum has occurred already.
350 I=0
360 WHILE B(I)<>SUM AND I<=SP
370 I=I+1
380 WEND
390 IF B(I)=SUM AND I<=SP THEN 440
400 SP=SP+1               :REM one more step
410 B(SP)=SUM             :REM Store SUM in array B
420 GOTO 200
430 REM -------------------------------------------------------
440 PRINT SUM; "* loops to step "; I
450 PRINT
460 NEXT N
470 END
```

Listing 2b: A *sample run.*

```
Program generates factorial sum sequences.

Lower limit, upper limit ? 24, 27
 24  26  722  5044  169  363601  1454  169 * loops to step 4

 25  122  5  120  4  24  26  722  5044  169  363601  1454
 169 * loops to step 9

 26  722  5044  169  363601  1454  169 * loops to step  3

 27  5042  147  5065  961  363601  1454  169  363601 * loops
 to step  5

Ok
```

Listing 3a: *The BASIC program to find palindromes by adding a number to its reverse image and repeating the process with the resulting sum.*

```
10 REM Palindromic Sums
20 REM by Bob Kurosaka
30 REM -----------------------------------------------------
40 SP$=" "               :REM One space inside quotes
50 D$="0123456789"
60 YES=(1=1)
70 DIM A(100)            :REM A() holds the digits.
80 CLS
90 PRINT"Program generates sequences ending in palindromes."
100 PRINT
110 PRINT "Lower limit (>10) and upper limit ";
120 INPUT LL, UL
130 LL=ABS(INT(LL))
140 UL=ABS(INT(UL))
150 IF LL<10 THEN 110
160 FOR N=LL TO UL
170 SP=0              :REM SP counts the steps before a cycle
180 REM ----------------------------------------------------
190 REM Break up the term into its component digits
200 M=N               :REM Make a copy of latest term
210 D=1               :REM D = no. of digits
220 T=INT(M/10)       :REM T = no. of "Tens" in M
230 A(D)=M-10*T       :REM Store rightmost digit in array A
240 IF T<>0 THEN D=D+1: M=T: GOTO 220
250 ODD=ABS((INT(D/2)<>D/2)) :REM Even or odd no. of digits?
260 REM ----------------------------------------------------
270 REM Print the latest term
280 FOR I=D TO 1 STEP -1
290 PRINT MID$(D$,A(I)+1,1);
300 NEXT I
310 PRINT SP$;
320 REM ----------------------------------------------------
330 REM Check for palindrome
340 FOR I=1 TO D/2
350 PL=(A(I)=A(D-I+1))
360 IF NOT PL THEN I=D/2 :REM Exit if not a palindrome
370 NEXT I
380 IF PL THEN 580
390 REM ----------------------------------------------------
400 REM Add each digit to its reverse image counterpart
410 FOR I=1 TO D/2+ODD
420 A(I)=A(I)+A(D-I+1)
430 A(D-I+1)=A(I)
440 NEXT I
450 REM Check for carry
460 FOR I=1 TO D
470 IF A(I)<10 THEN 500
480 A(I)=A(I)-10
490 A(I+1)=A(I+1)+1
500 NEXT I
510 IF A(D+1)=0 THEN 540
520 D=D+1
530 ODD=ABS((INT(D/2)<>D/2))
540 SP=SP+1
550 GOTO 280
560 REM ----------------------------------------------------
570 REM Indicate that a cycle has been found
580 PRINT "* at step "; SP
590 FOR I=1 TO D
600 A(I)=0
610 NEXT I
620 NEXT N
630 END
```

(continued)

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Listing 3b: A *sample run.*

```
Program generates sequences ending in palindromes.

Lower limit (>10) and upper limit ? 75, 80

75 132 363 * at step  2
76 143 484 * at step  2
77 * at step  0
78 165 726 1353 4884 * at step  4
79 176 847 1595 7546 14003 44044 * at step  6
80 88 * at step  1

Ok
```

Listing 4a: The BASIC *program to perform the delete-and-add routine for any integral power.*

```
10 REM Delete and Add
20 REM by Bob Kurosaka
30 REM ---------------------------------------------------------
40 N=50       :REM N=number of integers in starting sequence.
50 DIM SF$(3), A(N) :REM SF$() = suffixes, A() = sequence.
60 DATA nd, rd, th
70 FOR J=1 TO 3: READ SF$(J): NEXT J
80 REM ---------------------------------------------------------
90 CLS
100 PRINT "Program uses a delete-and-add process"
110 PRINT "to generate i^p for i=1 to ";N; "/ p."
120 PRINT: INPUT "Enter a value for p (power)"; P
130 P=ABS(INT(P))
140 IF P<2 THEN 100
150 REM ---------------------------------------------------------
160 PRINT: PRINT "Starting sequence:"
170 FOR I=1 TO N
180 A(I)=I
190 PRINT I;
200 NEXT I
210 PRINT
220 REM ---------------------------------------------------------
230 FOR R=P TO 2 STEP-1
240 DC=0                 :REM Counts the terms deleted.
250 FOR J=R TO N STEP R :REM Delete every Jth term
260 A(J)=0
270 DC=DC+1
280 NEXT J
290 REM ---------------------------------------------------------
300 REM Print deleted array
310 WSF=SGN(R-3)+2       :REM Select suffix
320 PRINT: PRINT "Delete every "; R; SF$(WSF); " term:"
330 FOR I=1 TO N
340 IF A(I)<>0 THEN PRINT A(I); ELSE PRINT "*";
350 NEXT I
360 REM ---------------------------------------------------------
370 REM Compute Partial Sums
380 K=1
390 FOR J=2 TO N-DC   :REM There will be N-DC valid numbers.
400 K=K+1             :REM K points to next term to be added.
410 IF A(K)=0 THEN K=K+1     :REM Skip zero (deleted) terms.
420 A(J)=A(J-1)+A(K) :REM Calculate partial sum.
430 NEXT J
440 N=N-DC      :REM Revise the number of valid terms in A().
450 REM ---------------------------------------------------------
460 REM Print Partial Sums
470 PRINT: PRINT: PRINT "Partial sums:"
```

(continued)

```
480 FOR I=1 TO N
490 PRINT A(I);
500 NEXT I
510 PRINT
520 NEXT R
530 END
```

Listing 4b: A *sample run.*

```
Program uses a delete-and-add process
to generate i^p for i=1 to  50 / p.

Enter a value for p (power)? 4
Starting sequence:
 1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17
 18  19  20 21  22  23  24  25  26  27  28  29  30  31  32
 33  34  35  36  37  38 39  40  41  42  43  44  45  46  47
 48  49  50

Delete every  4 th term:
 1  2  3 * 5  6  7 * 9  10  11 * 13  14  15 * 17  18  19 *
 21  22  23 * 25  26  27 * 29  30  31 * 33  34  35 * 37  38
 39 * 41  42  43 * 45 46  47 * 49  50

Partial sums:
 1  3  6  11  17  24  33  43  54  67  81  96  113  131  150
 171  193 216  241  267  294  323  353  384  417  451  486
 523  561  600  641 683  726  771  817  864  913  963

Delete every  3 rd term:
 1  3 * 11  17 * 33  43 * 67  81 * 113  131 * 171  193 * 241
 267 * 323  353 * 417  451 * 523  561 * 641  683 * 771  817
 * 913  963

Partial sums:
 1  4  15  32  65  108  175  256  369  500  671  864  1105
 1372  1695 2048  2465  2916  3439  4000  4641  5324  6095
 6912  7825  8788

Delete every  2 nd term:
 1 * 15 * 65 * 175 * 369 * 671 * 1105 * 1695 * 2465 * 3439 *
 4641 * 6095 * 7825 *

Partial sums:
 1  16  81  256  625  1296  2401  4096  6561  10000  14641
 20736  28561

Ok
```

The delete-and-add process produces a power sequence.

every fourth term and list the partial sums of the remaining terms (see figure 1 for an explanation). Now delete every third term and again list the partial sums. Then delete every second term and list the partial sums one last time.

We stop at this point (we wouldn't delete *every* term, would we?) and note the remarkable results: The sequence consists of the fourth powers of the whole numbers.

This procedure generalizes to *n*th powers (begin by deleting every *n*th term, and so on). It was discovered by Alfred Moessner in 1951 and proved by Oskar Perron in the same year. A thorough treatment can be found in "On the Moessner Theorem on Integral Powers" by C. T. Long in the *American Mathematical Monthly*, vol. 73 (1966), pages 846–851.

Listing 4 performs the above delete-and-add routine for any integral power. For larger powers, the initial list of whole numbers should be extended in line 40. (Hint: For the *n*th power, only 1/*n*th of the list will remain to the conclusion.) For very large powers, the use of extended or double precision may be in order.

I hope you find these procedures and their results as enjoyable as I do. I would welcome any references and sources on these or other number sequences. ■

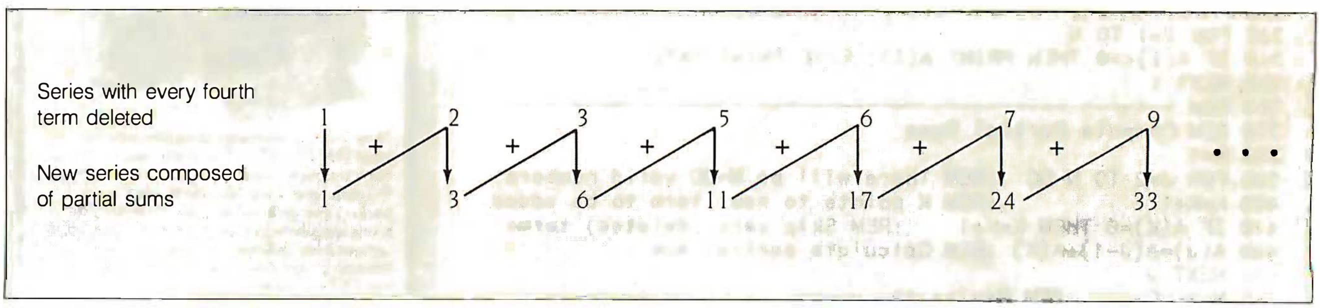

Figure 1: *In the delete-and-add program, partial sums are taken to produce a new sequence of terms. The first term is unchanged. The second term is added to the first term to produce a new second term. That new term is added to the third term to produce a new third term, and so forth.*

(continued from page 24)
word silly is not an identifier; it is a *tag* and is conceptually in a disjoint symbol table from identifiers. Were the self-referential item next not included in the structure, the tag could even be omitted. However, if I want to refer to the structure in other files (e.g., in extern declarations), I am forced to write stuff like

```
extern struct silly s3, s4;
```

that is, the tag itself is not a type. It has to be preceded by the word struct or union. The use of typedef offers a neater notation, to wit:

```
typedef struct thing{
    int a;
    char b[6];
    struct thing *nest;
    } Silly;
silly s1, s2;
```

That is, Silly becomes an actual type name. It should be mentioned that the C++ language removes much of the need for typedef by making the tag itself an actual type.

Now, why is all of this important? In a large program, composed of many independently compiled files, the only way to prevent accidental type incompatibilities is to put the global information in header files that get brought into desired source files by use of the #include directive. This information consists of constants and macros defined by #define, all type declarations, and all external variable declarations. In particular, global structures and unions will need such declarations, and the cleanest and easiest organization is to have separate header files for those declarations that do not reference allocated memory, like #define and typedef, and for those that do, like extern declarations for variables and functions. It is in the context of such organization that typedef makes for easier reading. It goes without saying that the first thing one must do before reading an unfamiliar program is to print out the header files and tack them to the nearest wall.

HERBERT KANNER
Palo Alto, CA

I was interested to learn some of the history of UNIX and C from Mr. Kanner's letter. I have never used C on a minicomputer system running the UNIX operating system and was not aware that enumeration data types were part of that environment.

Variations in C *was written for microcomputer programmers, and all of my C programming experience is on CP/M and MS-DOS micros. The compilers and interpreters I have used on these systems have kept close to the K&R standards of the C language, which do not use the enumeration data type or void declarator. Presumably, this situation will change once the proposed ANSI C standard is finalized.*

I agree with Mr. Kanner that judicious use of the #define preprocessor command is a useful programming technique. The one thing that bothered me in Variations in C *was the use of #define and typedef to create synonyms for C's reserved storage-class keywords. I want to emphasize that this is personal predilection I have. The technique that Mr. Kanner suggests, tacking up the header files on the nearest wall when you begin working with an unfamiliar program, is a good suggestion that helps to get around the problem of struggling with someone*

(continued)

else's "intuitive" redefinitions of C's reserved keywords.

—JOHN D. UNGER

MORE ON PAN-REIF ALGORITHM

"The Inversion of Large Matrices" by Thomas E. Phipps Jr. (April) was interesting. Pan and Reif's important contribution is that of providing an initial approximation to the inverse that permits the Newton iteration algorithm to always converge. This can be important for parallel processing. It is not appropriate, however, to use this algorithm for serial processing.

As a general rule, direct methods are more efficient than iterative methods. For matrix inversion there exist a number of good algorithms (Gauss, Gauss-Jordan, Cholesky) that involve far fewer arithmetic operations (for serial processing) than the Pan-Reif algorithm. To be specific, matrix inversion with Gaussian elimination requires about n^3 multiplications and an equal number of additions. Given that multiplications are slower than additions, they control the speed of the algorithm. Each iteration of the Pan-Reif algorithm needs two n^3 multiplications. If we iterate ten times (which seems conservative) we do twenty times more work than with Gaussian elimination. And if a microcomputer "poops out" with Gaussian elimination, it will also poop out with other algorithms. The accuracy of the computed inverse depends on the condition number of the matrix. If this number is high, the matrix is ill-conditioned and no method will calculate an accurate inverse. As an example, consider a 20 by 20 Hilbert matrix. These matrices are notoriously ill-conditioned, and both Gaussian elimination and the Pan-Reif algorithm compute garbage when trying to invert them. A good use of the Newton iteration is to improve the accuracy of an inverse matrix calculated by some other algorithm, such as Gaussian elimination. Suppose we are working in single precision, which on our particular computer gives seven decimal digits of precision, and that the condition number of the matrix to be inverted is 10^{-3}. The elements of the computer inverse will be accurate to about four digits. A few iterations of the Newton method (about three) will produce an inverse to full single-precision accuracy if we express the Newton method in the form:

$$B_k + 1 = B_k + B_k (I - AB_k).$$

As Forsythe and Moler (*Computer Solution of Linear Algebraic Systems*, Prentice-Hall, 1967, pages 78 and 79) point out, it is crucial to calculate the matrix inner products in AB_k with double precision and to calculate the correction $B_k (I - AB_k)$ separately and then add it to B_k.

Rather than regard the Pan-Reif algorithm as a practical one for matrix inversions on microcomputers, I think its most important use is pedagogical. As author Phipps mentions, it is fun to see the Newton iterates converge. It can also be instructive. Start first with a well-conditioned matrix: A unit matrix with random noise distributed between −0.1 and 0.1 added to the elements will do nicely. The Newton iterates will converge with a very small error term. Then try the algorithm with a 10 by 10 Hilbert matrix. Single precision fizzles completely, whereas double precision converges with an error term of about 10^{-4} (on a VAX-11/780). Now try a 20 by 20 Hilbert matrix. Not even double precision works now. I can think of no more illuminating demonstration of the effect of the condition number of a matrix on the inversion process.

RICHARD BRANHAM
Mendoza, Argentina ■

C·H·A·O·S M·A·N·O·R M·A·I·L

Conducted by Jerry Pournelle

FORTRAN FOR MICROS

Dear Jerry,

In the January "Chaos Manor Mail," page 366, you answered someone's request for information about FORTRAN as follows: "I just don't think there's an easy-to-use implementation of it for micros. Certainly there wasn't back when MacLean and I were first learning about these little machines." Jerry! How quickly you forget! Cromemco, that obscure little company that was one of the founders of the microcomputer industry, has had Z80 FORTRAN and RATFOR for almost eight years and 68000 versions since 1982 or so. All are solid as a neutron star and easy to use (in conjunction with the Screen text editor). The Z80 version runs on Cromemco's personal computer, the C-10, so one doesn't need one of the big S-100 hard disk multiuser metal boxes to use it.

JEFF JOHNSON
Mountain View, CA

Cromemco is an odd company. My original Ezekial was a Cromemco Z-2, and I was very happy with him. When it came time to replace him, though, Cromemco never answered any letters, and shortly after came out with their own DOS, effectively trying to isolate their users from the rest of the micro mainstream. My friend Gordon Dickson bought a Cromemco about then and had real trouble with software and suchlike.

Given Cromemco's early-on technical excellence, it's too bad they didn't grow into one of the giants. Some of Zeke's boards are still happily running!—Jerry

DESCRIPTIVE FILENAMES

Dear Jerry,

I have an Epson QX-10 for a specific dedicated task. Valdocs 1.19 was not asked for, but it was included in the package. I don't like Valdocs: 90 percent molasses and 10 percent bugs.

Valdocs does have one feature I am lost without: the Index Reference, which is generated by the wordsmith and can contain up to 16 keywords. The word processor automatically generates a filename of eight characters using the date and the sequence number of the document for that day. The wordsmith sees only the descriptive Index Reference string.

I also have an IBM PC XT on which I do word processing. I selected a word processor that is fast, hard to learn, and stores documents under filenames without reference to a descriptive string. I have to keep a log of what those cryptic filenames represent. I want a word processor for my XT that generates an array index (filename) to which is assigned the string (Index Reference) that I generate using keywords. I want to look at only the string, not the cryptic filename.

Do you know of any IBM-compatible word processors that have this feature?

P. C. KAMRATH
Columbus, NE

Yeah. Valdocs had some wonderful ideas. Pity it didn't come off, and now the whole QX line has been abandoned.

There are some directory shell programs that do sort of what Valdocs did, but they aren't automatic. The worst of it is that I've probably got what you describe somewhere in the labyrinth below Chaos Manor and don't know it. Sigh.—Jerry

WRITE ON

Dear Jerry,

On the strength of Chaos Manor recommendations, I got WRITE several weeks back and am now a believer. WRITE word-processing software makes computing fun—without an extra investment in tutorials or how-to books.

I haven't always been this happy with my Kaypro 2-X. For a year it sat in a corner, displacing dust. The software that came with it had devoured every last ounce of patience.

In effect, WRITE mobilized this $1800 investment. No exaggeration. For those owning CP/M hardware and not equipped with a hacker's dedication let alone expertise, WRITE is an absolute godsend.

Keep up them superb recommendations!

WINSTON MCLEAN
Bad Vilbel, West Germany

Thanks. Glad I could be of help. Now if I can just get Tony Pietsch to jigger up a V20/V30 version of WRITE to run on a PCompatible! The trouble is that WRITE is in 8080 assembly language; to get it running on an AT would take some major work. If I had WRITE for an AT (say the AT&T 6300 Plus), I'd convert like a shot.—Jerry

CHAINING CBASIC

I received a lot of letters about chaining and overlays in CBASIC. Apparently, things depend in part on versions. Sue Rosenberg's letter will explain what you can do now.

It's important, because CBASIC is still one of the best and most easily learned computer languages. Many of my most important programs were written in CBASIC, and even years after writing them I have been able to go back and make crucial modifications, add features, etc. I would be happier if my programs were in Modula-2; but the fact is that CBASIC is more than good enough, and I've never had the time or strong enough inclination to convert.

Sue Rosenberg, for those unfortunate enough not to know her, is a BIX moderator and one of the most careful people I know; when she explores a subject, she really *wrings it out. She's also one of five economists who are slowly convincing me that there may be something of a science to that discipline.*

Dear Jerry,

The first letter in your May Chaos Manor Mail complains that Compiled CBASIC won't let the user put data in common blocks, chain to a program, and then go back to the original. This is untrue.

You can set up a root module, say ROOT.CMD, with a common block that can contain all kinds of data types, including dimensioned variables, strings, and all sorts of overlays, called, for example, OVERLAY1.OVL, OVERLAY2.OVL, . . . , OVERLAYN.OVL. To execute the program, you would type ROOT, which can chain to any of the overlays or to itself.

For example, if ROOT and OVERLAY1 were on the logged-in drive, ROOT could chain to OVERLAY1 with CHAIN OVERLAY1, and OVERLAY1 could chain to ROOT with CHAIN ROOT.CMD. Any module can chain to any module, in-

(continued)

cluding itself. The important thing to remember is that if a file extension is not specified in the chain statement, the compiler assumes an extension of OVL. This has tripped me up a few (well, more than a few) times, when I wanted to chain back to the root and forgot to include the extension.

Another important thing to remember is that the common blocks have to be identical in all the chained programs. The easiest way to ensure this is to have the common statements in a separate .BAS file that you include as the first statement in each module.

It's true that you enter each module at the beginning of the module and not at the point where you left to chain. What you can do to go to a point other than the start is to set up a jump table (ON . . . GOTO) as the first statement (after any necessary initialization) and use a variable in common to dispatch you to the proper location.

There is yet another solution for the CBASIC user running MS-DOS. Microsoft has a Compiled CBASIC clone, Business BASIC, that is similar, but not identical, to CB80/CB86. In Business BASIC, no module can be more than 64K bytes, but you can compile subroutines separately and link them together, so the overall code size can be greater than 64K bytes. Most commands are similar to Compiled CBASIC commands, although the syntax is sometimes different, and error handling, garbage collection, and chaining are philosophically different. In chaining, Business BASIC keeps files open; CBASIC closes them. CBASIC code is more compact; Business BASIC is generally faster.

It is not a completely painless process to bring CBASIC programs over to Business BASIC. A fair amount of conversion can be handled by a conversion program supplied with Business BASIC.

But I think that Microsoft, like Digital Research, is not putting much effort into maintaining, let alone upgrading, Business BASIC. Alas.

SUE ROSENBERG
McLean, VA

I should have known all that, but, in fact, when I last did CBASIC programming I couldn't make it chain back properly to the root program; and Digital Research wasn't answering questions. Since that time I moved on to other languages.

If you chain back to the root, you will reset all the data in common, thus wiping it out. The solution is to have ROOT contain nothing but initializations and COMMON; chain from that to a trunk, which is the true beginning module for the program; and thereafter chain to overlays and back to TRUNK as you will. ROOT must have a common statement that defines the entire common block; this is different from the CP/M version and probably one reason why I had trouble with chaining. I am grateful to John Thompson of Madison, Wisconsin, and Dr. Fred Levit of Chicago for pointing this out. In my defense, both of them note that the points are obscurely made in the CBASIC documents.

It is unfortunate that both Digital Research and Microsoft have so thoroughly neglected their commercial BASIC languages. I suspect it's because Microsoft's Business BASIC didn't compete well against Compiled CBASIC; while Digital Research's neglect of CBASIC is more indicative of what's happening in that once-splendid company.

Those interested in CBASIC really must get in touch with Minnow Bear Com-

puters (P.O. Box 2233, Station A, Champaign, IL 61820-8233); the Minnow Bear CBC Tools for both CP/M-86 and MS-DOS CBASIC are really well done. CBASIC with Minnow Bear Tools is structured, easy to use, and portable. They also have an improved Run Time package that speeds up CBASIC considerably. No code rewrite is required; simply relink using the package.

There is also the CBASIC User Group (P.O. Box 40690, Cincinnati, OH 45240-0690). Between Minnow Bear and the User Group, programmers can get most—alas, not all—of the support Digital Research ought to be giving the language. —Jerry

MICROSOFT WORD, MOUSE

Dear Jerry,

Until about 16 months ago, I knew nothing about computers and had no desire to know any more. Since buying a Zenith Z-150, however, I've gotten quite fascinated with the technology. I've found your columns very interesting and informative and have followed many of your suggestions, with good results. (The Z-150 itself was partly a result of your columns.)

I've been delighted with Microsoft Word. Your extolling of XyWrite—along with a certain slowness in cursor movement in Word—had been prompting me to try the program. I'm currently writing a book based on my public radio series *New England Almanac*, and the writing involves editing about a thousand pages of transcribed interviews. But I'm going to be slow to try XyWrite now that I have discovered the way a mouse interacts with Word. I can't imagine editing being any easier than it is with a mouse—it's just like using a red pencil on paper.

I'm very pleased with Word overall, by the way. In particular, I'm convinced its mnemonic approach to invoking commands makes it one of the easiest programs for novices to learn; I've taught it already to three of them. Word has layers of shortcuts and speedups that you can learn as you get more and more comfortable with the program. Through it all runs a streak of logic that you can easily follow. I guess some people might feel that having three different ways to invoke a command is confusing . . . I find it to be one of the beauties of Word.

The elegance of Word reaches its highest point, I think, in its use of style sheets. I've been shocked to find out that the Macintosh Word hasn't got them yet. That's like having pancakes without the maple syrup.

Finally, the new Microsoft mouse (5.0) with its higher resolution runs rings around earlier mouses I've tried (e.g., Mouse Systems).

TOM LOOKER
Montague Center, MA

Thanks. I have the newest version of Microsoft Word; I'll have to try that. My problem with mice is that my work area isn't really set up properly to use them; I have about decided that I'll have to construct some special-purpose furniture, since mice are becoming more important. They certainly can't be beat for some jobs—provided, of course, that you can find the mouse and a spot bare of papers to use it on.

I'm in the process of changing over systems; it's time to give up my ancient CompuPro Z80 and VDM memory-map video board for something more modern. Problem is what I should get used to, so I'm fooling about with everything. Thanks for the suggestions.—Jerry ■

THE BEST OF BIX is a selection from some of the most interesting messages from BIX, the BYTE Information Exchange. Conferences covered this month are Commodore Amiga, Atari ST, IBM PC (and compatibles), Macintosh, and object-oriented programming languages. These pages represent a small window into the world of BIX.

For information on joining BIX, see page 286.

AMIGA

The Amiga conference remains very active as users and developers explore and share their discoveries. This month's window on the Amiga conference kicks off with a discussion of chain and overlay programming methods. A question of directories follows, with various techniques suggested for letting AmigaDOS know where you are. The major hardware thread concerns interfacing 5¼-inch disk drives to your Amiga, ending with how to get complete expansion bus specs from Commodore. The window closes with two major discussions on how to handle your mouse through Intuition.

"CHAINING" IN C

amiga/softw.devlpmt #1637, from drl [Dave Lundberg]

Could someone steer me in the right direction? I would like to "chain" from one C program to another.

amiga/softw.devlpmt #1638, from cheath [Charlie Heath]
a comment to message 1637

Aztec has a routine that will allow chaining in their library. You can do an AmigaDOS "Execute( )" call to run another program, but the calling program remains resident. As an alternative (I assume you have Lattice), you could figure out the correct set of LoadSeg for the new program and UnLoadSeg for the old one, which would allow you to terminate the original program before starting the new.

You might also be able to achieve this with overlays or an Amiga library, both of which would allow you to load new stuff from disk without using more RAM.

amiga/softw.devlpmt #1639, from jdow [Joanne Dow]
a comment to message 1638

Rather than the clumsier approach of chaining, which seems to be a BASIC trick, why not carefully think out an approach using overlays with a modest-size main program which is the top-level menu? That would be an almost perfect use of the overlay structure. It also allows much better control over program flow.

amiga/softw.devlpmt #1663, from drl

Thanks for the input. I have shied away from overlays simply because I have not used them before and don't understand how they work. I may give LoadSeg/UnLoadSeg a try, since this chain is a once-only thing, that is, the first program is a title page which will chain to the main program, never to be returned to.

Is it possible to UnLoadSeg the program running, then LoadSeg the new program? This would be ideal since I would like to keep memory as unfragged as possible. Any ideas?

amiga/softw.devlpmt #1665, from jdow
a comment to message 1663

Oh boy—that one is tailor-made for overlays! The main point to watch for is that there is no direct communication between the two halves of the overlay program. It all must take place through the main program. The main loads overlay one and calls it. When it returns, the main unloads the first and loads the second overlay, then calls the second in normal fashion. This has many of the benefits of chaining, with the added benefit of tighter control over what runs when. (After all, some yo-yo might try to run the second program without entering the first at all. With CLI it'd probably be quite a likely event once the user figured out the structure.)

amiga/softw.devlpmt #1666, from cheath
a comment to message 1665

Overlays really aren't that hard; you don't change much at the program source level except perhaps for separating things into separate source files. I haven't tried the Amiga overlays, but in general, all you have to do is specify a "tree" structure for the input files. You also need to link in an overlay object file. Has anyone else used the AmigaDOS overlays yet who can shed more light on this?

amiga/softw.devlpmt #1669, from drl
a comment to message 1665

You talked me into it. We'll see what those overlays can really do. Thanks for the help. If I get stuck, I'll let you know.

PROBLEM WITH EXECUTE FILE

amiga/softw.devlpmt #1652, from greggw [Gregg Williams, Senior Technical Editor, BYTE]

I'm writing an execute script that has a compiled file on the RAM disk. I want to copy it to wherever I am (this assumes that the current directory is somewhere on one of the disks). I can't find a way to do this in AmigaDOS. If we were in UNIX, I could say

```
cp ram:<filename> .
```

where "." means "where I am right now." But I can't find any such thing in AmigaDOS.

Am I overlooking something *real* obvious? In any case, any ideas?

amiga/softw.devlpmt #1654, from jdow
a comment to message 1652

Alas, there is no symbol for "where I am now" in AmigaDOS utilities. Some new utilities could be generated, but they'll for sure be much bigger than the old ones.

amiga/softw.devlpmt #1657, from cmcmanis [Chuck McManis]
a comment to message 1654

Certainly there is! Use " " for the current directory. Not intuitive but it does work. Another neat trick is a "visit" command. It works something like this

```
visit :
assign foo: " "
cd newdir
leave :
cd foo:
```

This lets you pop into another directory for a moment, type leave, and be back where you were. Note that "newdir" above should be the first parameter passed; I don't have my book handy and can't remember the syntax.

amiga/softw.devlpmt #1658, from jim_kent [Jim Kent]
a comment to message 1657

Chuck, I heard about the

copy file " "

trick at the BADGE meeting. Whenever I try it, it just copies it to the parent device of the directory I'm at. If I'm in df1: it works, but if I'm in df1:letters it ends up in df1:. Am I unique?

amiga/softw.devlpmt #1659, from jdow
a comment to message 1658

No, you are not unique. " " is a long form for :, it seems.

amiga/softw.devlpmt #1660, from lnoland [Les Noland]
a comment to message 1652

Can do!
Sorry Chuck, but Jim is right;

copy file " "

just places the file in the root directory, not in the current directory. There is a way that is simple and will work, however: If you model your execute file after the following, you should be in good shape:

```
.k file
.bra {
.ket }
cd >ram:curdir
copy <ram:curdir >nil: from {file} ?
delete ram:curdir
```

Of course, you can change "ram:curdir" to anything you like. And if the name of the file isn't variable, you can dispense with the first three lines and save that ridiculous disk access to :T (unless, of course, you have other parameters to pass).

5¼-INCH DISK DRIVES

amiga/tech.talk #499, from agima [Neil Halistar]

I am connecting a 5¼-inch IBM drive up to the Amiga. I don't have the external 3½-inch drive. Is it OK to use the Amiga's power for the 5¼-inch?

amiga/tech.talk #501, from duck [Dale Luck, Commodore-Amiga]
a comment to message 499

If the power consumption of the 5¼-inch is same or less than the 3½-inch, it should be OK. However, we cannot make any promises that it won't affect other items that you may hook up that also get their power from the Amiga if the disk drive sucks up too much power. Each of the power pins on the external connectors has been spec'd for a maximum current. We have added all those up and spec'd the power supply to be able to supply just enough current.

amiga/tech.talk #502, from jdow
a comment to message 499

No, it is definitely not OK to use the Amiga's power. Also, those 5¼-inch drives will only be accessible from the PC emulator. I seem to remember that was what you wanted, so go for it—with an external power supply.

amiga/tech.talk #503, from neil [Neil Katin, Commodore-Amiga]
a comment to message 499

It is *not* OK to connect a 5¼-inch drive to the Amiga without providing it with extra power; the motor-on surge is more than the Amiga can provide (under worst-case conditions).

amiga/tech.talk #504, from cheath
a comment to message 503

Neil, do you know of anybody manufacturing the 96-track 5¼-inch drives that will hold 880K (that is 96 tracks, right?) of data and thus can be accessed as if they were 3½-inch drives? That would seem to make a lot of sense to me for anybody who needed a 5¼-inch drive for IBM emulation, but who also wanted to make use of the drive under AmigaDOS.

amiga/tech.talk #505, from jdow
a comment to message 504

How much are people willing to spend? The hack can be done. Modern 96-tpi (tracks per inch), 5¼-inch drives do it even better than my hack of an older version Mitsubishi. Newer drives have "door open" switches built in. The only real problem is getting the 23-pin connectors. A dual box shouldn't be very expensive compared to an HD (except on a bux/bit basis). I could probably build a few and get them out my door for under $450.

amiga/tech.talk #518, from neil
a comment to message 504

There are several disk manufacturers that have 96-tpi, double-sided 5¼-inch drives. Flipping out my handy book of disk drive specs, I find a Tandon TM 65-4, World Storage Tech. (no model #), Tokyo Electric Co. FB-504, Control Data Corp. CDC-445, Mitsubishi M4551. There are many others—check Mini-Micro Systems' annual peripherals report.
There is one catch, however. Our system assumes that the DISKCHANGE signal (pin 2) will go active when a disk is removed. You will probably want to wire up a switch and a flip-flop to emulate this feature.
Happy Hacking.

amiga/tech.talk #519, from jdow
a comment to message 518

The latest revision of the Mitsubishi M4853 drive supports that. Alas, the ones I bought were an earlier revision, so I had to do mucho kludging. There would still be some strapping and such needed, but the green wire count would reduce materially. (What I don't know is whether that drive now uses some LSI part instead of LSI/MSI parts, which allow strapping in the motor latch as easily as the revision I have.)
Care to generate some kind of discussion over in hardware about the expansion bus and how to handle the hardware aspects of it? I have some preliminary documents dated early this year. Is this still proprietary info or can I feed it into the system here as people ask? If it's still proprietary, I'll keep it under my hat, as much as that hurts. That's the basis on which I got it and I don't wish to violate the confidence.

amiga/tech.talk #520, from neil
a comment to message 519

Re: Expansion architecture availability
The expansion architecure is no longer proprietary. However, we would prefer if people got the document directly from Commodore-Amiga; this

(continued)

allows us to know who has it, and who we should mail updates to.

Our current policy is to mail a copy to anyone who asks for it. We'll keep this up until the load gets too high; by then it should be stable enough to publish (hope, hope . . .). To get your copy, call Cheryl Gibbons, (408) 395-6616, and ask for an expansion architecture packet.

The expansion stuff is an amazing step forward for personal computers: There are no switches on any of the boards. This is one of the most intimidating things for a novice to do—set all those bit switches. In addition, the software can figure out, at run time, what boards are in the system and will attach the correct driver to each board. To install a new driver into the system is as easy as dragging an icon into the "expansion" directory; nothing else is required.

All this is currently being shipped to version 1.2 alpha-test sites. Beta is coming up, and we hope to send it to a wider audience.

If you have specific hardware questions, mail to me (neil) and I will make sure the right people see the questions.

INTUITION AND THE MOUSE

amiga/softw.devlpmt #1608, from drl

Has anyone actually used the SetMPort( ) routine to change the port that Intuition uses to read the mouse? I would like complete control of the mouse, but I don't want the user to have to physically move the mouse to the second game-port connector. I would rather "trick" Intuition into using the second game-port connector, so that I can then access the first connector by opening the game-port device. I know that it is possible to steal the mouse events by inserting an input event handler ahead of Intuition, but I would rather use the game-port device, since it handles a lot of the dirty details for you.

A second problem, also dealing with Intuition, concerns stealing sprite 0 (Intuition's cursor). I would like to use all 8 hardware sprites (greedy me) using the simple sprite routines. A point to note is that I am using Intuition in my program, so "killing" Intuition (if that is even possible) is not an answer. I am using it to "cook" the keyboard input and to give me tick events.

amiga/softw.devlpmt #1615, from cheath
a comment to message 1608

Good luck on both accounts. As far as I know, while Intuition is active it wants mouse port 0 and sprite 0. You can probably read the mouse directly (i.e., not through a device driver) without interfering with Intuition, but Intuition would still get the mouse inputs, too, using processing time as well as possibly doing something with the events.

amiga/softw.devlpmt #1617, from drl
a comment to message 1615

That seems to be a bit of a problem. Even if I were to give in and say OK, I would make the user switch his mouse to the other port and not use sprite 0; the arrow sprite would still be visible. Although thinking about it, I suppose the arrow could be redefined as "transparent."

amiga/softw.devlpmt #1618, from cheath
a comment to message 1617

You can do a "SetPointer" to a couple words of NULL data to get rid of the pointer.

amiga/softw.devlpmt #1623, from duck
a comment to message 1608

What's the matter, 6 or 7 sprites not enough? Some of the other programs on the market cheat by just calling FreeSprite(0). Not too friendly for Intuition 'cause it will think it still has a handle on it.

amiga/softw.devlpmt #1636, from drl
a comment to message 1623

Oh, I guess 6 or 7 sprites is enough. Yes, I did try FreeSprite(0) and Intuition still thinks it has control of it. It keeps changing the position and image back to the arrow. I guess my main concern is getting Intuition to lay off mouse port 1, so I can access it using the game-port device (which processes the mouse input very efficiently). Any ideas on that subject?

IDCMP (INTUITION DIRECT COMMUNICATION MESSAGE PORT) EVENTS

amiga/softw.devlpmt #1599, from skrenek [Steve Krenek]

My program is getting a little bogged down with MOUSEMOVE and MOUSEBUTTON messages and losing a lot of memory (5 to 10 messages at a time at 56 bytes a pop). I wouldn't care so much that the memory doesn't get returned if it used the *same* 200 to 600 bytes each time. But it seems to lose an additional 200 to 600 bytes each time my program gets behind. My loop is similar to one on pages 8 to 14 of the Intuition manual; I just have a lot to do. Will this memory be returned in a later version, or will I have to periodically close, then reopen my windows to reclaim this memory and keep my program from suffering memory crashes?

amiga/softw.devlpmt #1601, from cheath
a comment to message 1599

Are you replying to all messages that you receive? You shouldn't lose memory if all the messages have been replied to. Perhaps Intuition has to allocate more space for messages and doesn't free up it's local pool. You might consider flushing the input when you get behind. Whenever you get a MOUSEMOVE event, set a flag and continue to read messages until you get something other than MOUSEMOVE (including "no more messages"). (Also, make sure to reply to each message after reading.) Then, test for the "mouse moved" flag before processing each event.

amiga/softw.devlpmt #1602, from skrenek
a comment to message 1601

Right. According to the documentation, Intuition does allocate more memory for the messages and doesn't return that memory. RKM (volume 1, pages 3 to 108) seems to imply (and it seems to be true) that the newly allocated memory is not reused if you get caught up, then behind again. Instead, it seems even more is allocated. So each time you get behind, that amount of memory is permanently lost. Well, not permanently. It's returned if you close the window, but that doesn't help if you run out of memory and crash.

As I said, my program is similar to the one in the Intuition manual. The only difference is that instead of setting a flag inside the loop, my program completely ignores MOUSEMOVE messages inside the loop, but responds if the last message as it leaves the loop was a MOUSEMOVE.

```
Wait( . . . );
while(message = GetMsg( . . . );
    {
    copy the info
    class = message - > Class;
    Reply(message);
    if(class != MOUSEMOVE) ProcessMessage( . . . );
    }
if(class == MOUSEMOVE) ProcessMove( . . . );
goto Wait;
```

amiga/softw.devlpmt #1610, from jbitt [John Bittner]
a comment to message 1599

If your application permits, you could do an SmodifyIDCMP( ) and turn off REPORTMOUSE whilst you do your processing, then do it again when you're ready for more Mouse Info.

amiga/softw.devlpmt #1614, from cheath
a comment to message 1602

Hmm. You shouldn't have any problem with that, I don't think. Are you getting behind because of menu activity? You'll keep getting MOUSEMOVE events while the menu is active, unless you set window - > flags &= REPORTMOUSE; while the menu is on-screen.

ATARI ST

The Atari ST conference remains a great source for technical information on this machine. This month's peek at the conference begins with hopeful questions on Atari ST/IBM Convertible disk compatibility. The next section is a rather long look (with code samples included) at screen handling problems related to menu selector boxes. The peek ends with a quick discovery of (and factory response to) an undocumented control vector and a surprisingly civil discussion of programming editors for the ST.

IBM CONVERTIBLE/ATARI ST DISK COMPATIBILITY

atari.st/main #143, from rhonesty [Robert Honesty]

The company I work for got in one of the new IBM PCs with a 3½-inch disk drive. So, I took a 720K disk from the ST in to try it out. No luck. IBM (predictably) wouldn't read it. I tried alternate plan two. Formatted on the IBM and tried reading on the ST. Success! Now I can skip the plan to get a 5¼-inch drive. I tried out VIP WKS files with 1-2-3. Nirvana! If I get the time I'll try and figure out why IBM has such problems.

atari.st/main #144, from al [Alastair J.W. Mayer, author of BIX's CoSy software]
a comment to message 143

Problems are probably due to some subtlety in the way formatting is done. Anyway, a couple of questions: Assuming the disks are formatted on IBM (so both IBM and ST can read them), can you write a file with the ST that the IBM can read? (I think your message implies this, but not sure.) What other machines using 3½-inch disks is the ST read- and/or write-compatible with? Anybody got firsthand experience?

atari.st/main #145, from timoren [Tim Oren, Knowledgeset Corp.]
a comment to message 143

The reason for this is that the PC and the ST use different disk controller chips—with the ST using an "older" type. The upshot is exactly the effect you describe: PC-formatted disks read on the ST, but not vice versa. Not being a hardware person, I can't describe the reason in detail.

atari.st/main #146, from jtuermer [Joerg Tuermer]
a comment to message 143

Did you try a disk formatted on the ST, but with the boot sector being an exact copy of the IBM boot sector (this can be made with a disk monitor)? Maybe the IBM is more finicky than the ST as to what it expects to find (like an IBM logo).

atari.st/main #147, from rhonesty
a comment to message 144

Yes, the IBM can read ST files.

atari.st/main #165, from ptoland [Paul Toland]

I've just logged on for the first time in a couple of weeks and have seen the stuff on reading IBM 3½-inch disks. I've tried reading disks from my Data General One on the ST and they read OK as well. Going the other way is a bust, and the info from the DG/One looks as though it's having trouble picking up the first directory block.

(continued)

atari.st/main #171, from dsmall [David Small]
a comment to message 165

I believe you will find that disks formatted on the ST are unreadable with NEC and NEC-like (Intel 8272) floppy controllers, as in IBM anything. However, you can read and write IBM-formatted disks with the ST. This applies to 5¼-inch disks, but I can't think of a reason it would not apply to 3½-inch disks as well.

SELECTOR BOX PROBLEMS

gem/atari #25, from jruley [John Ruley]

TITLE: fsel_input

```
/* this is a code fragment to display a file selector
box */
/* works in Hippo.C—should work in Alcyon or others */
char d_path[256], f_spec[256];
short int ret;
strcpy(d_path," \ \ *.*");
strcpy(f_spec,"________________.______");
graf_mouse(0,0);
graf_mouse(257,0);
ret = fsel_input(d_path,f_spec,&button);
graf_mouse(256,0);
. . .
/* ignore all the graf_mouse commands—that's 'cause
I've got the mouse turned off when I start.*/
```

Problem—when the selector box goes away, it leaves a big gray blotch in the middle of the screen. So I need something that will save the screen before, and restore it after, the fsel_input call.

gem/atari #32, from alexl. [Alex Leavens]
a comment to message 25

You could do a form_dial on the area to save it. Code fragment is

```
int return;
int (all your system variables)
*
*
return = form_dial(0,0,0,0,0,Box_x, Box_y, Size_x,
Size_y);
if(return == 0)
   printf("Error in allocation memory for box );
*
Now do your fsel_input stuff . . .
*
return =
form_dial(3,0,0,0,0,Box_x,Box_y,Size_x,Size_y);
*
```

Ta-da! You're done. Box_x and Box_y are the x and y coordinates of the upper left corner of the box. Size_x and Size_y are the size of the space you want to save (should be greater than or equal to the menu that you want to draw).

If you want to get fancy, you can use functions 1 and 2 of the form_dial command to draw a growing and shrinking box, respectively.

gem/atari #35, from alexl.

A form_dial(0, . . .) saves whatever's under the area that you've defined, and a form_dial(3, . . .) restores it (by telling the system to do a re-draw). I admit it ain't real clear in the Abacus books. It ain't real clear in the DRI documentation either . . .

gem/atari #36, from jruley
a comment to message 35

Sorry Alex—I just tried it, and it does not work.

I'm not sure what the form_dial(0 . . .) did, but the form_dial(3 . . .) attempted to restore a GEM desktop—I got the clear top line, and gray in the rest of the screen. Maybe this is happening because I'm not using a window?

This is all sort of beating around the bush anyway—does anybody out there savvy the raster ops for blitting? I think that's more what I need. . . .

gem/atari #37, from alexl.
a comment to message 36

Absolutely. I savvy the blitter ops (having used them plenty myself). What do you want to know? By the way, you say you're not opening a window . . . what exactly do you mean? Are you not using the "open virtual workstation" command (v_opnwk)? Or something else? Please explain further; maybe I can figure out the problem.

gem/atari #38, from jruley
a comment to message 37

Ummm . . . might be better if I set up a short demo program and put it in listings. I am using the open virtual workstation but am sending text and graphics directly to the screen, without opening a window with the w_whatever( ) commands.

Let me put up some code in listings and we can talk then.

gem/atari #39, from jruley
a comment to message 38

Okay, I've generated a demo which shows the problem—it's in listings as "idiot.c"—compiles under Hippo (with my own XBIOS—if you need it, I will post that too), should compile under Alcyon. It's a GEM application. Operation should be obvious if you read the comments. Run it with all three screen-save routines—none, mine (non-GEM, using physbase( ) and a 32K character array), and Alex's (using form_dial, as we've discussed). If you can fix it so that form_dial works, or suggest an alternate routine (blitting?), I'll be VERY grateful!

gem/listings.st #7, from jruley

TITLE: idiot.c

```
/*   idiot.c
   an example to show my problems with
     screen save & restore—J. Ruley   */
/* static globals: */
/* set up for GEM operation */
static short int xr,yr;
static unsigned char *gbuf,scrn[32000],*physbase( );
/* set up for GEM operation */
/* set up for GEM operation */
main( ){
short int work_in[12],work_out[57],handle;
char d_path[256],f_spec[256];
short int ret,x,y,i;
handle = graf_handle(&x,&x,&x,&x);
for(i=0;i<10;i++)work_in[i] = 1;
work_in[10] = 2;
v_opnvwk(work_in,&handle,work_out);

/* now set up a test screen */

v_clrwk(handle);
ret = vst_effects(handle,12);
vst_height(handle,16,&x,&x,&x,&x);
```

```
ret = vst_point(handle,16,&x,&x,&x,&x);
xr = work_out[0];
yr = work_out[1];
x = xr / 4;
y = yr / 2;
v_gtext(handle,x,y,"Testing . . . ");

/* post an alert box to select the type of screen save
*/

ret = form_alert(2,"[1][Screen save
type:][none|mine|alex's]");

/* save the screen */

sav_scrn(ret);

/* get a filename */

strcpy(d_path," \ \ *.*");
strcpy(f_spec,"________________.______");
i = fsel_input(d_path,f_spec,&x);

/* restore the screen in the selected way */

rst_scrn(ret);

/* wait for a keypress */

conin( );

/* and quit */

v_clsvwk(handle);
appl_exit( );
}

/* subroutines: */

sav_scrn(n)
short int n;
{
short int ret, i;
if(n = = 2){
        gbuf = physbase( );
        for(i=0;i<32000;i++)scrn[i] = *gbuf++;
        }
if(n == 3){
        ret = form_dial(0,0,0,0,0,0,0,xr,yr);
        }
}
rst_scrn(n)
short int n;
{
short int ret, i;
if(n == 2){
        gbuf = physbase( );
        for(i=0;i<32000;i++)*gbuf++ = scrn[i];
        }
if(n == 3){
        ret = form_dial(3,0,0,0,0,0,0,xr,yr);
        }
}
```

gem/atari #41, from alexl.

TITLE: Saving/Restoring Screen

I spoke with Leonard Tramiel yesterday, and he suggested the following:

1) If you're using the fsel_input call, pay attention to the GEM message buffer (which will tell you that you need to do a redraw), and then do it.

2) If you don't want to do that, use (as you figured) the blt calls, to blit the screen memory to a safe location, and then blit it back again. See my listing of Crabs.C in the listings section for some code on how to use the blt. If you need more help, drop me a line. I'm going to see if I can't get Atari to let me post the source code to the demo accessory and application that come with the developer's kit.

gem/atari #42, from timoren
a comment to message 32

To be strictly technical, form_dial doesn't actually save the desktop area. Instead it tells the system to redraw it. Subtle distinction but important.

gem/listings.st #8, from alexl.

TITLE: File Selector Listing

This is a listing of a simple program which will open a (non-functional) window, and then a file selector box, which will let you do all sorts of file selector types of thingies.

SELECT.C

Test program to show how to pull up a file selector dialog, and save the underlying window. Note that although the form_dial successfully redraws the window, that part of the internal structure of the window gets roached by the file selector. This is because the window itself is not being redrawn (which is up to the programmer, and which I've left out, being the lazy sot that I am).

```
#include <osbind.h>
#include <define.h>

#define HIDE_MOUSE graf_mouse(256,&dummy)
#define SHOW_MOUSE graf_mouse(257,&dummy)

int contrl[12], intin[256], ptsin[256], intout[256],
ptsout[256];
int handle;

int res1[4] =
{
0, 15, 320, 170
};

int res2[4] =
{
130, 15, 380, 170
};

int res3[4] =
{
130, 35, 380, 330
};

main( )
{
int i, dummy, mx, my, num_colors;
int charw, charh, boxw, boxh;
int wind_handle;
long boxadd;
int mgbuf[8], pxy[4];
char decimal[4];
char d_path[256],f_spec[256];
int x,y,w,h,xdial,ydial,wdial,hdial;

/* Set the system up to do GEM calls*/

appl_init( );
```

(continued)

```
/* Get the handle of the desktop */
handle=graf_handle(&charw,&charh,&boxw,&boxh);
/* Open the workstation */
for (i=1; i< 10; ++i) intin[i] = 1;
intin[10] = 2;
v_opnvwk(intin, &handle, intout);
pxy[0]=0; pxy[1]=0; pxy[2]=intout[0]; pxy[3]=intout[1];
/* Find out what res mode we're in */
num_colors = intout[13];
vs_clip(handle,1,pxy); /*turn on clipping*/
```

Now open a *very simple* window, strictly designed to show if we are, in fact, restoring the desktop after the call to fsel_input . . .

```
    /* Open a window. Note that even though all
elements of the window are present (slider, kill box,
etc.) None of them work! */
    wind_handle = wind_create(0x0FFF,50,50,200,150);
    i = wind_open(wind_handle,50,50,200,150);
x=y=w=h=0; /* size of smallest box, i.e., non-
existent */
```

Now, get the size of the file selector input box, depending upon the resolution mode that we're in. Note that these are hand-calculated values. I looked *real close* at the screen and tried to figure out how many pixels the sucker was.
*/

```
    if(num_colors < 3)        /* Monochrome
resolution */
    {
      xdial = res3[0];
      ydial = res3[1];
      wdial = res3[2];
      hdial = res3[3];
    }
    else
    if(num_colors < 5)        /* Medium res,
color (4 colors) */
    {
      xdial = res2[0];
      ydial = res2[1];
      wdial = res2[2];
      hdial = res2[3];
    }
    else              /* Low res, color (16
colors)    */
    {
      xdial = res1[0];
      ydial = res1[1];
      wdial = res1[2];
      hdial = res1[3];
    }
      /* reserve room on the screen */
    form_dial ( 0, x, y, w, h, xdial, ydial, wdial,
hdial );
    /* draw a growing box */
    form_dial ( 1, x, y, w, h, xdial, ydial, wdial,
hdial );
/* get a file name */
strcpy(d_path,"\\*.*");
strcpy(f_spec,"________.___");
i = fsel_input(d_path,f_spec,&x);
    /* draw shrinking box */
    form_dial ( 2, x, y, w, h, xdial, ydial, wdial,
hdial );
    /* free up screen area */
    form_dial ( 3, x, y, w, h, xdial, ydial, wdial,
hdial );
/* Wait for a mouse click to end the program . . . */
evnt_button(1,1,1,&mx,&my,&dummy,&dummy);
/* Close the window */
wind_close(wind_handle);
/* Close the workstation */
v_clsvwk(handle);
  /* Release GEM calls */
appl_exit( );
}
/*-----Plot(x,y)-------*/
Plot(x,y)
{
int pxy[4];
  pxy[0]=x; pxy[1]=y; pxy[2]=x; pxy[3]=y;
v_pline(handle,2, pxy);
}
/*-------End of Plot (x,y)------*/
/*-------rand( )-------*/
/*This function will return an 8-bit random number*/
rand( )
{
return(Random( )&0x00FF);
}
/* End of
rand */
```

SYSTEM VECTOR EXPLORATIONS

atari.st/tech #172, from hisoft [Dave Howorth]

For trivia freaks, there is a (to my knowledge, undocumented) system vector at $502 which points to the screen dump routine, called by the BIOS trap and Alt-Help. If you change it, you can do screen dumps on any printer of your choice. The Amiga conference has people from Amiga on it who read messages like the one above and then say, "We'll define it so you can use it," or "*Don't* use it—it's gonna change." Is there anyone from Atari on this conference with similar knowledge?

atari.st/tech #178, from jtittsler [Jim Tittsler, Atari Corp.]
a comment to message 172

The vector at $502 (scr_dump) is a safe vector for the ROM TOS only. We will maintain it in future versions of the operating system. There are also individual vectors for printer device output:

prtblk character-output vectors

Prtblk( ) uses four vectors to output characters to printer devices. The vectors are in protected OS memory. "prv_lsto" initially points to the PRN: device output status, and "prv_lst" initially points to the PRN: output driver; "prv_auxo" initially points to the AUX: (RS-232) device output status, and "prv_aux" initially points to the AUX: output driver. Prtblk( ) uses the PRN: or AUX: vectors based on bit 4 of the printer configuration word (see the guide). Output of Prtblk( ) may be redirected by modifying the appropriate vectors.

Prtblk( ) Output Vectors			
prv_lsto:	1	ds.l	; (506) - > _lstostat( )
prv_lst:	1	ds.l	; (50a) - > _lstout( )
prv_auxo:	1	ds.l	; (50e) - > _auxostat( )
prv_aux:	1	ds.l	; (512) - > _auxout( )

In general, the policy is, if the vector is listed in the "System Variables" section of the guide, their locations and meanings in future revisions of the ST BIOS will not change.

A QUESTION OF EDITORS

atari.st/tech #191, from davjon [David Jones]

TITLE: Program Editors

One thing that occupies my mind over here in the U.K. is, What is *the* best ST program text editor? I find that most of the editors that I have used on the ST (1st Word, GST-EDIT, Modula-2 Editor, MicroEMACS, Metacomco ED, Hippo-C, et al.) always have some annoying feature, like not auto-indenting, for example. I would be really interested to know what other developers think about the available editors.

atari.st/tech #192, from sprung [Ron Sprunger]
a comment to message 191

I've given up on 1st Word and TDI M2 editors, and use only MicroEMACS, which is adequate, though lacking somewhat. All I want is the Turbo Pascal editor, which I can run completely from the home position on the keyboard, and which I can make behave like the Alpha Micro editor VUE. EMACS is not bad, but it's always in insert mode, uses commands in drastic disagreement with those of VUE or WordStar, pages backward awkwardly, has no built-in search and replace (macros are neat, but I don't want to use them for every search and replace, and especially not for globals). It also inserts real tabs, which I have to filter out before sending text to the M2 compiler. Still, it is far and away the best available for programming and does not require me to fiddle with a silly mouse, or grope for function keys.

atari.st/tech #194, from sgrimm [Steve Grimm]
a comment to message 192

I always use Regent Word to program, for the simple reason that it is very, very fast. I hate having to wait for EMACS to update the screen when scrolling through a file. Also (and I know this isn't of world-shattering importance), you can select a file to load with one keystroke. The only complaint I have about Regent Word is that it can't load files from subdirectories.

atari.st/tech #195, from mmallett [Mark Mallett]
a comment to message 192

User sprung says: "EMACS is not bad, but it's always in insert mode." Editors being like religions, this is probably one of the major fissures in the faiths of the followers of editors: moded vs. non-moded editors. Many would claim that one of the great points of EMACS is that it is always in the same "mode." (I am one who would claim this.) Having to remember, when using an editor, whether one is in insert or command mode is something that can drive a person like me insane (maybe that is what did it). Sprung also comments, "It also inserts real tabs," which have to be filtered out before being given to a compiler. I would claim that the problem is in the compiler. I would class as unusable an editor that refuses to store tabs as tabs (e.g., the MIX editor).

atari.st/tech #199, from conover [Harry Conover]
a comment to message 192

MicroEMACS isn't bad, but it can't be compared to a real programming editor like vi, which I understand will be soon available for the ST. I still haven't learned how to go directly to line *n* to correct a diagnostic-detected error. Can you tell me how?

atari.st/tech #202, from alexl.
a comment to message 199

Get to the beginning of a file. Type <ctrl> u, then enter the line number for the argument. Then press the down arrow key. Ta-da!

atari.st/tech #203, from sprung
a comment to message 195

You misunderstand me on modes. I mean "insert" as opposed to "overwrite."

I don't care if an editor splits the work between edit and command modes, and I use editors of both persuasions. As for tabs, certainly the M2 compiler is remiss in not ignoring them, but it is not alone in that respect. I personally prefer the tabs and don't mind running everything through detab before compiling.

IBM PC AND COMPATIBLES

The IBM PC conference excerpts concentrate on software this month, with three discusions centering on various aspects of DOS. First, there is a question (and, yes, answers) about format problems with specific hard disk/controller/DOS combinations. Next, BIXen get into a thorough look at *exactly* where in memory DOS begins and ends. Finally, someone asks how to create a file of precise printer output for debugging purposes. Several software solutions are proposed.

DOS 3.1 FORMAT PROBLEMS

ibm.pc/pc.hardware #779, from smack [Steve Mack]

I have a WD (Western Digital) controller and a Rodime 30Mb HD that were formatted with DOS 2.1 until a couple of days ago. I got tired of 8K clusters and wanted to do a low-level format anyway, due to a new bad sector, so I BACKUP'd, formatted, and tried to bring up DOS 3.1. The FDISK went OK, made entire disk my DOS partition, but then "FORMAT C:/s/v" would say "Format complete" but also said "Invalid media or Track 0 bad—disk unusable, format failure."

Several more attempts led me to get a new drive and controller under warranty (Statewide Microelectronics by the way—quick swap; no hassles), but the new set did the *same thing*. Finally, I tried DOS 2.1 again and it runs fine, formatting with no errors. Next, I tried DOS 3.1 with a partition size of 100 cylinders, instead of the 639 on the entire disk, and this worked.

Next I tried "FORMAT C:" with no /s/v, but on the entire disk as DOS partition, and still got the error. Then I ignored the error and did "SYS c:" and copied COMMAND.COM over. Lo and behold, all is fine now! 2K clusters and all! Restored 30 some-odd floppies and all is fine. Does anybody have any idea of what just bit me? Am I hallucinating? Better part of two days makes me want an answer even though it works now.

(continued)

ibm.pc/pc.hardware #780, from sak [Sal Magnone]
a comment to message 779

I get all kinds of fun things with my WD controller. Sometimes it doesn't format in 3.1. Other times (when I had a Victor Speed Pac) it refused to catch. That means the computer does not manage to recognize the fixed disk. The faster you go, the more often it'll refuse to catch. Now I just got a V20 and the drive refuses to catch maybe 1 out of 10 times. I'm not the only one with these problems!

ibm.pc/pc.hardware #783, from conniek [Conrad S. Kageyama]
a comment to message 779

Sigh. You've run into the tried-and-true DMA boundary problem with FORMAT.COM. . . .

First, the cure to get you formatted and running. If you did not do it from a plain vanilla system (no TSRs loaded, no CONFIG.SYS), then try it that way and see what happens. If it still bombs from a plain vanilla system, then change your BUFFERS= to 99 and try it again. This should do it for you. There is most likely absolutely nothing wrong with either your drive or your controller. The problem lies in the fact that one of FORMAT's buffers *cannot* lie across a 64K boundary. By cranking up the buffers (each one takes 512 bytes of RAM), you're simply moving that buffer to another location, hopefully not across a boundary.

Now, once you're all fixed up and running, you can start playing with your normal system to modify it so you won't get that error message. As you add new TSRs to your AUTOEXEC, you will be moving this load limit, and the same buggy could crop up. In my experience, the easiest fix is to alter my BUFFERS= by one buffer at a time for a 512 byte adjustment, or my RAM disk by 1K for a 1K adjustment.

Also, if you get this error message, a sure-fire way to confirm the DMA boundary problem is to load Debug and then look at the registers by doing an R at the — prompt. If the register is in the range of D thru F or 0 thru 3, then you've confirmed the problem.

If it's any consolation, this bug is also evident in DOS 2.1 but was *supposed* to be fixed in 3.x. It is now reputed to be fixed in 3.2, but I haven't had any reports yet.

MS-DOS Load Addresses

ms.dos/other #424, from stevebh [Steve Booth]

OK, here is a real problem: I am a software developer, primarily using Lattice C's large model to develop a large application program. One of the real problems with Lattice C in the large model is that it can (by definition) modify any location in memory. Unfortunately, somehow we have managed to write our software so that it clobbers MS-DOS. We have an analyzer that can catch our program doing this, and thereby determine what is going wrong, but we can't seem to find out just where in memory MS-DOS is loaded *exactly*.

I called Microsoft—they told me to call IBM. I called IBM, they told me to call ComputerLand. ComputerLand told me to get Norton's MS-DOS book. I did. It doesn't tell where MS-DOS is loaded, and further it does not tell how to find out. I am at a loss to know where to look next. HELP! I have managed to learn that when MS-DOS is booted, it loads IO.SYS, then MSDOS.SYS, then COMMAND.COM into memory, but how do you find out where? Where are the FATs stored? Where are the BUFFERS stored? Why is none of this in any of the documentation?

ms.dos/other #425, from barryn [Barry Nance]
a comment to message 424

"User memory"—where the very first program (DOS) can be loaded—begins at 00500 (hex) in IBM PCs. 00000-00400 are used for the interrupt vectors and 00400-00500 are used as a BIOS/DOS data area.

The ending address depends on which version of DOS you're using, of course. Does that help?

ms.dos/other #426, from stevebh
a comment to message 425

Not really. I already know where MS-DOS starts, and as you say, on an IBM, it's at 500 hex, but where does it end? Where does it put its FATs? Where do the file buffers start? Where does COMMAND.COM start? Where does it end? What is between my user program and the top of DOS (wherever that is)?

ms.dos/other #427, from dmick [Dan Mick]
a comment to message 426

It is, as Barry says, dependent on the version you're using. The only thing between the top of DOS and you is your environment, which DOS builds at load time. FATs and buffers and COMMAND.COM are all lower than where you load by the environment length. Why in the world would you want to know this for a C program? Are you trying to collect stats about DOS? In my opinion, ya shouldn't be writing lower than your load address *period*, because that's just not the way to play the game. But I'm interested enough to ask, so . . . whattya doin'?
(Or maybe the fact that DOS is contiguous is what you wanted?)

ms.dos/other #428, from barryn
a comment to message 426

I just took a look with DEBUG.COM, and I found out the following:

(I have DOS 3.1, with BUFFERS=20, FILES=20, and ANSI.SYS.)

1. The permanent portion of DOS ends at 0BED:05AA on my system.
2. The FATs are apparently brought into memory when necessary, and are not permanently resident.
3. The file buffers are apparently in low memory, just before DOS, in the area 0050:0A00 or thereabouts.
4. COMMAND.COM is loaded into high memory . . . on a 640K machine, it would be at the 617K mark (or so).
5. I don't understand what you mean by "between my program and DOS."

Does that help a little more?

ms.dos/other #429, from dmick
a comment to message 428

Sorry, that's right, COMMAND.COM loads high. I have PC-DOS 2.10 on an XT, BUFFERS=20, ANSI.SYS and got 8C2:0 as the first command load address (where the first resident program was). It appeared that there were fragments of directories (implying buffers) all through this general area of core, seeming to follow no certain pattern, although I'm sure it must. I know that DOS tries to keep FATs and DIR of the current subdirectory in memory to speed access times . . . don't know where, though. That's what the MediaChange function of the block device drivers is all about, though—to check if that stuff needs reloading.

ms.dos/other #439, from rduncan [Ray Duncan]
a comment to message 428

The DOS buffer pool is much higher than that . . . it lies between the DOS kernel (MSDOS.SYS or IBMDOS.COM) and COMMAND.COM. What you may be seeing was a dedicated disk buffer for one of the drivers. COMMAND.COM is divided into 3 parts. The "resident" part sits above DOS and below your program. This part is fairly small and contains the handlers for the critical error, Control-C, and termination interrupts, among other things. The "transient" part sits at the top of memory and can be overlaid by other programs. It is reloaded from the disk when needed using the COMSPEC variable in the environment. It contains the batch file interpreter, intrinsic commands (like COPY, DEL, etc.), and so forth. The "initialization" part sits just above the "resident" part when the system is booting. It is mainly responsible for interpreting the AUTOEXEC.BAT file, and is then discarded. Like dmick said, as long as you don't write into any memory *below* where your program loads, you aren't going to have problems. Poking into the innards of DOS seems to be the wrong approach . . . figure out what is wrong with the program that is causing the trouble instead.

ms.dos/other #441, from stevebh
a comment to message 427

It's not that I *want* to know it, it's that this darned C program *writes* on top of MS-DOS, and I'm trying to find out where in the program it's doing it. I have a Logic Analyzer that will catch any write to any memory location, but in order for it to be useful, I have to know where MS-DOS is, in order to catch the write.

ms.dos/other #443, from dmick
a comment to message 441

Well, what I'd do is load the C program with Periscope or some other debugger that is resident. What? You don't have PS or Atron? Well . . . they're great for this type problem 'cause you could breakpoint writes to any location lower than your load address. In lieu of that, however, why don't you load Debug or CORELOOK or sumpin' else that allows you to examine memory, then look for where *that* program starts, by looking for its environment/pspseg. Then exit that program and you know where the next one (the C program) will load. The logic analyzer can then be used to see when addresses below that load address are accessed, assuming you can single-step your C code.

PS: With Debug, for example, the address you get after typing DEBUG <ret> is the "new load address" after Debug installs itself. Look below the CS:IP Debug gives you for environment (easily recognized by strings . . . PROMPT, COMSPEC, etc.). The paragraph above the end of the environment (marked by 00 00) is the Memory Control Block for Debug's psp-code segment and is marked by 4D as the byte in offset 0. The *next* paragraph is Debug's psp (goes on for 10 paragraphs or 100 hex bytes), then Debug's code. Your load address will be where Debug is now, after you exit Debug and run your errant program. (Is all this as clear as mud?) Perhaps a diagram. . . .

xxxx:0000 Environment for Debug
(COMSPEC = c: \ comm ^ Hand.com,00h,etc.)
xxxx:0000 4D . . . mcb for Debug's code and psp to follow
>xxxx + 1:0000 CD 20 . . . psp for Debug (starts with INT 20H)
xxxx + 1:0000 will be your C program's load address.
(There, the horse is dead!) Hope *this* helps, too.

IMAGE FILE SPOOLER

ms.dos/utilities #310, from rlamb [Richard Lamb]

I have a question that I hope some of the assembly language hackers can help me with. I often find, especially when installing word processors, that I need to find out *exactly* what is being output to the printer. I need a disk file that duplicates the bytes sent to the printer. However, many word processors do not have a "print to disk" function, and even those that do frequently don't send the same thing to disk that they do to the printer. Therefore, what I would like to do is create an assembly language program that would stay resident, listen to all output sent to the STDPRN device, and send it to an open disk file. I have a public domain utility called FSPOOL which is supposed to do exactly that, but doesn't work on the Zenith Z-100 I tried it out on. At any rate, here is how I plan to tackle it: Use function 46h of INT 21 to force handle 4 (STDPRN) to duplicate onto an open disk file. Then use 4Bh (EXEC) to load and execute a second copy of COMMAND.COM. Since the new command interpreter would inherit the old environment, its PRN would be redirected. Using the second copy of COMMAND.COM, I can then load whatever application program I want. Finally, after quitting the application and exiting the second COMMAND.COM, the utility would close the disk spool file and terminate.

Before I start on this, I'd like to find out if there is a better way. Somehow, two copies of COMMAND.COM, one utility, and one application all loaded into memory at once seems a bit inelegant. I am trying to avoid using any IBM-specific interrupts or BIOS services. Seems like the DOS services should be sufficient. Anyone have any suggestions? The completed program will be placed into the public domain.

ms.dos/utilities #311, from barryn
a comment to message 310

I wonder if the WP programs that don't support print-to-disk perhaps bypass DOS and issue INT 17 (Print a Character) BIOS calls directly? Such programs would be difficult to deal with. On the Zenith, is INT 17 a printer BIOS routine?

ms.dos/utilities #312, from dmick
a comment to message 310

My documentation on CDUP is awfully sketchy. It says that if the read/write pointer for the original file is moved, so will be the duplicated file handles pointer. It does *not* say anything about read or written data to either. DUP is more explicit about this, and says essentially that you will have a dual reference to the file, so one would assume CDUP is the same with the "forcing" applied. However. If the application you are using does not use file handles (read WordStar or other ill-behaved DOS 1.x programs, even some released after DOS 2.x but updated by lazy programmers), then you're out of luck here. The other option I would suggest is this:

Enumerate all the standard DOS functions that send stuff to the printer, including 40h (write to handle), and AUX out, and PRN out, and the old (FCB-style) writes; then catch them all with an INT 21h filter, and process them accordingly (write to a file, hopefully without getting into reentrance problems). Of course, this filter would have to be smart enough to figure out that it was indeed PRN (or LPT1: or COM1: or whatever) that was receiving the output/file write for those cases where the function is not specific; and then

Tear your hair out trying to debug all this.

I'd cop out, myself, like FSPOOL does, and intercept the last element in the chain of getting things printed, the BIOS call. That is really the only appropriate place for a robust routine. On IBM clones, the call is INT 17H; on your Z-100, the call is BIOS_PRNFUNC, and its vector is an offset only into segment 40H and is located at 40:48h. See the PUP guide for reference as to what the call does, input/output, etc.

A question: why the second copy of COMMAND.COM? Seems like, if you just wanted to catch the data in another handle, the call to DUP would do it. Or am I missing the boat completely here?

ms.dos/utilities #317, from rduncan
a comment to message 310

Why not just EXEC the application directly after FDUPing the printer handle, rather than doing it via COMMAND.COM? Otherwise, your proposed method looks right to me, if you want to avoid IBM-specific interrupts and BIOS services, etc.

ms.dos/utilities #318, from rlamb
a comment to message 312

Well, you have certainly brought up some valid concerns in your message. Indeed, after studying the manual, I realized that the very

(continued)

programs I'm trying to work on are the ill-behaved ones. (WS is one of the problem children, XyWrite III another. I'm not sure what method Xy uses to print, however.) The reason for the second COMMAND.COM was that I wanted to avoid writing enough code to allow the routine to handle any application, a command-line parser, etc. Pure laziness. My current method for handling this problem is to use Zenith's CONFIGUR program (performs an identical function as IBM's MODE command) to change the output to the AUX: port, then capturing it with a Tandy Model 100. Although I'm limited to about 30K bytes, it's beginning to not seem so inconvenient. As to the use of the DUP function to force redirection of the PRN handle, I'm taking Peter Norton at his word on that. Before he made specific reference to that use of the DUP function, I hadn't a clue as to what to use it for. Does anyone have the source to FSPOOL? Perhaps I can modify it to use the Zenith's BIOS call rather than IBM's INT 17H.

ms.dos/utilities #319, from dmick
a comment to message 318

Well, I don't have the source, but I have unassembled the code with Debug and it's not too bad. If you have ASMGEN and a copy of the .COM file you should be in business. What? You've never heard of ASMGEN? It generates .ASM source from .COM or .EXE files and a file of instructions you create (5a is a data byte, 100 to 200 are 00 reserved for stack, etc., . . . that kind of thing). Great for reverse- (perverse-?) engineering this thing or that, especially if it's small and easily understood. I think it's already on listings; if not, I can post, but you may be able to just use FSPOOL and Debug. Or look at the former and create your own code. It's pretty easy, as I recall.

I have used FSPOOL to debug WS. It's hard to beat seeing just what that^$%&(*) is sending to my printer to make it enter compressed mode, do 50 form feeds, and beep at me! Good luck. Hope we've helped out here.

MACINTOSH

The Macintosh conference this month was busy with questions concerning the effects of new Macs, and Mac upgrades, on existing software and future purchase plans. Our excerpts from the conference begin with a spine-chilling tale of hard-disk adventure. Next, a problem with RamStart on the Mac Plus and various solutions are discussed. BIXen mdelugg asks questions about the virtues of upgrading and gets a number of replies from those who have gone before him. Finally, we wrap up with two threads of speculation on new products, the first on possible CD-ROM directions, and the second with directions all its own.

MACINTOSH HARD DISK

macintosh/hardware #106, from microprose [Russell Finn]

TITLE: It Was a Dark but Non-Stormy Night. . . .

Now that my hands have stopped shaking, I feel I should share my experience with other Macintosh users. I have had my "dream system" (Mac Plus, HD 20, ImageWriter II, Personal Modem) at home for less than a week; having acquired Red Ryder 8.0, I have begun to download software from various systems. In short, life is good.

Tonight, however, while I was perusing one of my latest acquisitions (the MacinTalk documentation), the lights in my apartment *blinked* once—twice—three times, and I found myself facing a blinking question mark. Almost immediately, the HD 20 started whirring and blinking, so I waited for the desktop to reappear. And waited. And *waited.*
And . . . the blinking question mark came back!

I became a little nervous at this. Manually resetting the Mac using the programmer's switch produced the same results as before. Clearly something was amiss. I popped the System Tools disk into the slot, and in moments the familiar desktop had reappeared. I waited for the "Hard Disk 20" icon to emerge. And waited. And . . .

"[Hard Disk icon] This disk is unreadable. (Eject) (Initialize)"

I stared in horror at the dialog box. In just under a week I had accumulated over five megabytes of data; had they all gone to the great bit-bucket in the sky? Was I being punished for not buying IBM? I started to look for some useful utility—FEdit, MacTools—but realized that none of the versions I had were HFS-compatible. There seemed no hope . . . unless . . .

I reached behind the HD 20 and threw the power switch; the drive quickly coasted to a stop. Then, breathing a prayer to the Great Spirit Woz, I turned it back on. And waited. And . . .

Window after window appeared on my screen—applications, fonts, VCO face files . . . *they were back*! All five megabytes! Order had triumphed over chaos!

Satisfied, I went to the kitchen for a Diet Coke.

MORAL I: Don't panic!

MORAL II: When you can't afford an uninterruptible power supply, you have to learn to accept some anchovies in the great pizza of life.

MORAL III: Does anyone have a good HFS-compatible backup utility?

macintosh/hardware #107, from cgibson [Chris Gibson]
a comment to message 106

I have found that anytime an abnormal termination occurs while my HD 20 is on-line, when I power up the HD 20 after the termination, the HD will sit there, furiously doing something, sometimes for quite awhile. While I don't know exactly what's going on, I would guess that the hard disk is left in a less than perfect state, and it takes the time to delete internal temp files, or check the directories, or rebuild some index. I make no pretenses on my expertise in this area, but what I can say is this: if your HD freaks, power down, then switch on the HD *only*. As long as it is making noises, and the light is blinking, don't interrupt it. *Wait* until the light glows steady, then power up your Mac. (Whoops, I don't know if this works with the old ROM—I only use my HD 20 with my Mac Plus, not my 512K.) Anyway, microprose is right: DON'T PANIC!!

macintosh/hardware #108, from lloeb [Larry Loeb]
a comment to message 106

(Getting up after falling on floor, laughing) Woz (gasp, chortle) rewards the faithful.

macintosh/hardware #109, from lloeb
a comment to message 107

Well, since microprose doesn't have Strike Force Eagle out for the Mac yet, maybe this is the start of a new game: HD CRASH! Survive massive data loss! (Batteries Not Included.)

macintosh/hardware #111, from paul.hoffman [Paul Hoffman]
a comment to message 106

MORAL I is especially true. Here's another that the folks at Apple don't admit to: Hitting the programmer's switch is *not* the internal equivalent of turning the Mac off and on. Somehow, resetting does not clear everything internally. If you get a bomb, reset, and one of your disks seems trashed:
—Take two deep breaths.
—Turn the Mac off for 5 seconds (the vision of black on the screen may be good for the soul).
—Turn it back on.
This has happened to me many times during software development.

RAMSTART/MAC PLUS PROBLEMS

macintosh/mac.plus #58, from dpallen [David P. Allen]

I have been trying to use RamStart with the new ROMs and everything works OK until RamStart tries to massage the system file into the RAM disk. At that point comes the big bomb with ID = −03. Everything else seems to work OK with the RAM disk, and I can move the system file over manually after the RAM disk is created, and it seems to work OK when I change the default manually to the RAM disk Finder and system file.

I tried a patch of RamStart, suggested by a chap over in CompuServe, but it didn't help. Any suggestions?

macintosh/mac.plus #59, from deu [William Deu]
a comment to message 58

Yeah, I think I had the same problem. My guess is it has something to do with the system file's boot blocks. I worked around it this way:
—First, I boot with the system disk, with RamStart in a folder by itself.
—Second, I then open the folder and launch RamStart.
—Third, I copy whatever I need to copy into my RAM disk.
—Fourth, I then stick the system disk in and launch TMON or some other application. Then I quit it and when I'm back to the Finder I don't have anymore problems.
—Fifth, I'm not sure why this works.

(PS: I'm using RamStart v1.21 with the patch from CompuServe.)

macintosh/mac.plus #60, from dpallen
a comment to message 59

Here is the solution to the RamStart problem as presented by a chap on CIS. I tried it and it works. It is necessary to do the hard disk patch to get rid of the occasional error message.

Patching of RamStart Versions 1.21 and 1.22 to Operate with Mac 128K ROMs:

The patching can be undertaken with MacTools, FEdit, MacZap, or similar utilities which are capable of searching for text strings and then writing changed ones to disk.

****

To patch version 1.21:

In sector $0C, offset $B4, replace 4EBA 0682
with 4E71 4E71

In sector $0D, offset $17A,
replace 6700 0012 006E 8000
with 6000 0012 006E 8000

If you're using a hard disk, you may need to apply the following patch (Gary had to use it for both the Corvus and the Warp Nine):

In sector $06, offset $190,
replace 41FA 0388
with 6000 000C

The symptom for this last problem is a message "can't find our drive #."

****

To patch version 1.22:

In sector $0C, offset $36, replace 4EBA 0678
with 4E71 4E71

In sector $0D, offset $F8,
replace 6700 0012 006E 8000
with 6000 0012 006E 8000

If you're using a hard disk, you may need to apply the following patch (Gary had to use it for both the Corvus and the Warp Nine):

In sector $06, offset $132, replace 41FA 0384
with 6000 000A

The symptom for this last problem is a message "can't find our drive #."

CONSIDERATIONS FOR MAC UPGRADE

macintosh/mac.plus #61, from mdelugg [Michael Delugg]

Question: I've got a 512K with single-sided drives. While I often find myself spending time "re-organizing" my files so as to not run out of disk space, I don't find it *too* bothersome (yet). I mainly use the Mac to help me run a "small" business (billing, scheduling, etc.), and so far, my third-party memory upgrade (to 512K) seems to be holding its own. The point is: What improvements would I realize from the Mac Plus upgrade (probably the RAM, too) as opposed to any drawbacks? I've seen a lot of messages dealing with power supply problems and incompatible software. Will Copy II Mac back up to the 800K drives? My three most-used applications are OverVUE 2.0, MS-Word, and Red Ryder.

macintosh/mac.plus #62, from pkarnig [Peter Karnig]
a comment to message 61

I use Mac Plus, Word, File, Excel, Red Ryder 8.0. My small business has 512K Macs. I can only say that the Mac Plus is quite a bit faster and utilizes Switcher much, much better. Copy II does not work on 800K disks, but you can use the hard disk copy tool to copy applications to a RAM disk, then copy it to your 800K. This works. I use version 1.21 and have just heard of a new version: 1.22. Hope this helps.

macintosh/mac.plus #64, from ccrawfor [Chris Crawford]
a comment to message 61

My two-penny opinion is this: You should definitely do the $300 ROM and disk drive upgrade. For that money, you get faster operations and a disk with more capacity. This can be very important in terms of allowing a system disk with all the fonts and desk accessories that you want.

The next upgrade, the new board with the SCSI port and the 1 Mb of RAM, is considerably more expensive and definitely worthwhile if you expect to buy a hard disk soon, as SCSI drives are faster and cheaper than the drives that connect through the old serial ports. If you do not expect to purchase a hard disk, then the only value of the board is for an extra 512K of RAM; I do not think this is a good buy. There are better ways to get more RAM for your Mac.

Finally, the new keyboard is of value to those who do a lot of numeric entry. It does interfere slightly with mouse operation, so I do not want it for my own use.

macintosh/mac.plus #65, from lloeb
a comment to message 64

I tend to agree. If you want more from what you have now, the Plus is a good upgrade. But if you see those 68020 machines over the horizon . . . well, consider if you really need the logic board before [the new machines are introduced].

macintosh/mac.plus #66, from stike (Jim Stikeleather)
a comment to message 64

Chris, I appreciated your two-cent opinion. I have been wrestling with whether to upgrade or not for about a month now. I had pretty much come to the same conclusion as you. The Mac goes in next week. It's always nice to have my decision reinforced.

(continued)

macintosh/mac.plus #71, from ccrawfor

On the question of using an old keyboard on the Mac Plus: I took two Macs, one a standard Fat Mac, the other a standard Mac Plus, and swapped keyboards. Both seemed to work just fine. I did *not* put them through a torture test, just light use.

macintosh/mac.plus #72, from tom_thompson [Tom Thompson, Technical Editor, BYTE]
a comment to message 64

I'll raise ya two, Chris (*clink*). I agree with you on this, and I can offer yet another reason for not going to the new logic board. Unless your dealer has the new cables handy, you're going to have a Plus that you can't hook to your existing printer and modem, thanks to the DIN-8 connector on the serial ports.

If you have a ton of peripherals that use the DB-9 connector or the +5V out of the serial ports, consider things carefully before taking the plunge.

FUTURE PRODUCT SPECULATION

macintosh/news #362, from frankb [Frank Boosman]

TITLE: Another Slimy Rumor

Have you ever wondered what Bill Atkinson has been working on since MacPaint? I have. Oh, sure, he did MacVision, but that probably took him a month or so. Then there was PaintMover, but that was probably a week job. Rolodex most likely took him all of an hour. So what has he been up to? What fantastic software has he been designing?

Well, we know he's working on an updated version of QuickDraw—one that will allow device-independent graphics, with color, high resolution, and all that. And it would seem to be a safe bet he's working on a color version of MacPaint—unless doing the first one burned him out on painting programs.

So we're back to wondering what he's doing with all this extra time. In the book *Inside MacPaint*, the author asked him just that question. His answer? Well, his answer was that he was working on something neat, but he doesn't like to talk about things before they're finished. He likes to spring them on people.

Last weekend, I watched "Hackers" on PBS. In it, they talked with Bill briefly. He used MacPaint to demonstrate a concept he said he had been thinking about of late (this was about a year ago, mind you). What he demonstrated—again, using MacPaint pictures—was sort of a Filevision-type CD-ROM interface. You know, click on an object and get information. His idea looked pretty nifty, especially considering it was a year ago, when no one really cared about CD-ROM.

So, is that the mysterious program Bill is working on? We do know that Apple is committed to CD-ROM—in a recent CompuServe conference, Jean-Louis Gassee said they would be introducing products "soon." And they wouldn't want to introduce a CD-ROM product without software.

Have I stumbled onto it? Or do you think I'm just barking up the wrong tree?

macintosh/news #366, from frankb

I've never seen PaintMover (could someone upload it?), but from the article I read, it appears to be a utility for working with full-page MacPaint documents. You can enlarge areas to poster-size, smooth them, etc. . . . again, this is definitely secondhand.

macintosh/news #368, from ccrawfor
a comment to message 362

I know the guy at Apple who is responsible for marketing projects involving laser disk and CD-ROM. He is in a research group, not a product development group, and I have never gathered the impression that he is close to anything like a product. Then again, it is considered bad form to pry.

macintosh/news #370, from tom_thompson
a comment to message 366

I've got version 0.3. It does handle full-page Paint documents. Essentially you get two windows, one for input (your MacPaint file) and one for output. Then you select the region you want copied to the output window by clicking and dragging over the desired area in the input window. Next, you select "copy," plus any scaling function, and inverse or XOR bit operations, and see the result appear in the output window. Finally, you save the output to a MacPaint file. It is *very* good for handling stuff that won't fit within the MacPaint window. I had a portion of a chart to copy for a new document, and it covered a full 8- by 11-inch page. I simply selected the region I wanted in PaintMover, copied it over, saved, and made some minor edits to get a new chart. I would have had to perform several major operations to transfer it using MacPaint. It's one of those nifty utilities that you don't need for several months, but when you need it, you need it bad.

macintosh/news #376, from ccrawfor
a comment to message 368

I called my friend at Apple today and he was appropriately evasive about the subject of CD-ROM products—this is in itself an indication that something is cooking after all. He did read me some comments that had already been cleared for a speech he gave at the Microsoft conference; fairly bland stuff, but the implication seems to be that Apple is looking very seriously at CD-ROM. One point that he was explicit on was that Apple is trying hard to get a good standard set up. The immediate fruit of this standards stuff is a set of VTOCs on each CD-ROM for each of the major machines. With 550 Mb, you can afford multiple VTOCs.

Finally, he cautioned against premature expectations for CD-ROM. A lot of people seem to think that this technology is just around the corner, and his opinion (I think it was a personal opinion, not an Apple policy) is that it will take a few years to mature.

Sorry this is all so vague, but he did not want to play Corporate Blabbermouth, and I didn't want to pry.

macintosh/news #384, from kerskine [Keith Erskine]
a comment to message 376

Chris, could you explain VTOCs? I'm not familiar with that abbreviation.

macintosh/news #386, from ccrawfor
a comment to message 384

Oops, sorry; I should have known better, for it is a tad obscure. It means "Volume Table of Contents" and is a table of all files on the disk and their locations (more precisely, the locations of the first part of the file). Floppies use VTOCs, hard disks use VTOCs, and so must CD-ROMs, unless you are setting up a really weird system. The idea Apple is promoting is to rig the CD-ROM with a number of VTOCs. each one designed to be accessible to the operating system of each of the major machines. Instead of coming up with One Universal Standard that everybody can be happy with, the idea is to compromise down to two or three semi-universal standards that everybody can live with. Sounds to me like one of the more pragmatic solutions to the old standards bugaboo.

macintosh/news #387, from mwelch [Mark Welch]
a comment to message 386

Multiple VTOCs make a lot of sense if you have IBM users who want to access a CD-ROM using DOS filenames, and Mac users of the same disk who want to access it using the desktop. And those who are quite interested are invited to join the cd.rom and storage conferences.

OBJECT-ORIENTED PROGRAMMING LANGUAGES

One of the important facets of BIX is the staging of "special events." This month, the special event on Object-oriented Languages seemed particularly appropriate for inclusion here. The threads cover possible definitions of object-oriented programming languages (OOPLs) and a practical application using Smalltalk.

DEFINITIONS OF OBJECT-ORIENTED LANGUAGES

smalltalk/expert.forum #17, from bstroustrup [Bjarne Stroustrup, AT&T Bell Labs]

What is a really good definition of an object-oriented language?

"Really good" may be too much to ask for, since there are several different schools of thought, but here is mine:

A language supports object-oriented programming if it provides an inheritance mechanism. That is, in Simula67 and Smalltalk terminology: subclasses. The language is object-oriented if it enforces the rule that *all* communication between objects must be in the form of calls of methods (sometimes called member functions).

smalltalk/expert.forum #25, from ltesler [Larry Tesler, Apple Computer Inc.]

What is a really good definition of an object-oriented language?

A language in which statements tell objects to perform actions and to transmit results, instead of telling procedures to operate upon data.

In an object-oriented language, a statement is more like a stage directive in a play (Smith: exit stage left) than an imperative command (Kick out Smith!).

smalltalk/expert.forum #39, from cox [Brad Cox, Productivity Products International Inc.]

I agree with Bjarne that a "really good" definition is probably too much to ask for until today's wealth of personal definitions can be sifted for areas of consensus. Assembler, FORTRAN, C, Ada, C++, Objective-C, and Smalltalk are points on a continuum of increasingly object-oriented languages, and it is hard to divide a continuum into crisply separated regions with any "really good" definition.

I propose two definitions in my book, one broad enough to encompass even statically bound languages like Ada, and the other narrower, to include only languages with dynamic binding. By the broad definition, an object-oriented language (1) allows code suppliers to define new types for export to code consumers and (2) allows code consumers to use them as genuinely new types rather than as an unconnected conglomeration of data declarations and functions. Ada's package facility qualifies under this definition since, for example, it is possible to define a new type (e.g., Point) as a collection of data declarations (e.g., a Point is a pair or integers) and operations on that data (e.g., point arithmetic operators), and to export the package describing the new point type to consumers who may use them as if they were predefined types of the language, without concern for their implementation.

I prefer the narrower definition that results from adding the requirement that (3) the decision as to which piece of code should be executed, given a particular data-name/operator-name pair in the source, must be made as late as possible: at run time, not at compile time. The primary reason is that late binding allows highly reusable code to be produced that adjusts automatically to the environment that its user places it in. Early binding requires that the user invoke the compiler and have access to the supplier's source code to adjust the code to his needs, the first of which is not generally possible at run time and the second of which inhibits the development and use of highly reusable code by requiring code suppliers to trust consumers to respect their proprietary interest in source code.

smalltalk/expert.forum #67, from j.jones [Jeremy Jones, Coral Software Corp.]

Creating new types is a fundamental activity in most programming languages including non-OOPLs. This does not distinguish them. What distinguishes OOPLs is that behaviors are associated with types. This leads to a definition for OOPLs: An OOPL is a programming language that deals with entities that can have both state and behavior. These entities are often called "objects."

I believe that this definition includes all languages that claim to be object-oriented. But perhaps this definition is not exclusive enough. By this definition, ALGOL68 is object-oriented since procedures can have "owned" variables, variables that are local to a procedure and whose state is maintained even when the procedure is not dynamically active. So perhaps the definition could be extended to: An OOPL is a programming language that provides tools for dealing with entities that can have both state and behavior. Some of these tools are "message passing," "inheritance," "classes," "subclasses," "polymorphism," and "encapsulation."

Here is the rationale for these tools:

There needs to be a way to initiate behavior in objects; this is the reason for "message passing."

If you have a language that deals with objects, it is useful to have the capability to create objects that are "just like" other objects, without actually making copies of everything. This is "inheritance."

It is also useful to have a capability that allows many objects to share the same behavior, but have different state. This is the reason for having "classes" and "instances."

Once you have inheritance, it is useful to have the capability to create an object that is "just like" another object "except" for minor differences. This is the origin of "subclasses."

It is useful to have different kinds of objects respond to a request in their own particular ways. This is "polymorphism."

Since objects already have state and behavior, it seems natural that the state of an object can only be changed by its own behavior. This is "encapsulation."

smalltalk/expert.forum #71, from j.jones
a comment to 67

This note describes the way Object LISP and Object Logo deal with the issues brought up in my last note.

Object behavior is initiated by telling an object to evaluate an expression. The functions and values associated with symbols depend on the current object. Herein lies the main difference between Object LISP and other OOPLs. Object LISP is a "pure" OOPL in the sense that every operation involves an object, but the object is implicitly *self*.

Sharing knowledge is accomplished by supplying a list of objects to inherit from when an object is created. Conceptually, this list of objects is searched, in sequence, on every function call or variable reference

(continued)

until a value is found. Since each parent object also inherits from a list of objects, there may be duplicates in the search path. These duplicates are actually eliminated when the object is created so that the search path is linear. The last of a series of duplicates is retained. The search stops when the global object is reached.

Classes and instances are implemented by using the conventional procedure "exist" to create an instance's state. Any object that has an exist procedure can be considered a class. An instance is created by creating an object that inherits from a class, then calling exist to create the state. This is done in one operation by calling "oneof."

Subclasses with overriding or shadowing of functions is accomplished automatically, since the search for a binding stops when the first one is found, and any object can have a binding for a particular symbol.

Polymorphism is also accomplished automatically since the same symbol can have as many different function bindings as there are objects.

Encapsulation is not accomplished via the object system in Object LISP. A very good encapsulation technology already exists in many LISPs. This is called "packages." Packages allow you to have many different "namespaces" in a system, and to specify which names are accessible outside of a package. This encapsulation technology is used successfully in some very large systems such as Macsyma and the LISP Machine. Our view is that encapsulation is orthogonal to an object system. Objects are mainly an inheritance and dispatching technology. Accomplishing encapsulation with objects is overextending the technology, hence the confusion of whether or not to allow subclasses to access and change a superclass's state.

There is one other OOPL tool that I forgot to mention in my last note; this is "method combination." It is the ability to create a behavior that is a combination of other objects' responses to the same request. This is accomplished in Object LISP by using the "usual" facility. This allows a procedure to call the "usual" procedure at any time during its execution. The "usual" procedure is the one that would have been called if the current definition did not exist. Anytime a procedure is written that is a specialization of an inherited procedure, the "usual" procedure should be called somewhere within the procedure.

Object LISP purposefully does not supply a "super" capability. This is because a procedure should not normally explicitly call any procedure in a parent object except the "usual" one. If an object overrides an inherited definition, that definition should always be used.

What do other people think of this method of categorizing characteristics of OOPLs?

smalltalk/expert.forum #72, from j.anderson [Jim Anderson, Digitalk Inc.]
a comment to 67

That was an excellent summary of the "essence" of object-oriented languages, Jeremy.

In order for an OOPL to be an effective tool for problem-solving on a personal computer there are some additional attributes of an object-oriented programming system which I believe are essential.

Language Issues

Jeremy described the fundamental features: "message passing," "inheritance," "instances," "subclasses," "polymorphism," and "encapsulation." I add two more requirements:

1. Safety

Although a strict interpretation of encapsulation (separation of internals from externals) accomplishes safety, several of the OOPLs claim they feature encapsulation while they allow internals to be changed from the outside (from other objects or objectless code). This is unacceptable in a long-running environment with a valuable population of objects where a prototyping style of development results in making changes and errors at a rapid pace. The only object "deaths" that are acceptable are via suicide or garbicide (garbage collection).

2. Garbage Collection

This is a language feature because I code differently when automatic garbage collection is present. Garbage collection stated in terms of Pascal means I must say "new" but I never have to say "dispose." It is a convenience and eliminates a major type of programming error: disposing too soon. Garbage collection is essential in a long-running environment where diverse activities are performed.

Environment/Implementation Issues

Language issues alone are too abstract. I need support from an environment in order to do practical object-oriented programming.

1. Performance

The environment must be highly responsive for effective program development and application use. It has to be fast enough so that I prefer to be working in it rather than outside of it.

2. Organization of Object Population

I need to be able to systematically locate the classes, methods, and other objects in the environment. I need to be able to quickly browse through them.

3. Exploratory Programming

I need to be able to change (and add new) classes, methods, and other objects quickly in order to do exploratory programming. I don't want lengthy edit/compile/link/test steps. I need a debugger which permits me to see the complete problem state and to resume execution after errors are corrected.

4. Access to Other Languages

I want to be able to call non-OOPLs in order to access existing applications and to utilize the strengths of other languages.

5. Access to Underlying OS

I want to be able to utilize the features of the host operating system in order to access files, keyboard, mouse, display, printers, communications ports, date, and time.

THE METHODS BIX BROWSER

smalltalk/expert.forum #11, from j.anderson

Eva, you asked if there were any useful applications. I'm using one now. I'm accessing BIX using my 4.77-MHz Compaq with a "BIX Browser" window implemented in Smalltalk by George Bosworth. With the Bix Browser, I can review all BIX activity using a mouse, without touching the keyboard.

The BIX Browser window has four panes (views). The three at the top contain lists of BIX groups, conferences, and topics. When I select a group, I get the list of conferences in that group. When I select a conference, I get the list of topics in that conference. When I select a topic, I am automatically "joined" to that topic, whether or not I was previously registered. Then I can go to the large TTY-emulator pane below to browse the messages in the selected topic. There is a special group ":joined" which shows all the conferences I have joined.

The TTY-emulator pane is multipurpose. I can read messages via menus. If I type at the end, inputs are sent over the communication line and echoed back. If I type before the end I have the normal Methods text editor. I can evaluate Smalltalk expressions like "50 factorial" (very useful) and get

30414093201713378043612608166064768844377641568960512000000000000

So, here is an application which replaces the somewhat complex text dialogue of BIX with the simpler "point and click" Smalltalk-style interface.

[Editor's Note: The source code for the Methods Bix Browser can be downloaded from the long.messages topic of the Digitalk conference.] ■

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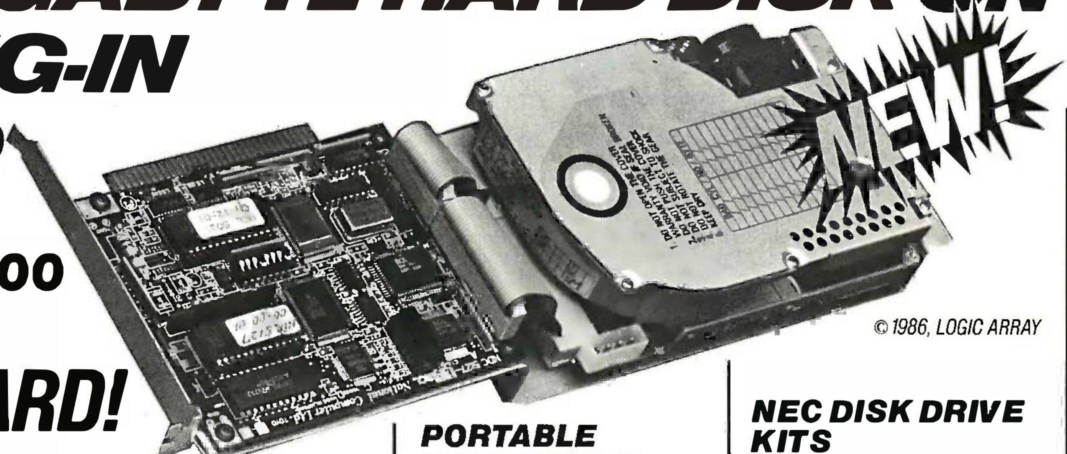

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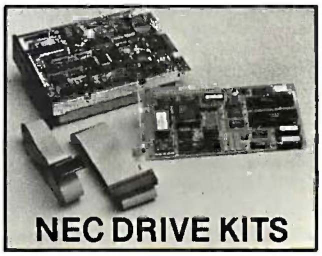

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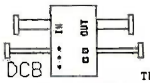

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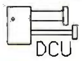

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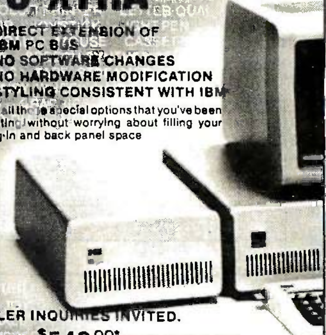

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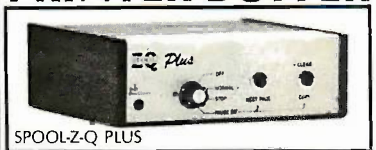

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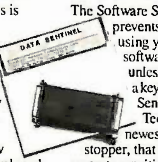

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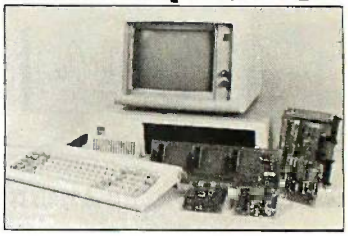

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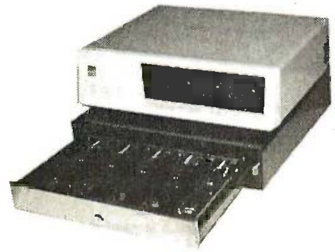

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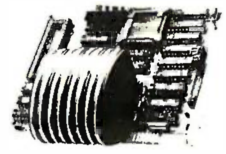

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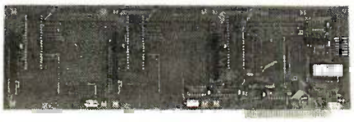

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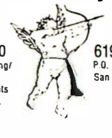

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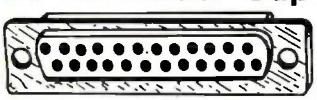

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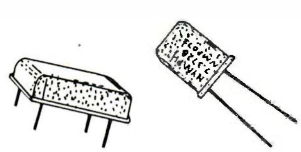

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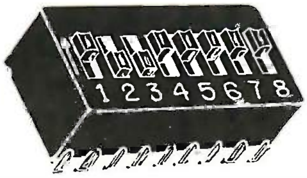

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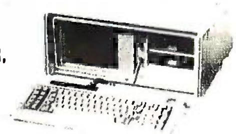

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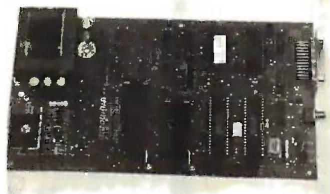

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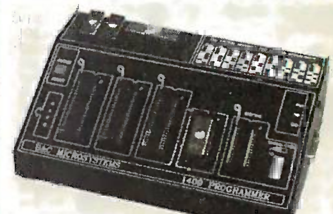

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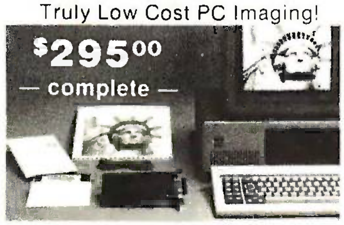

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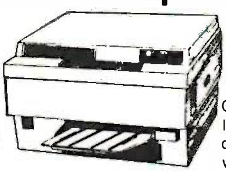

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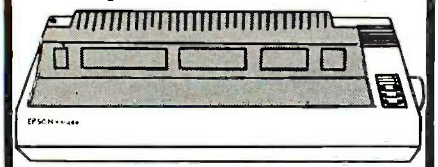

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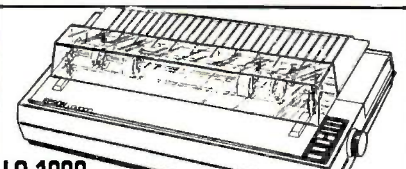

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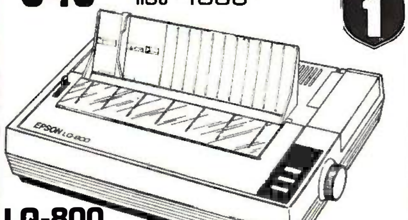

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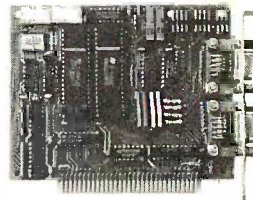

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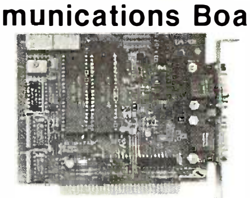

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As you leaf through the pages of this magazine, you will see diskettes advertised at prices as low as 33¢. Every one, of course, claims to be the "best".

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!*

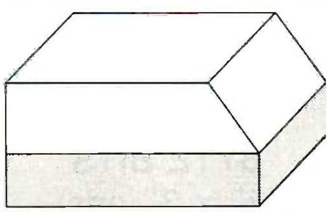
Save your money: buy Super Star™ diskettes!

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.

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DSDD	(P/N3801)	**.62ea.**
SSDD96	(P/N3802)	**.78ea.**
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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"

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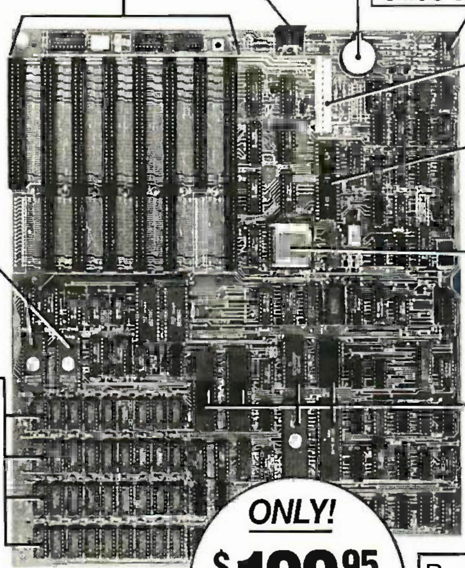

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1013A	3.95	8250	10.50	TMS5501	14.95
1015A	6.75	IM6402	7.75	2651	8.95

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1702(1mS)	$3.90	2732A-4 (450nS)	$4.50
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2758 (5V)	5.50	2732A-2 (200nS)	8.95
2716 (450nS)	2.95	2764 (450nS)	2.95
2716 (350nS)	3.95	2764 (250nS)	3.95
2516 (5V)	2.95	2764 (200nS)	4.95
TMS2716	7.50	TMS2564 (450nS)	9.95
TMS2532	5.60	MCM66764 (450nS)	19.95
2732 (450nS)	2.95	MCM68766 (350nS)	21.95
2732 (250nS)	3.75	27128-3 (300nS)	9.50
2732 (200nS)	4.95	27128 (250nS)	15.95
CMOS EPROMS		27C32	$9.95
27C16	$7.95	27C64	10.95

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2101 (450nS)	$2.29	MK4118	$4.95
21L02 (450nS)	.99	TMM2016-2 (200nS)	4.10
2102-1 (450nS)	.79	TMM2016-15 (150n)	4.95
21L02-2 (250nS)	1.39	TMM2016-1 (100nS)	6.10
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2114L-2 (200n)	1.89 8/13.90	HM6116LP-2 (LP)	9.95
2147 (55nS)	4.50	Z6132 (300nS)	32.95
4044-4 (450nS)	3.25	HM6264P-15 (150)	32.95
4044-3 (300nS)	3.75	HM6264LP-15 (LP)	36.95
4044-2 (200nS)	4.35	74S189 (35nS)	1.85
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4116N-2 (150nS)	1.25	41256-150 (150n)	2.75
4116N-3 (200nS)	1.10	41256-200 (200n)	2.75
4116N-4 (250nS)	.99	TMS4050 (300nS)	1.85
4164N-150 (150n)	4.25	TMS4060 (300nS)	1.85
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4008	.95	4034	1.91	4071	.28	4511	.79
4009	.39	4035	.79	4072	.26	4512	.79
4010	.39	4039	1.95	4073	.28	4514	1.18
4011	.24	4040	.75	4075	.28	4515	1.79
4012	.24	4041	.75	4076	.75	4516	1.19
4013	.35	4042	.65	4077	.35	4518	.85
4014	.75	4043	.85	4078	.35	4520	.75
4015	.39	4044	.69	4081	.29	4555	.95
4016	.35	4046	.80	4062	.29	4556	.95
4017	.65	4047	.69	4085	.95	4566	1.35
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4020	.69	4050	.34	4094	2.95	MC14406	12.95
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LM318CN	1.45	LM741CN	.33	CA3046	1.25
LM318H	1.55	LM741H	.40	CA3059	2.65
LM319N	1.19	LM741N	.29	CA3060	2.85
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7403	.18	7450	.19	74128	.49	74160	.75
7404	.18	7451	.19	74132	.45	74181	1.75
7405	.23	7453	.19	74136	.75	74182	1.15
7406	.49	7454	.19	74141	.65	74184	2.25
7407	.49	7459	.25	74142	2.95	74185	2.25
7408	.24	7460	.37	74143	3.70	74190	.67
7409	.19	7470	.29	74144	2.95	74191	.67
7410	.19	7472	.29	74145	.59	74192	.67
7411	.24	7473	.29	74147	1.49	74193	.67
7412	.38	7474	.34	74148	1.19	74194	.87
7413	.34	7475	.38	74150	1.09	74195	.87
7414	.49	7476	.34	74151	.55	74196	.75
7416	.49	7478	4.60	74152	.67	74197	.86
7417	.49	7480	.69	74153	.53	74198	1.15
7420	.19	7482	.95	74154	1.19	74199	1.15
7421	.35	7483	.45	74155	.69	74221	1.19
7422	.45	7485	.55	74156	.59	74251	.75
7423	.56	7486	.35	74157	.59	74273	1.65
7425	.28	7488	1.95	74158	1.65	74276	1.89
7426	.29	7490	.35	74159	1.58	74279	.75
7427	.25	7491	.65	74160	.79	74283	1.40
7428	.55	7492	.45	74161	.69	74284	2.90
7430	.18	7493	.35	74162	.69	74285	2.90
7432	.29	7494	.85	74163	.69	74290	1.49
7437	.25	7495	.50	74164	.69	74298	1.49
7438	.29	7496	.69	74165	.69	74365	.55
7439	.56	7497	2.70	74166	.85	74366	.55
7440	.19	74100	1.50	74167	2.75	74367	.55
7441	.79	74107	.24	74170	1.25	74368	.55
7442	.45	74109	.37	74172	4.75	74390	1.45
7443	1.15	74116	1.45	74173	.69	74393	1.33
7444	1.15	74121	.29	74174	.89	74490	2.25
7445	.69	74122	.44	74175	.89		

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74LS04	.24	74LS124	2.75	74LS253	.59
74LS05	.25	74LS125	.49	74LS257	.59
74LS08	.27	74LS126	.49	74LS258	.59
74LS09	.28	74LS132	.59	74LS259	2.95
74LS10	.25	74LS136	.39	74LS260	.59
74LS11	.33	74LS138	.59	74LS261	2.49
74LS12	.33	74LS139	.59	74LS266	.55
74LS13	.39	74LS145	1.19	74LS273	1.45
74LS14	.59	74LS148	1.38	74LS275	3.29
74LS15	.33	74LS151	.55	74LS279	.59
74LS20	.26	74LS153	.55	74LS283	.68
74LS21	.29	74LS154	1.49	74LS290	.88
74LS22	.29	74LS155	.69	74LS293	.78
74LS26	.29	74LS156	.69	74LS295	.98
74LS27	.29	74LS157	.69	74LS298	.88
74LS28	.29	74LS158	.89	74LS324	1.75
74LS30	.25	74LS160	.69	74LS347	1.95
74LS32	.33	74LS161	.69	74LS348	1.95
74LS33	.53	74LS162	.69	74LS352	1.25
74LS37	.35	74LS163	.69	74LS353	1.25
74LS38	.39	74LS164	.69	74LS363	1.29
74LS40	.25	74LS165	.90	74LS365	.48
74LS42	.44	74LS166	1.90	74LS366	.48
74LS47	.74	74LS168	1.15	74LS367	.45
74LS48	.74	74LS169	1.15	74LS368	.45
74LS51	.25	74LS170	1.40	74LS373	1.39
74LS54	.29	74LS173	.67	74LS374	1.33
74LS55	.29	74LS174	.67	74LS375	.69
74LS73	.39	74LS175	.87	74LS377	1.38
74LS74	.34	74LS181	1.95	74LS385	1.95
74LS75	.39	74LS190	.85	74LS366	.45
74LS76	.39	74LS191	.85	74LS390	1.15
74LS78	.39	74LS192	.78	74LS393	1.15
74LS83	.59	74LS193	.78	74LS395	1.15
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74LS86	.39	74LS195	.69	74LS424	2.95
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74LS92	.54	74LS197	.79	74LS670	2.29
74LS93	.54	74LS221	.89	81LS95	1.45
74LS95	.75	74LS240	.95	81LS96	1.45
74LS96	.89	74LS242	.95	81LS97	1.45
74LS107	.39	74LS243	.95	81LS98	1.45
74LS109	.39	74LS244	1.25	25LS2521	2.55
74LS112	.39	74LS245	1.45	25LS2569	3.50

74S00/PROMS*

74S00	$.29	74S74	$.55	74S158	$.99	74S260	$1.19
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74S03	.29	74S86	.55	74S161	1.89	74S287*	1.95
74S04	.45	74S112	.55	74S174	1.19	74S288*	1.95
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74S08	.39	74S114	.55	74S188*	1.49	74S374	2.09
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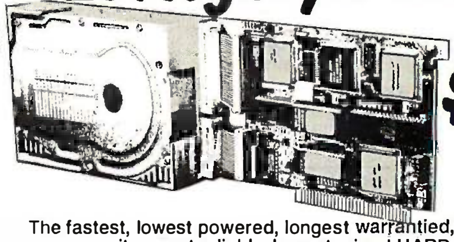

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• Hayes & Bell 212A/103 Compatible
• CCITT V.22, V.22 bis

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

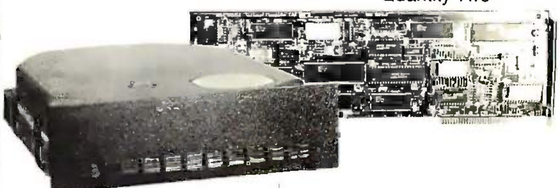
Eclipse 1200 100% Hayes, with status lamps.	EDP-1200	179.00
Eclipse 1200B internal with software	EDP-1200B	179.00
Eclipse 2400 External, Hayes Compatiple	EDP-2400	359.00
Avatex 1200 baud external, Hayes	AVA-1200	99.00
Hayes Smartmodem 2400 baud modem	HYS-2400	59900
Team 1200 Hayes Compatible, 300/1200 baud.	TEM-SM1200	189.00
UltraLink 1200 data and voice on same line.	UTL-1200A	99.00
CTS 212AH 1200 baud, auto dial	CTS-212AH	179.00
Terminal software for CTS 212AH	CTS-212SFT	35.00
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
ROOIME RO-202E 27 Meg.	659	629
RODIME RO-203E 40 Meg.	995	959
ROOIME 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 MK5670 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
OMTI 5510 half card	139
ADAPTEC 2010A software install	189
WESTERN DIGITAL WD/1002	139

• SCSI/SASI Winchester Controllers •

XEBEC 1410A 5¼" foot print	219
OMTI 20L	119

• Winchester Accessories •

Installation Kit with manual	10
Winchester enclosure and supply	139
Dual 20/34 cable set	25
Switching power supply	49

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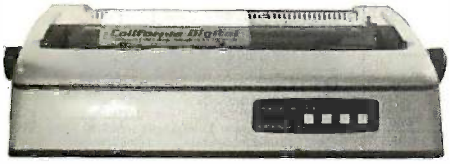
California Digital

17700 Figueroa Street • Carson, California 90248

Letter Quality Printer
F-10 DAISY WHEEL

$429

Quantity Two



Single unit price is $499. But if you have already purchased an F-10 printer from California Digital, we will honor the $429 price on the second printer.

FREE
Accessory Pak
Includes 6 Daisy Wheels & 2 ribbon cartridges
With F-10 Purchase

The F-10 Daisy Wheel printer is the perfect reasonably priced 40 character per second word processing printer. This printer is "extremely" similar to C. Itoh's F-10-40 Starwriter printer, however we have been advised by legal counsel for the C. Itoh Company that we should refrain from referring to the F-10 printer as a Starwriter.

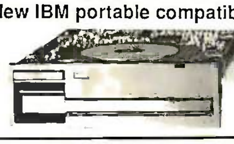
This printer auto installs with Wordstar and Perfect Writer, features extensive built-in word processing functions that allow easy adaptability and reduced software complexity. Industry standard Centronics interface provides instant compatibility with all computers equipped with a parallel printer port. The F-10 accepts paper up to 15 inches in width.

These printers were originally priced to sell at over $1400. Through a special arrangement California Digital has purchased these units from a major computer manu-facturer. We have a limited number of these popular printers left.... while they last we're offering a special Accessory Pak, including six Diablo daisy wheels and two ribbon cartridges, with every F-10 printer already priced at a fraction of their original cost.

Options available: sheetfeeder, tractor feed, buffered memory and an assortment of printer cables for a variety of computers.

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
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Dual enclosure for 5¼" drives			59
34 pin edge connectors			5
Scotch head cleaning kit			19
Flip & File Storage tubs			15

MASS STORAGE ALTERNATIVE
TAKE IT WITH YOU!
Bernoulli Box

was $3540 now only

$1595

The **Bernoulli Box**, by Iomega, features 10 & 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 possibility of head crash!

Expandable... grow at you own pace by adding inexpensive cartridges.

When **security** is essential, don't lock up your system... just lock up the cartridges.

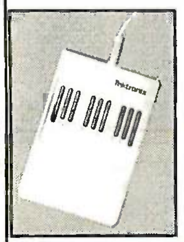
The Bernoulli Box delivers **performance** that often exceeds the very best hard disk drives. Hard disk speeds and floppy convenience....the **Bernoulli Box**. At this price, don't be caught wishing you'd had one after a loss of irreplacable data.

Data Transfer Rate: 1.13 Mbytes/second
Start/Stop Time: 5/7 seconds
Average Access Time (milliseconds): A210H-35ms
A220H-38 ms

		LIST	OUR PRICE
10+10 MEG.	A2210H	3450	1595
20+20 MEG.	A220H	4540	2095
Bootable Controller	PC2B	255	159
10 MEG. Cartridge		79	49
20 MEG. Cartridge		99	65

TEKTRONIX MOUSE

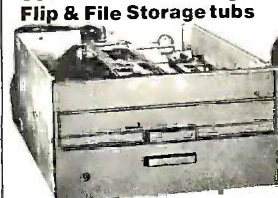
$79



- 200 dots-per-inch resolution
- Programmable baud rate
- Multiple protocols
- Programmable buttons
- Serial interfaces
- Runs on any surface
- Free of pads or grids
- Microsoft TM compatible driver

Moving your cursor has never been so easy! This mouse combines the best features of optical and mechanical technology into one high performance mouse.The Tektronix mouse was private labeled by LogiTech for Tektronix The 200 dots-per-inch resolution requires less desk space and gives you precision control. This mouse is fast and precise in the most demanding environments. And it has a programmable baud rate so you can use it with almost any of your favorite software.

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

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 purchasea plotter whichwas originally priced at $795 foronly $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

CP/M 2.2 Operating System

$14.95

Complete with manual by Digital Research

Originally $185.00
Now only $14.95

(10+ = 9.95 - -100+ Call)

Quick-Link 300

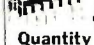
$59

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 auxiliary printer port. All this is available for only $59.

MEMORY

4164 DYNAMIC MEMORY 150ns



$.99
Quantity 100

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

VISA

Shipping: First five pounds $3.00, each additional pound $.50
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Now Compatible With C-128!
RS232 Adapter for VIC-20, C-64 and C-128

The JE232CM allows connection of standard serial RS232 printers, modems, etc. to your VIC-20, C-64 (excluding the SX-64 Portable), and C-128. A 4-pole switch allows the inversion of the 4 control lines. Complete installation and operation instructions included.
• Plugs into User Port • Provides Standard RS232 signal levels • Uses 6 signals (Transmit, Receive, Clear to Send, Request to Send, Data Terminal Ready, Data Set Ready).

JE232CM. $39.95

Voice Synthesizer VIC-20 & C-64
Plug-In – Talking in Minutes!
JE520CM. $99.95

300 Baud Auto Modem
Mitey-Mo (For C-64). $54.95

Parallel Printer Interface
2K Buffer, Expandable to 10K!
MW350 (For VIC-20, C-64 & C-128). $54.95

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All kits come complete with documentation

TRS-80 MODEL I, III
TRS-16K3 200ns (Model III). $5.95
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TANDY 200
M200R. . . . . $74.95 ea. or 2 for $129.95
Tandy Model 200 Expansion

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Erases all EPROMs. Erases up to 8 chips within 21 minutes (1 chip in 15 minutes). Maintains constant exposure distance of 1". Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact- 9.00"L x 3.70"W x 2.60"H. Complete with holding tray for 8 chips.

DE-4 UV-EPROM Eraser. . . . **$74.95**
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30013	Zilog Data Book (85).	$14.95
30032	National Linear Supplement (84).	$ 6.95
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Howard Industries (4.68" sq., 60 cfm)
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EG&G Rotron (3.125" square, 20 cfm)

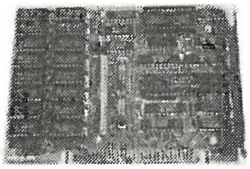
NEW! BMC 13" Color Composite Monitor

for VIC-20 and C-64
Also compatible with other computers with composite output (i.e. Apple II, II+, *IIe**)
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 for $219.95
RCA-3-DIN (Universal Computer to Monitor Cables for Atari, Commodore & TI). . . . $3.49

NEW PRODUCTS!

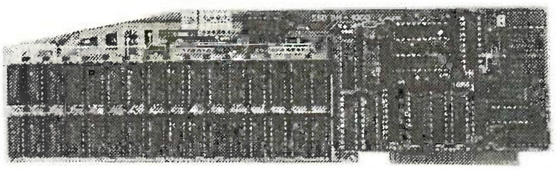
ZUCKERBOARD Expansion Memory Half Card and Clock/Calendar for the Tandy 1000



The **Zuckerboard Expansion Memory Board** allows you to expand the memory of your Tandy 1000 (128K Model) as much as 640K! 256K DRAM chips increase your computer's memory by either 256K or 512K, bringing your total system memory up to either 384K or 640K. The memory board also includes a DMA controller chip. Optional clock/calendar plugs directly onto the memory board. Manual included.

TAN-Clock	Clock/Calendar Option (only).	$ 39.95
TAN-EM256K	Includes 256K RAM.	$ 99.95
TAN-EM512K	Includes 512K RAM.	$139.95

BIG BOARD 1MBYTE RAM CARD for Apple II, II+ and *IIe**



Introducing a third generation memory card that gives you both great expandability and great versatility at an extraordinary price. **Versatility to** users means that BIG BOARD is compatible with software written for the Synetix SSD (Flashcard) as well as for Jameco's JE868 128K RAM Card. Big Board makes available 426K of worksheet space, using the program THE Spreadsheet Version 2.0. It is compatible with PLUSWORKS XM for running Appleworks on the Apple II. Versatility also means that BIG BOARD comes complete with RAMDISK software for DOS 3.3, ProDOS, Pascal 1.2, and CP/M for Microsoft's Softcard. A separate driver is available for the AppliCard (StarCard).

BIG BOARD-256K	256K RAM.	$199.95
BIG BOARD-512K	512K RAM.	$249.95
BIG BOARD-1M	**1Meg RAM. . . . .**	**$299.95**

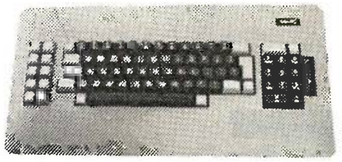
1 Yr. Warranty! estes External Power Supply for the Commodore 64

• Input: 117VAC @ 60Hz • Output: 5VDC @ 3 Amps, 10VAC @ 250mA • Short circuit protected and current limited • Transient spike suppression on 2 auxiliary 110VAC sockets • Switch on front serves as power switch for the computer and other peripherals • RFI/EMI filtered • Adjustable linear regulator • Has less than 50mV ripple rms at full load • 5 Amp primary fuse • Two conductor with ground line • Color: brown • Size: 7½"D x 5½"W x 2½"H • Weight: 5 lbs.

CPS-10. . . . . . . $39.95

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!*

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IBM-MB	Motherboard.	$169.95

Regular List $734.58
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Additional Add-Ons Available!

IBM-KB	83-Key Keyboard.	$ 79.95
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IBM-EGA	Enhd. Graphics256KRAM . .	$349.95
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. $69.95
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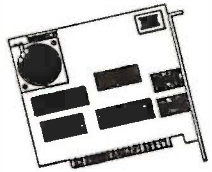
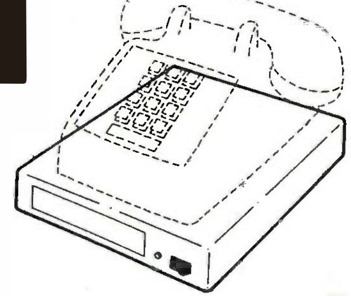
These truly Hayes compatible, intelligent 1200 baud modems have features found on the expensive name brand modems. Choose either the internal Jade 1200 baud Smart-Card, including software for your IBM PC compatible; or our best selling Jade 1200 baud external modem for any computer with a serial RS-232C port. We guarantee you will be satisfied.



$149

INTERNAL OR EXTERNAL

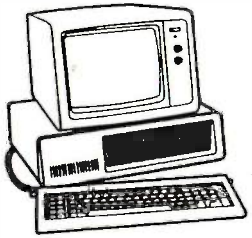


JADE XPC or XPC-AT

JADE XPC

- 640K of RAM
- 4.77 MHz 8088
- 7 MHz turbo mode
- 135 watt power supply
- 360K disk drive
- Floppy disk controller
- 5151-style keyboard
- 8 expansion slots
- PC-style case
- 90 day warranty

$788



XPC-AT

- 1 MB of RAM
- 6 MHz 80286
- 8 MHz turbo mode
- 200 watt power supply
- 1.2 MB disk drive
- Floppy/hard disk controller
- AT-style keyboard
- 8 expansion slots
- AT-style case
- 90 day warranty

$1988

OPTION #1
Two disk drives
Mono graphics card
Parallel printer port
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20 MB hard disk
Mono graphics card
Parallel printer port
PGS MAX-12E monitor
XPC $1588 XPC-AT $2888

OPTION # 3
20 MB hard disk
Color graphics card
Parallel printer port
Hitachi high res color monitor
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IBM Compatible
Lap Computer

$1188

- 768K of RAM
- 720K disk drive
- Includes FREE software

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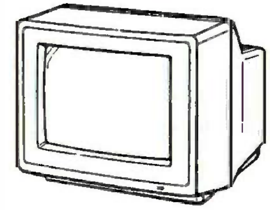
Manufactured by Hitachi

- IBM PC color graphics compatible
- High resolution 640 x 240
- Excellent dot pitch .38 mm
- 16 true colors, 2000 characters
- Accepts standard RGB input signals
- Non-glare picture tube
- New designer sculpted case

$289

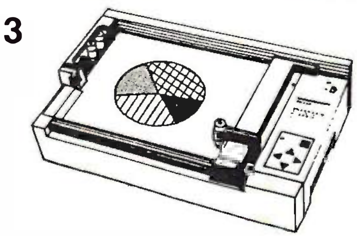
List Price $699

Free PC RGB cable included



MANNESMANN TALLY PIXY 3

3-PEN PLOTTER



$198

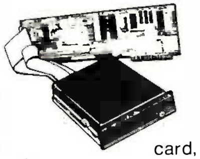
LIST PRICE $799
YOU SAVE OVER $600!
Limited Quantity

We're probably making a mistake selling this high speed plotter for only $198. They are easily worth at least $500 more. Compare the features to plotters costing $2000 or more.

- High speed 8 IPS plotting
- 3-pen auto select
- 8 colors available
- Serial interface
- Full graphics + built-in fonts
- 8½ x 11 paper or transparencies

	LIST	JADE
8 extra water base pens	$30	$16.95
4 extra oil base pens	$30	$16.95
100 sheets 8½ x 11 paper	$9	$4.95
50 sheets 8½ x 11 transparencies	$9	$4.95
Plotter software for IBM PC	$195	$59.95

HARD DISK SYSTEM



FOR YOUR IBM PC

$399.95

Complete with controller card, data cable, and mounting hardware, totally PC/XT compatible.

	List	Jade
10 MB Internal Kit	$990	$399.95
20 MB Internal ½ High	$1550	$445.95
10 MB Hard Disk Card	$699	$399.95
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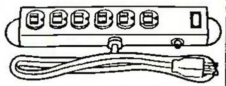

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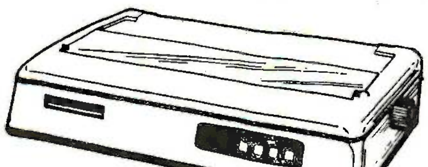

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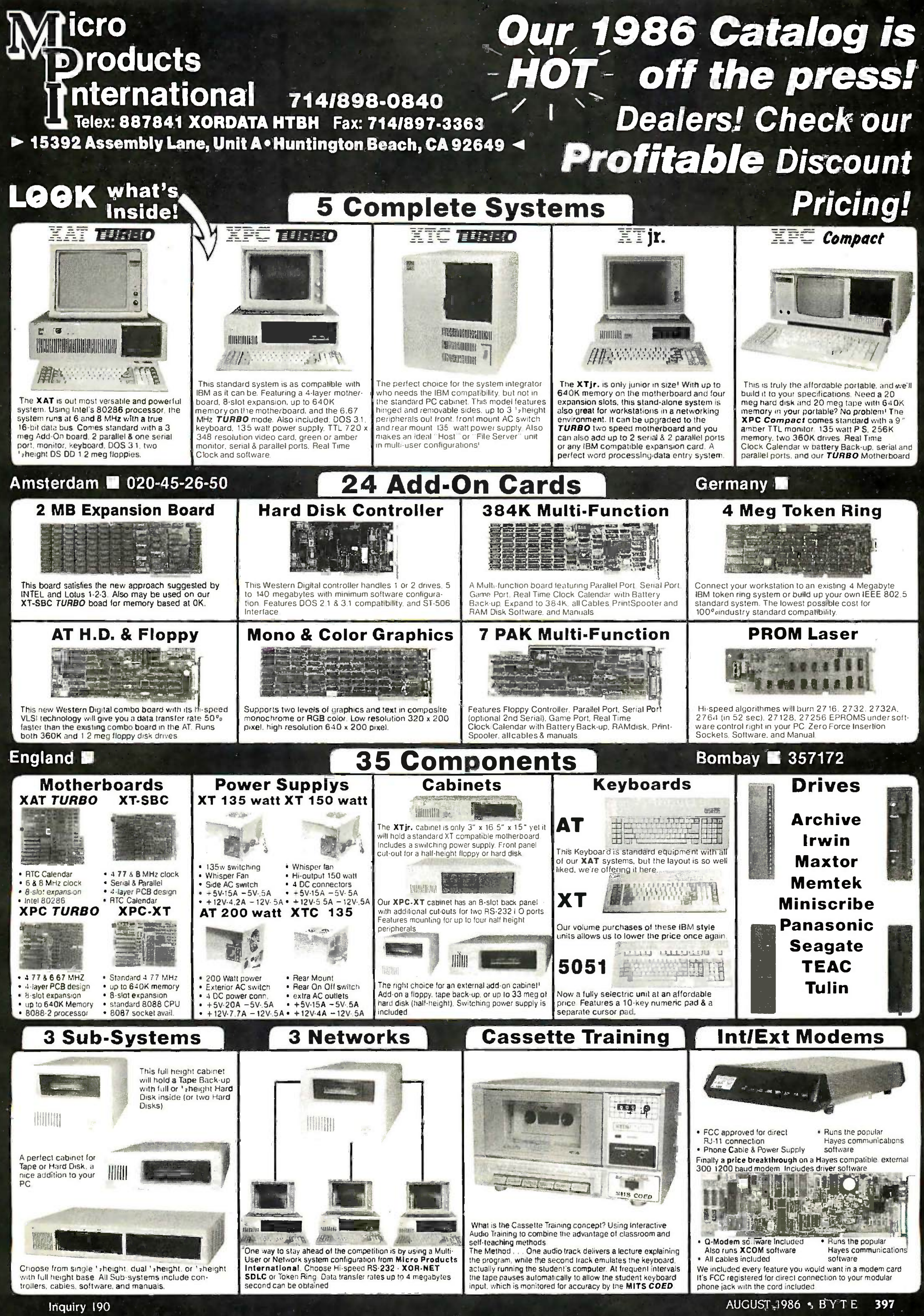

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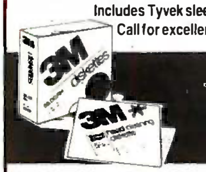

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Seagate 30 M.B., High Speed Hard Disk	$645.00
20 M.B. Hard Disk Kit (drive, controller, cables)	$400.00
135 W. Power Supply	$ 65.00
I/O Card for XT or AT	$ 75.00
LOGIMOUSE	$ 85.00
8087-3 Co-Processor	$120.00
80287-3 Co-Processor	$215.00
SEIKOSHA SP1000 (80 column) Printer w/Cable	$195.00

LUCKY COMPUTERS
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1701 Greenville, Suite 602, Richardson, TX 75081

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Inquiry 172

TURBO PC/XT

COMP. SYSTEM: 640K
ONE DRIVE
MONOGRAPHIC CARD
W/PP, AT STYLE
KEYBOARD, HI-RES.
MONITOR W/SWIVEL
BASE & 6 MONTHS
WARRANTY

$679 ONLY

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Inquiry 36

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OUTSIDE OKLAHOMA: NO SALES TAX

640 Kbyte MOTHERBOARD KITS: Zenith 150: $78.10
IBM PC/XT, Compaq Portable & Plus; hp Vectra

DYNAMIC RAM			
1M	1000Kx1	100 ns	$70.00
256K	64Kx4	150 ns	4.00
256K	256Kx1	100 ns	5.50
256K	256Kx1	120 ns	3.40
256K	256Kx1	150 ns	2.85
128K	128Kx1	150 ns	4.25
64K	64Kx1	150 ns	1.35
EPROM			
27512	64Kx8	250 ns	$23.00
27C256	32Kx8	250 ns	6.95
27256	32Kx8	250 ns	5.20
27128	16Kx8	250 ns	3.65
27C64	8Kx8	200 ns	4.75
2764	8Kx8	250 ns	3.40
STATIC RAM			
43256L-12	32Kx8	120 ns	$35.00
6264LP-15	8Kx8	150 ns	2.99

V20/V30 8 Mhz $ 14.00
80287-8 8 Mhz $365.00
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Inquiry 196

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- DISPLAYS 16 COLORS OUT OF 64 COLORS
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$259.95

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FULL ONE YEAR WARRANTY

- EGA AND CGA COMPATIBLE
- SCANNING FREQUENCIES: 15.75 KHz / 21.85 KHz
- 14" BLACK MATRIX, NON-GLARE SCREEN
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- .31 DOT, 25MHz
- 16 COLORS OUT OF 64
- TEXT SWITCH-GREEN/AMBER

$499.95

BUY BOTH $699!

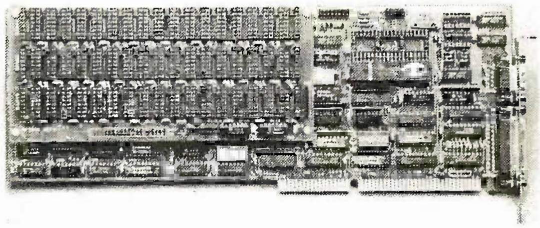
20 MB HARD DISK SYSTEM

INCLUDES HARD DISK CONTROLLER, CABLES AND INSTRUCTIONS. ALL DRIVES ARE PRE-TESTED AND COME WITH A 1 YEAR WARRANTY.

$389.95

AT MULTIFUNCTION CARD $199.95

ADDS UP TO 3 MEGABYTES OF USER EXPANDABLE MEMORY



- SHIPPED WITH ZERO K RAM, USER EXPANDABLE TO 1.5 MEGABYTES RAM ON BOARD, UP TO 3 MEGABYTES WITH OPTIONAL PIGGYBACK CARD
- USES 64K OR 256K DYNAMIC RAMS
- PARALLEL PORT & GAME PORT
- SERIAL PORT
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PIGGYBACK MEMORY CARD (NO MEMORY INSTALLED) $49.95

EXPANDED MEMORY CARD $199.95

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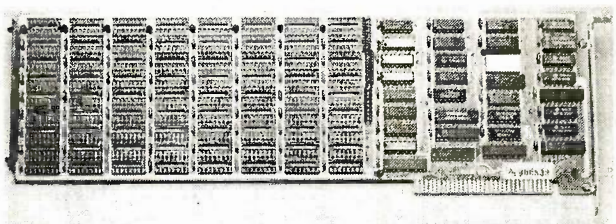

- CONFORMS TO LOTUS/INTEL EXPANDED MEMORY SPECIFICATIONS (EMS)
- SHIPPED WITH ZERO K RAM, USER EXPANDABLE TO 2 MEGABYTES
- USES 64K OR 256K DYNAMIC RAMS
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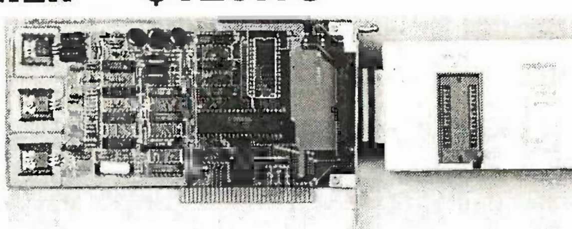
- SOFTWARE INCLUDES EMS DEVICE DRIVERS, PRINT SPOOLER AND RAMDISK

EPROM PROGRAMMER $129.95

FOR IBM PC/XT/AT AND COMPATIBLES



- PROGRAMS 27xxx SERIES EPROMS UP TO 27512
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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

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

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	2.35	DS8833	2.25
DAC1020	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

IC SOCKETS

	1-99	100+
8 PIN ST	.11	.10
14 PIN ST	.11	.09
16 PIN ST	.12	.10
18 PIN ST	.15	.13
20 PIN ST	.18	.15
22 PIN ST	.15	.12
24 PIN ST	.20	.15
28 PIN ST	.22	.16
40 PIN ST	.30	.22
64 PIN ST	1.95	1.49
ST=SOLDERTAIL		
8 PIN WW	.59	.69
14 PIN WW	.69	.52
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.28
24 PIN WW	1.49	1.35
28 PIN WW	1.69	1.49
40 PIN WW	1.99	1.80
WW=WIREWRAP		
16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	6.95	CALL
40 PIN ZIF	9.95	CALL

ZIF=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

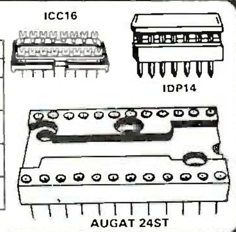
INTERSIL

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



DIODES/OPTO/TRANSISTORS

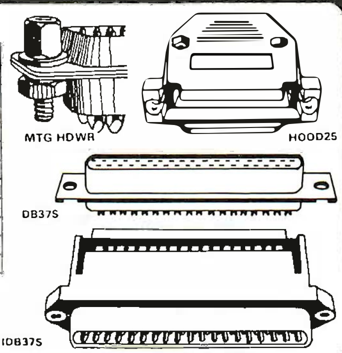
1N751	.25	4N26	.69
1N759	.25	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP04	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	.99
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

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



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

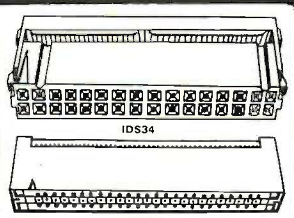
DIFFUSED LEDS

		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



SWITCHES

SPDT	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.39
SPST	MINI-PUSHBUTTON N.C.	.39
SPST	TOGGLE ON-OFF	.49
BCD OUTPUT	10 POSITION 6 PIN DIP	1.95

DIP SWITCHES

4 POSITION	.85	7 POSITION	.95
5 POSITION	.90	8 POSITION	.95
6 POSITION	.90	10 POSITION	1.29

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	SINGLE COLOR 10'	COLOR CODED 1'	COLOR CODED 10'
10	.18	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.50
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

HARD TO FIND "SNAPABLE" HEADERS

CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER, ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
1x40	RIGHT ANGLE	1.49
2x40	STRAIGHT LEAD	2.49
2x40	RIGHT ANGLE	2.99

SHORTING BLOCKS

GOLD CONTACTS SPACED AT .1" CENTERS

5/$1.00

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.

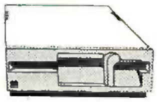
Sincerely, Nicholas Chabra

CALL FOR VOLUME QUOTES

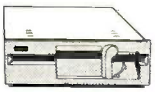
Inquiry 151

20MB HARD DISK SYSTEM ONLY $389.95!

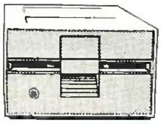
DISK DRIVES
FOR APPLE COMPUTERS



AP-150 $99.95
- ½ HT, DIRECT DRIVE
- 100% APPLE COMPATIBLE
- SIX MONTH WARRANTY

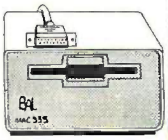


BAL-500 $129.95
- TEAC MECHANISM-DIRECT DRIVE
- 100% APPLE COMPATIBLE
- FULL ONE YEAR WARRANTY



AP-135 $129.95
- FULL HT SHUGART MECHANISM
- DIRECT REPLACEMENT FOR APPLE DISK II
- SIX MONTH WARRANTY

DOUBLE SIDED!



MAC535 $249.95
- 3.5" ADD-ON DISK DRIVE
- 100% MACINTOSH COMPATABLE
- DOUBLE SIDED 800K BYTE STORAGE
- HIGH RELIABILITY DRIVE HAS AUTO-EJECT MECHANISM
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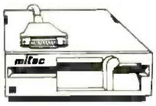

AD-3C $139.95
- 100% APPLE IIc COMPATIBLE, READY TO PLUG IN, W/SHIELDED CABLE & MOLDED 19 PIN CONNECTOR
- FAST, RELIABLE SLIMLINE DIRECT DRIVE
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ADAPTS STANDARD APPLE DRIVES FOR USE WITH APPLE IIc

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IBM-AT	$68.00
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APPLE COMPATIBLE INTERFACE CARDS

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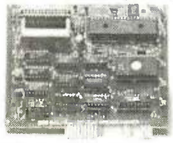
MODEL RP525



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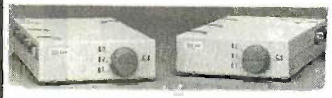

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BAL PRINTER BUFFERS
- FREES COMPUTER FOR OTHER TASKS WHILE PRINTING LONG DOCUMENTS
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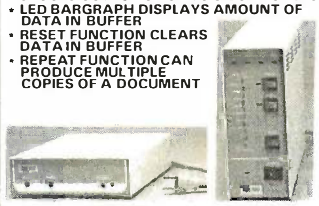
- REPEAT FUNCTION CAN PRODUCE MULTIPLE COPIES OF A DOCUMENT



SP120 SP110

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N-MD2F	DS/QUAD SOFT	$34.95
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QUME QT-142 ½ HT DS/DD (FOR IBM)	$79.95

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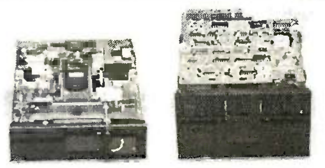

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CAB-2SV5 CAB-1FH5

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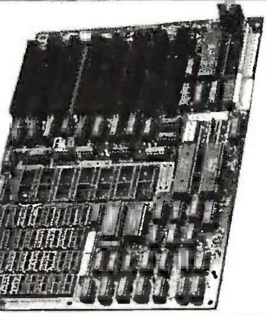

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COMPOSITE COLOR
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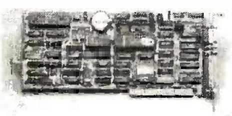
PERFECT FOR THE 640K MOTHERBOARD



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- 1 RS232 SERIAL PORT; OPTIONAL 2nd SERIAL PORT
- PARALLEL PRINTER PORT
- GAME PORT
- CLOCK/CALENDAR
- SOFTWARE: CLOCK UTILITIES, RAMDISK, SPOOLER

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- SOFTWARE INCLUDED

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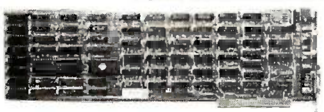

- 4 VIDEO INTERFACES: RGB, COMPOSITE COLOR, HI-RES COMPOSITE MONOCHROME, CONNECTOR FOR RF MODULATOR
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- STANDARD DB37 FOR EXTERNAL DRIVES
- RUNS QUAD DENSITY DRIVES WHEN USED WITH JFORMAT

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AN ATTRACTIVE STEEL CASE WITH A HINGED LID FITS THE POPULAR PC/XT COMPATIBLE MOTHERBOARDS

- SWITCH CUT-OUT ON SIDE FOR PC/XT STYLE POWER SUPPLY
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- FULLY IBM COMPATIBLE
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- 83 KEY — SAME LAYOUT AS IBM PC/XT KEYBOARD

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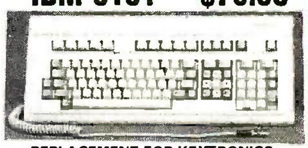

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Listed below are some computer bulletin boards that carry program listings from BYTE. Programs are for noncommercial use in connection with BYTE articles only. Some BBSs may charge an annual maintenance fee, and you must pay your own telephone charges.

Western Canadian Distribution Center (3420 48th St., Edmonton, Alberta T6L 3R5) will be supplying listings to its member bulletin board systems.

Edmonton, Alberta, (403) 454-6093
Meadowlark, Alberta, (403) 435-6579
Montreal, Quebec, PComm Systems, (514) 989-9450
Prince George, British Columbia, (604) 562-9519
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B·O·M·B

BYTE's Ongoing Monitor Box

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32	344	Best of BIX	BIXen

BOMB *Results*

MASSIVE APPEAL

The winner of $100 for gaining the most votes in the May BYTE is Leonard Laub for his theme article covering "The Evolution of Mass Storage." In second is "Easy C," featuring tips for good code by Pete Orlin and John Heath, who will be splitting $50. Best of BIX, by the BIXen (regular participants on BIX), wins first in the in-house lineup, followed by Computing at Chaos Manor and According to Webster.

Leonard Laub also wins the $50 award for quality with "The Evolution of Mass Storage." Congratulations.

R·E·A·D·E·R S·E·R·V·I·C·E

TO GET FURTHER information on the products advertised in BYTE, either pick up your touch-tone telephone and use TIPS (if you are a subscriber), or fill out the reader service card. Either way full instructions are provided following this reader service index which is provided as an additional service by the publisher, who assumes no liability for errors or omissions. *Correspond directly with company.

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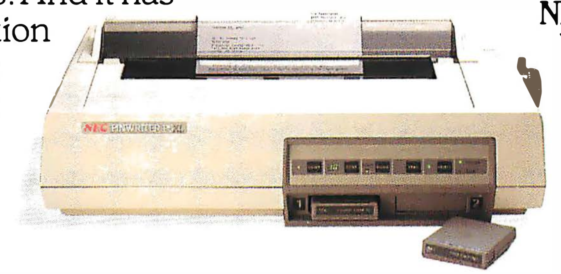

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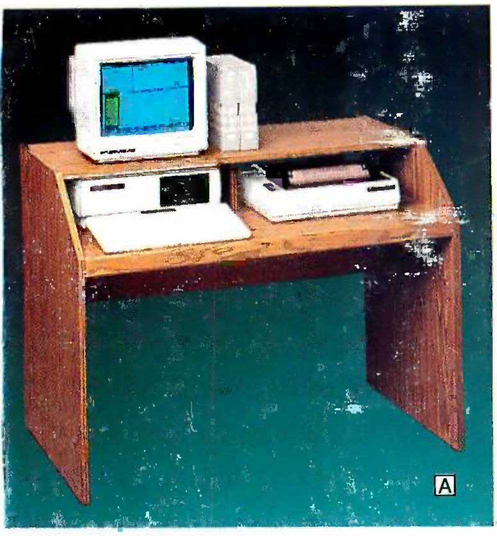

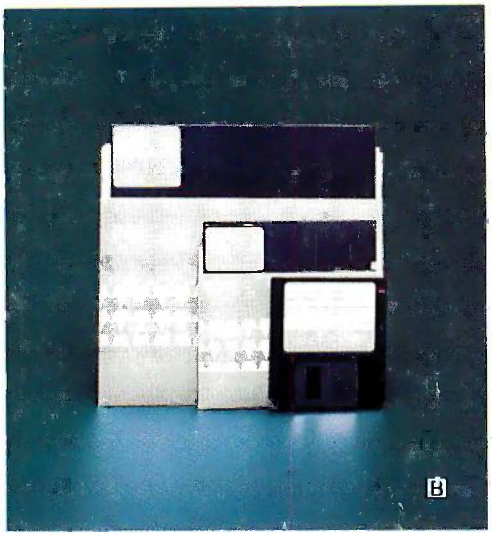

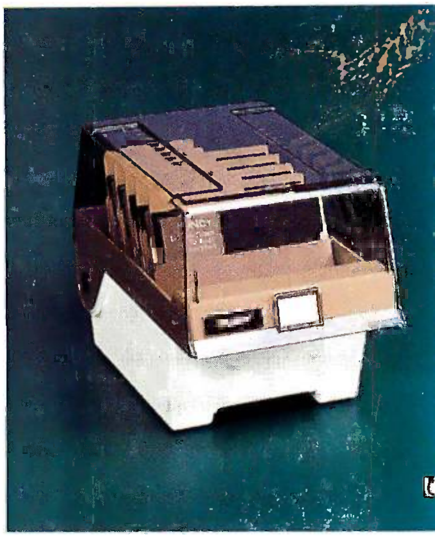

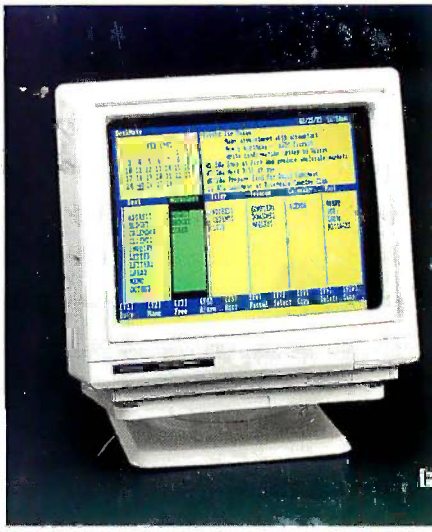

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