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A Tale of Four Covers

Since "Graphics Hardware" is the theme of this issue of BYTE, Phil Lemmons suggested that it would be only fitting if the cover were—what else?—computer-generated! Although I have experimented briefly with graphics packages in the past, this was to be my first serious attempt at a finished computer painting (pixeling?). In mid-August I received, on loan, the following: (1) ZSoft Corporation's PC Paintbrush, a graphics program for the IBM PC and compatibles marketed by IMSI, (2) Sigma Designs' Color 400 graphics board, which yields 16 colors at a resolution of 640 by 400, (3) a Princeton Graphic Systems SR-12 RGB high-resolution monitor, and (4) a Summagraphics SummaSketch digitizing tablet and pen. These were driven by an Eagle Turbo PC with a hard disk. Now, my background is art, not computers. So it was with some concern that I faced my assignment: familiarize myself with the system and produce sketches and a BYTE cover . . . in three weeks.

Getting Started

I began with an exploration of PC Paintbrush's features. This required only occasional reference to the manual, since the program's basic functions are quite intuitive. After only several minutes, I began to form my first impression of what it's like to use computer graphics—a sense of power.

Take a simple operation, one an artist performs repeatedly: changing paint color and brush size. Traditionally, this involves, at the very least, cleaning one brush and finding another; quite possibly it will require finding and opening another tube or bottle of paint. Big deal, you say. But to change brush color and size on the computer took only two whisks of the wrist across the digitizing tablet (to move the cursor and click on the appropriate menus) and only about 4 seconds to complete. Compared to this, the old-fashioned way is pure drudgery.

The same can be said of all the various functions of the PC Paintbrush program, such as cut-and-paste routines, erasing, color fills, "spray-painting," enlarging/rotating/reducing, and zooming in. It wasn't long before these functions were becoming second nature to me. Manipulating an image on the screen was virtually effortless—and fast.

The Sketches

After only a few hours, I began working on the three sketches you see reproduced here. This was a breeze. First, I drew and saved to disk a blank BYTE cover in the correct proportions; whenever I wanted to try out another idea, I simply called up this file and started a new sketch with the BYTE logo already in place. Conversely, when any sketch reached an interesting stage, I simply saved that version to disk and then continued from that point with further experimenting. Most of my work in the program was done in the freehand drawing mode.

The Cover

The cover wasn't exactly planned. After I had finished three sketches, I wanted to experiment with a finished image so that I could show Phil and Ross [Rosslyn Frick, BYTE's art director] what the final cover would be like. Since two sketches contained flowers, I decided to paint a rose. With a handful of sentimental greeting cards for references, I started in.

This was great fun! I started with a solid red area shaped like a rose. Then I began refining the image with different shades and hues created by mixing patterns of the 16 basic colors. The zoom feature came into its own for touching up edges and close-up work on the computer chip. Highlights? A flick of the wrist sends a "spray" of white onto a petal. A background? Create your own pattern; one touch of a button sends it cascading over the screen. Want to see what another looks like? Save the old version, fill in a new background, save this version, and compare the two back and forth. In about three hours I had a finished painting, background, shadows, and all.

Ross and Phil liked what I had done so far on the system. In fact, Ross was so pleased with the image of the rose that she was in favor of putting it on the cover. And, of course, that's exactly what we did. After making one 20-minute alteration (enlarging the chip and putting it on a more prominent petal), the image was ready to be photographed for final layout and color separations.

—Robert Tinney


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Staff-written highlights of late developments in the microcomputer industry.

Apple Introduces Add-ons for II, Macintosh

Apple Computer Inc. unveiled several new and enhanced peripherals for Apple II and Macintosh computers.

The Apple II RAM Expansion Card is a standard-slot card for the II, II+, and IIe. In its standard form, it holds 256K bytes of RAM but has sockets for up to 1 megabyte (using 256K by 1-bit chips). It also contains a 32K-byte ROM and a CMOS gate array interface to the I/O bus. Under ProDOS, DOS 3.3, and Pascal, the expansion memory can act as a RAM disk or as direct-access memory (built-in firmware handles memory moves for assembly-language programs). Information about pricing and availability of the card could not be obtained before we went to press.

The UniDisk 3.5 ($499) is a 3½-inch disk drive that interfaces directly to Apple IIc computers; other Apple II models must contain the IIc upgrade ROM to use the UniDisk. The 800K-byte 135-tpi drive works with ProDOS, DOS 3.3, and Pascal. Apple said it runs approximately 30 percent faster than previous Apple II drives.

Third-party products supporting both the UniDisk 3.5 and the memory card include Quark's Catalyst 3.0 (a Macintosh-style "desktop" for the Apple II) and Virtual Combinatics' Pinpoint (desk accessories for Appleworks).

The $595 Imagewriter II adds four-color printing capabilities, increased speed, and an expansion slot to Apple's standard dot-matrix impact printer. The Imagewriter II can print at 250 characters per second in draft mode, 180 cps in correspondence mode, and 25 cps in near-letter-quality mode. It can also handle graphics from 72 to 160 dots per inch, can print on paper from 3 to 10 inches wide, and can accept Apple's new $225 cut-sheet feeder. The printer uses a fabric continuous-loop ribbon that is available in black or in a four-color style (black, magenta, cyan, and yellow). An RS-232C serial connection links the printer to either the Macintosh or the Apple II. A single expansion slot can be used to expand the Imagewriter II's 1K-byte buffer to 32K bytes with a $99 card. Or the slot can be used for an Appletalk card that is scheduled to be released early next year. Apple said that Sorcim's SuperCalc 3a, Software Publishing's pfs:Graph, and Broderbund's Dazzle Draw will support the Imagewriter II's color capability.

Apple's Hard Disk 20, which is scheduled to be available this month and sell for less than $2000, attaches to the serial port of a Macintosh external disk drive. The disk has a formatted storage capacity of 20.77 megabytes, a transfer rate of 500 kbits/second, and an average seek time of 85 milliseconds. The drive, designed to fit beneath the Macintosh, includes a second port for daisy-chaining devices. Systems that use the Hard Disk 20 will still have to boot from a floppy disk. Third-party developers will be supplied information on the drive's new hierarchical file structure.

The Apple Personal Modem ($399) is a Hayes-compatible 300/1200-bps modem that attaches to the RS-232C port of the Macintosh or Apple II. Apple's new $399 Color Monitor IIe and Color Monitor IIc are electrically identical but have different cases. The IIe model has an optional stand ($25). Both are 13-inch composite (NTSC) video monitors.

In other Apple news, the company has clarified its policy on the Switcher program, which allows concurrent RAM residency of several Macintosh programs. While Switcher will be licensed to third parties for bundling with other software and also be sold by Apple dealers for about $20, it will still be available for free on services such as CompuServe. Although Apple doesn't encourage this practice, it will be allowed because the company had earlier advocated it.

Intel Sampling 80386 Microprocessor

Intel is now selling samples of its CMOS 32-bit 80386 microprocessor and related CPU boards and software tools. The company claims a sustained performance of 3 to 4 million instructions per second for the chip. The 80386 has a direct address space of 4 gigabytes and virtual memory capacity of 64 trillion bytes. It contains on-chip hardware for memory

(continued)

management, multitasking, four-level software protection, and self-testing. A pipelined architecture lets the 80386 fetch, decode, execute, and memory-manage instructions all at the same time. The chip supports both segmentation (with segments up to 4 gigabytes) and paging. It was designed to be fully compatible with all software written for Intel's earlier iAPX 86 microprocessors (the 8086, 8088, 80186, 80188, and 80286).

The 80386 can run applications concurrently under several different operating systems. The chip has 32-bit registers and data paths and demultiplexed 32-bit address and data buses. The 32-megabytes/second local bus allows access to an off-chip cache of any size in two clock cycles.

The 80386 will be available in a 132-lead pin-grid array package in both 12- and 16-MHz versions. In sample quantities, it will cost $299. Full-production quantities won't be available until late 1986. Although the 80287 can work as a numeric coprocessor for the 80386, a faster 80387 coprocessor is being planned.

Intel is also selling Multibus I and II single-board computers using the 386 for $3860 each. PL/M and C compilers and an assembler are also available. The UNIX System V and iRMX operating systems are planned for 1986 release.

AT&T Will Sell Alloy MS-DOS Emulator for UNIX PC

An add-in board allowing AT&T's UNIX PC to run PC-DOS programs should be available from AT&T this month. The DOS-73 board is made by Alloy Computer Systems, which granted AT&T exclusive marketing rights earlier this year.

The DOS-73 card, which might be named something else by AT&T, includes an 8-MHz 8086, 512K bytes of RAM, and a serial port. Software included with the card emulates some IBM PC functions while redirecting many MS-DOS function calls to comparable UNIX operations to be executed by the UNIX PC's faster 68010 processor. The DOS emulation can be accessed from the console or from either remote terminal. A PC-DOS application can operate concurrently with other UNIX programs in separate windows, but only one PC-DOS program can run at a time on the system. The card is capable of emulating the Hercules graphics card for the IBM PC.

At press time, AT&T would not disclose pricing or availability for the card. However, Alloy said that AT&T would receive shipments in October at prices that would let it sell the card for about $1000.

Northwest Instruments Unveils Hardware-based Software Analyzer

Northwest Instruments Systems took the wraps off its SoftAnalyst, a hardware system for the IBM PC and PC AT that lets programmers nonintrusively analyze high-level software written in Pascal, C, FORTRAN, and Ada. The product uses a microprocessor probe that fits in the PC's CPU socket. The SoftAnalyst, priced from $9955, can report on program flow, execution time, response time, and execution bottlenecks.

Nanobytes

Alsys Inc., Waltham, MA, the company founded by Jean Ichbiah, principal designer of the Defense Department's Ada language, plans to release a validated Ada compiler for IBM's PC AT in December. . . . **Boston Software Publishers** released MacIndex, a $50 program that prepares indexes from MacWrite documents. . . . **AT&T** began shipping samples of its 1-megabit memory chip during the summer. It will grind into full production in early 1986. . . . **LeBlond Software**, Indianapolis, IN, has released Concerto, a $99 enhancement for Lotus Development Corp.'s Symphony. It lets developers design Symphony add-in modules in BASIC instead of assembly language. . . . Meanwhile in Lotusland, Lotus said future versions of its business software, including 1-2-3 release 2 and Symphony 1.1, will accommodate installation upon and booting from a hard disk. . . . **Alpha Microsystems**, Santa Ana, CA, has been granted a patent for its VCR Backup Controller System, which allows IBM PC hard disks to be backed up on standard VCRs. . . . **Lattice** announced dbC III, a $250 set of C library functions that can access dBASE III data files. . . . **Motorola** introduced the MC68605 X.25 Protocol Controller (XPC), which fully implements the physical and data-link layers of the 1984 CCITT X.25 recommendation. The XPC generates the X.25 link-level commands and responses. At 12.5 MHz, the chip can handle serial communications at 10 megabits per second. In quantities of 100, it will sell for $50. . . . **Adaptec** brought out a 24-MHz version of its AIC-010 storage controller chip. . . . **Checkmate Technology**, Tempe, AZ, has redesigned its MultiRam memory-expansion cards. Apple IIe and IIc owners can now add a 65816 processor. Checkmate will bundle Micro Magic's operating system with the 65816 enhancement.

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At Kyocera, we think it's about time computers had an easier way of staying in touch. That's why we're introducing a telecommunications package featuring our 1200 bps modem and Microsoft's Access software for IBM-PC, XT, AT and all compatibles.

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"Mr. Watson, come here. I want you."

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The Kyocera 1200 modem with Microsoft Access software. If Alexander Graham Bell were around today, he'd wish it was his idea.

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CALCULATING PROBABILITIES

"The Technology of Expert Systems" by Robert Michaelsen, Donald Michie, and Albert Boulanger (April, page 303) mentioned a method of calculating probability used by some expert systems such as TAXADVISOR and MYCIN, in which the probability of one conditional AND another is taken as the minimum of their individual probabilities, and the probability of one conditional OR a second is taken as the maximum of their probabilities.

If a group goes to all the trouble to make an expert system, it really should take the time to calculate its probabilities correctly. The correct procedure for finding the probability in the case of an AND is to multiply the individual fractional probabilities. For an OR, one should calculate the probability of all of the conditionals' evaluating to "false," which is an AND operation, and then subtract the result from 1. As an example, the first of the two trees [see figure 1] is traversed from left to right using the first method of calculating probability; the second, using the correct method. The numbers at each branch are the probabilities of the tree so far evaluating to "true."

Multiplication and subtraction routines are fast compared to artificial-intelligence constructs. I do not believe that the time saved is worth the accuracy lost. What if a program given the above data had a threshold value of 0.5?

PHILIP GOETZ
Ellicott City, MD

Robert Michaelsen replies:
In response to Mr. Goetz's letter, I have the following comments. The people who built MYCIN were aware that they were not using "probabilities." Instead, they created their own calculations for dealing with uncertainty, based on confirmation theory, and called them "certainty factors."

They rejected the use of probabilities in their expert system because the system violated the assumptions about statistical independence and prior probabilities that are necessary with Bayes' rule. While it is true that certainty factors are subject to problems of interpretation not found with probabilities, they judged the interpretation problems to be less severe than those with statistical assumptions. (Other expert systems, e.g., PROSPECTOR, have used Bayesian revision to handle uncertainty.)

For a complete discussion of certainty factors and the reasons for their use, see E. H. Shortliffe and B. G. Buchanan's "A Model of Inexact Reasoning in Medicine," Mathematical Biosciences, *vol. 23, 1975, page 351.*

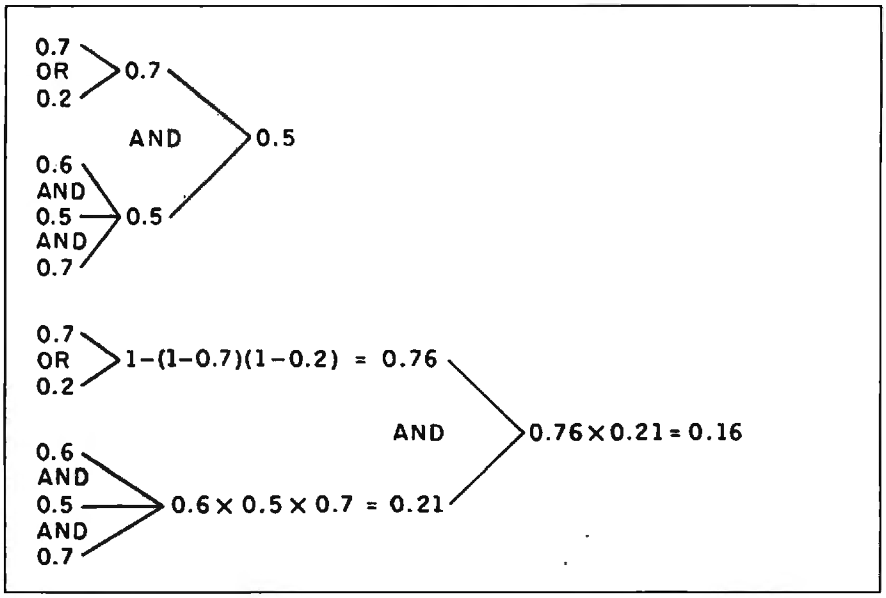

Figure 1: *Probability calculations using* AND *and* OR.

DECLARATIVE PROGRAMMING AND PARALLEL COMPUTING

I found your August issue very interesting and informative. I particularly appreciated the articles on declarative programming.

However, I believe I detected some myopia in the thinking of the authors. Several of the authors argued that declarative programming will be needed to make parallel computing work. However, their vision of parallel computing is an array of identical processors, all of which simultaneously make similar computations on arrays of numbers.

Very few people actually need this kind of numerical parallelism. Weather forecasters, seismologists, numerical aerodynamicists, and perhaps a few others do. For most people, even those facing massive number-crunching problems, the nature of the problems is different. They don't lend themselves to simultaneous computations on number arrays. The greatest use of declarative programming will probably have nothing to do with parallel computing.

In the meantime, parallel computing seems to be sneaking in the back door, in a guise completely different from the array computers most people seem to be thinking about. For instance, in the very same issue there were articles on the Commodore Amiga and the DSI-32 copro-

(continued)

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

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

cessor board, both of which allow dissimilar kinds of processes to go on in parallel, simply to unload the main CPU. The greatest use of parallel computing will probably have nothing to do with enormous arrays of identical processors doing similar computations on number arrays.

JOSEPH P. MARTINO
Sidney, OH

STAR MAPS

In the July BYTE, Bruce Webster describes a program that displays nearby star positions on a Macintosh ("New Perspectives on Nearby Stars," page 107). Programs like these are long overdue. In the premicro age I had to solve the same problems while researching exploratory routes among the stars (published in the October 1979 issue of *Spaceflight*), but the only maps that could be drawn on an available mainframe were on a line printer, with 132 horizontal "pixels"!

It may interest your readers to know that the Cartesian coordinate system used by Webster may be adapted to give coordinates referenced to the plane of the galaxy rather than that of the earth's equator. If X_G, Y_G, and Z_G are galactic coordinates, they may be calculated by:

$$X_G = -0.0672*X - 0.8727*Y - 0.4835*Z$$
$$Y_G = 0.4927*X - 0.4504*Y + 0.7445*Z$$
$$Z_G = -0.8676*X - 0.1884*Y + 0.4602*Z$$

with X, Y, and Z as used by Webster. The galactic plane is then the X_G-Y_G plane, and the galactic center is 10 kiloparsecs along the positive X_G-axis.

Lastly, I wish to bemoan the lack of an up-to-date collection of nearby star information. The list by Allen (1973) that was referenced by Webster in fact relies on a 1969 catalog (by Gliese). With the recent tremendous expansion in astronomical knowledge, there would be a lot known about nearby stars—but the information is uncollated, unpublished, and inaccessible. It would be a public service if an astronomer were to collect and publish the data—preferably in some machine form such as the Harvard catalog of bright stars, available to CP/M users.

TONY ORME
Aldershot, England

SWITCHING TO DVORAK

As a professional systems analyst for a large manufacturing company, it is my responsibility to estimate cost and return on investment for computer-oriented projects. Most of the time I have been able to rely on past experience and/or local

(continued)

LETTERS

sources to help with my estimates, until now. It seems that upper management is interested in the Dvorak keyboard for all computer-related hardware. This interest has come from hearing and reading about how efficient the Dvorak keyboard is over the QWERTY. Now management would like me to come up with some sort of estimate to switch over.

We have about 100 computer terminals in our plant and office used by various users (from factory workers to the president). In addition, we have 10 keypunchers who use either an IBM keypunch (remember the 80-column card—ugh!) or a key-to-disk system by Sperry. Also, we have five computer operators, and let's not forget the diehards in the programming department (of which I am a member).

I have to plead ignorance of this subject, so I am asking if you or any of your readers have heard of any company that has switched over to the Dvorak keyboard. If so, what benefits and heartaches were involved?

FRANCO ARDITO
Systems Analyst
Executive Offices
Buffalo Forge Company
490 Broadway
Buffalo, NY 14204

"A NEW LEVEL OF COMPUTING POWER"

Wow! Congratulations on a comprehensive look at state-of-the-art systems' capacity in your August BYTE. A new level of computing power is about to appear on our desktops, from high-powered personal audio/graphics in an innovative package ("The Amiga Personal Computer"), to 32-bit computational power ("The DSI-32 Coprocessor Board" and "BYTE West Coast: New Microprocessor Chips"), to new high-level languages ("Declarative Languages: An Overview"). BYTE has evolved considerably from the days when 8-bit controller/processors were being first assembled into general-purpose computers by "hobbyists."

Twenty years ago I was fortunate to be a member of a high school computer club whose members were permitted access to a local university's IBM System/360 during "idle time." One member of our group was programming in LISP, and we used to joke about the parenthetic delimiters as "impediments." I was chided for my tendency to use FORTRAN. I loved PL/I, but the problems I wanted to work on were heavily computational, and FORTRAN provided easy links to assembly-

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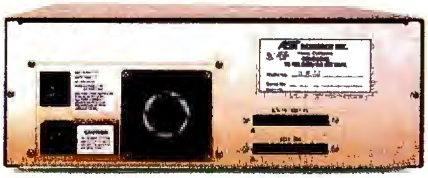

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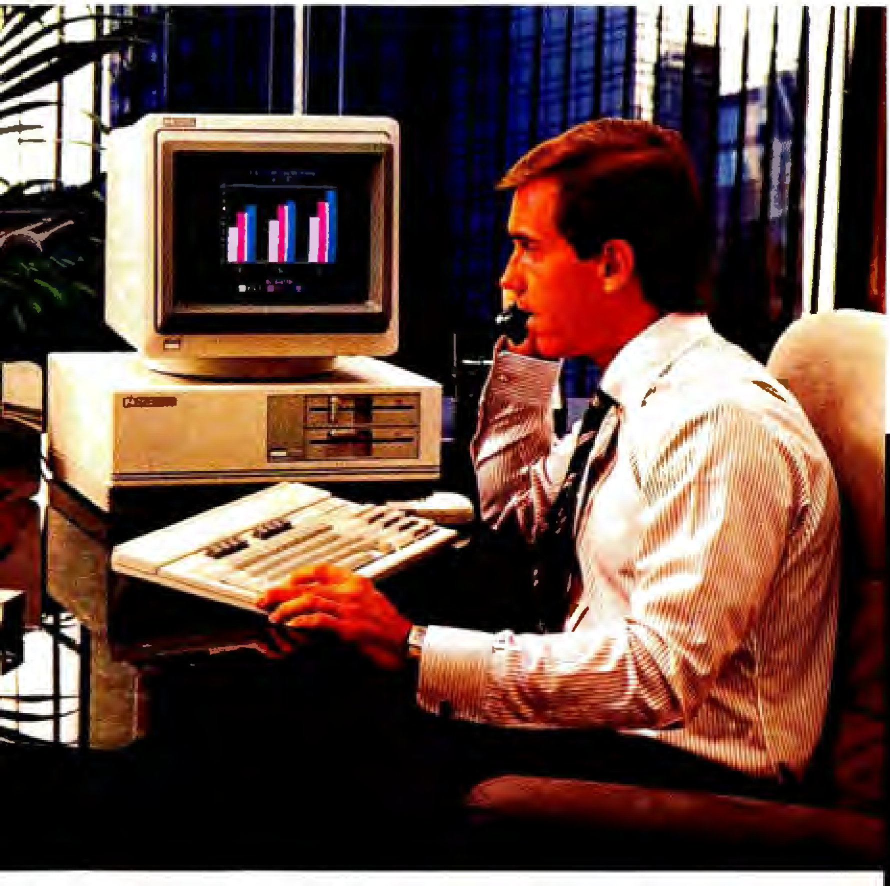

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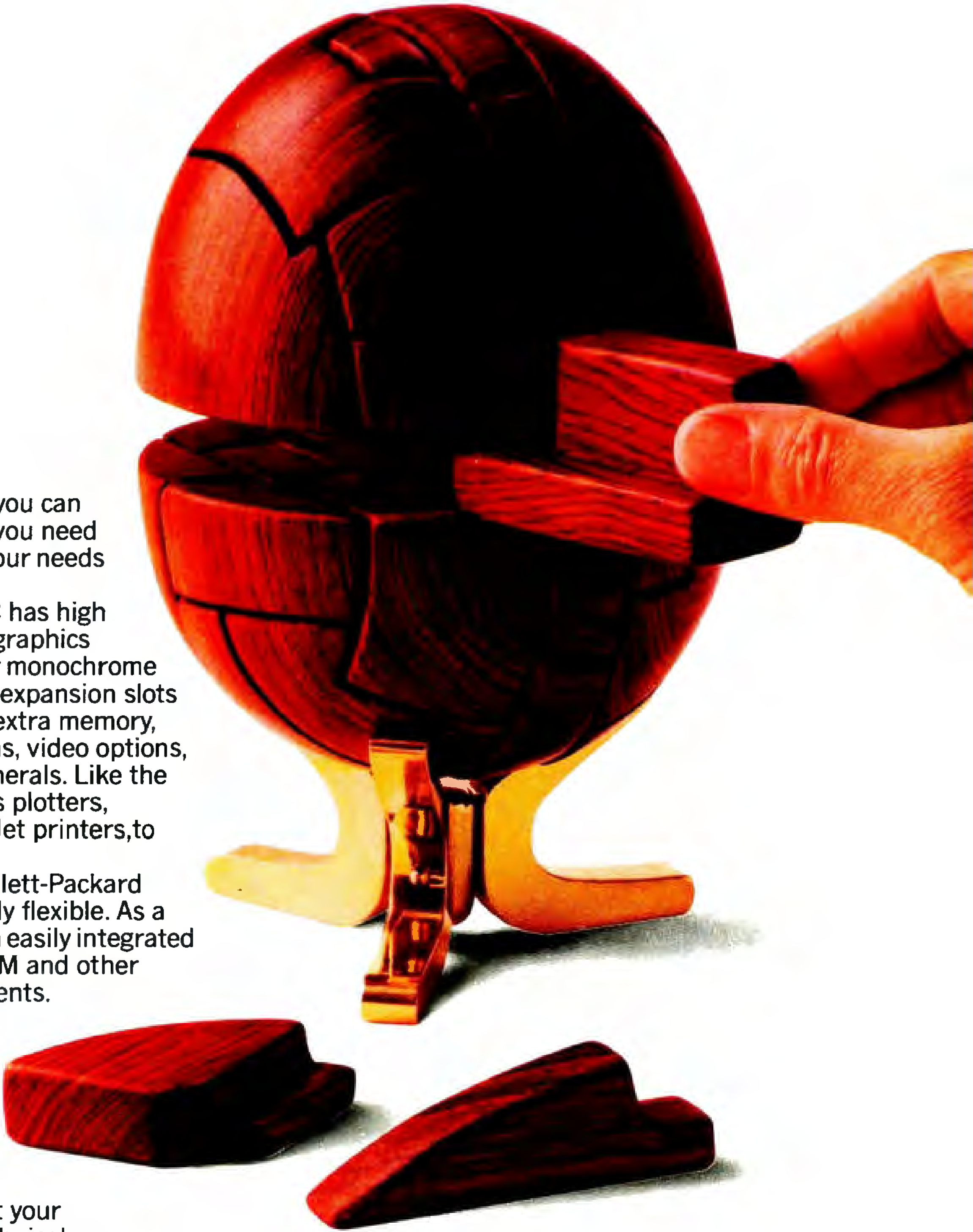

HEWLETT PACKARD
Business Computing Systems

Lotus 1-2-3 business graphics shown. Lotus and 1-2-3 are registered trademarks of Lotus Development Corporation. MultiMate™ is a U.S. trademark of Multimate International. R:BASE™ is a U.S. trademark of Microrim; Inc.

PG02513

language-coded routines as well as plotter library routines. Over the years, my programs have become strongly hierarchical, with multiple levels of function calls and constant evocation of external routines from my personal library.

I believe that for a computational language to survive, it must eventually evolve into a hierarchical functional language. Therefore, I applaud Dr. Peter Harrison for his work on FP and his intent to make FP available on VAX and PC systems in the near future ("Functional Programming Using FP," page 219). FP is a step *beyond* the level of block-structured languages, such as PL/I, and languages with symbolic array operators, such as APL. Welcome to a world where man speaks to machine with the logic of mathematics!

GARY R. CONRAD, M.D.
Iowa City, IA

COMPUTER-ACCESS INEQUITIES

The July Editorial ("Equal Access to Computers: Scruples or Rubles" by Phil Lemmons, page 6) seems to have been written with Jersey City State College in mind. JCSC is an urban college that largely serves a nontraditional, minority population. We are seeking funding to establish a Social Science Computer Resource Center to fulfill the following objectives:

1. The development of a consortium of social science faculty and students to transform every social science course into a computer-aided-instruction (CAI) offering.
2. The establishment of a research service for local businesses, government and social agencies and the development of a social science team method of doing research on the impact of the computer on human behavior.
3. The development of electronic communication systems to link JCSC social science faculty and students with other colleges, universities, and organizations.

Any suggestions? Thank you.

PHILIP A. RAGONE
Professor of Sociology
Jersey City State College
Jersey City, NJ
(201) 547-3261

Phil Lemmons's editorial correctly identifies "computer inequity" as a problem for disadvantaged schoolchildren. I would go further and suggest that the long-term effect of computer inequity, whether in the

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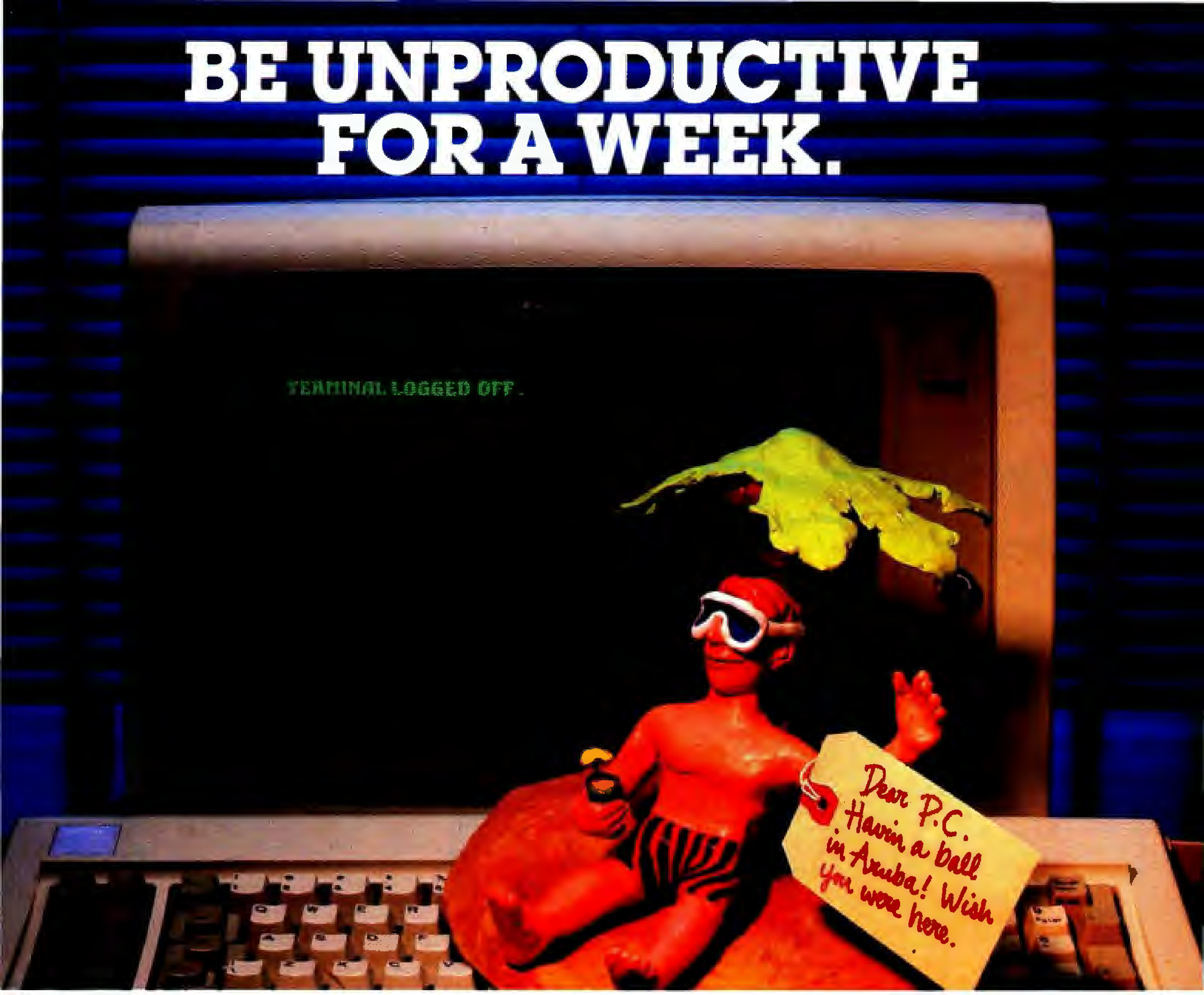

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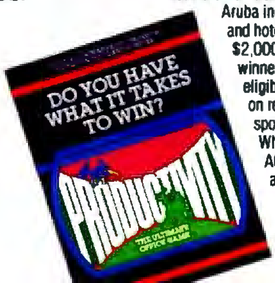

No purchase necessary. Entrants must be 18 years and older. All entries must be received by March 28, 1986. One entry per person. No facsimiles or mechanical reproductions will be accepted. Each entry must be mailed separately. Entries are the sole property of the sponsor. Sponsor is not responsible for lost, misdirected, or mutilated entries. The prize winners will be drawn from entries received with all questions answered. Drawings for all prizes to occur April 12, 1986. Winners will be notified by registered mail. Prizes are non-transferable. First prize will be a trip for two to Aruba including air transportation, from a major airport, and hotel for 7 nights. Trip value is approximately $2,000.00. Taxes are the sole responsibility of the winners. Winners are required to sign an affidavit of eligibility and liability. Winners names will be available on request. Decision of the judges is final. Sole sponsor is ACCO International, 770 South Acco Plaza, Wheeling, IL 60090. Employees and families of ACCO, ACCO distributors, and associated agencies are not eligible. Sweepstakes open only to U.S. residents. Void where prohibited.

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Inquiry 6

schools or in adult life, will be "information inequity." As computers blur the line between knowledge and information, those who have little or no access to information may become the underclass of the future.

While the price of declining hardware promises greater availability of computers to all, continuing restrictive software license agreements—"one user, one machine"—theoretically perpetuate inequality.

ELLEN MOSS POLER
New York, NY

LOGO DIALECT DIFFERENCES

I was glad to see the Logo program in "The Expert Mechanic" by Michael Fichtelman (June, page 205). I typed it in, but I found that IBM Logo "doesn't know how to WORD?" in the procedures Search, Change, and Disp.

Am I the victim of differences between Logo dialects, or was something left out of the program listing?

TERRY R. GRANT
Manchester, MO

Michael Fichtelman replies:
I'm afraid Mr. Grant is the victim of the difference between Logo dialects. Expert Mechanic is written in Terrapin Logo, but I don't think the difference is insurmountable. In Terrapin Logo, the predicate WORD? returns TRUE if its input is a word, while the predicate LIST? returns TRUE if its input is a list. This is similar to the operation of the ATOM and LISTP predicates in Common LISP. If IBM Logo has an equivalent predicate, the translation should not be difficult.

MAKING DO WITHOUT COMMUNICATIONS SOFTWARE

I read with interest Monsieur Desjardins's description of the "Morocco Principle" for unidirectional "ASCII Transfer" (Letters, August, page 24) between computers that require communications software only on the receiving hardware. Without realizing it, two years ago I discovered a similar "Mt. Pleasant Principle" for transferring ASCII files between CP/M machines *without any* communications software. To do this, the receiving machine is first readied with the following instruction:

```
A>PIP MYFILE.TXT = RDR:
```

The ASCII file is then sent from the other machine using

```
A>PIP PUN: = MYFILE.TXT
```

PUNCH and READER send data to, or receive data from, the serial communications port.

With the serial ports set to the same baud rate, etc., I have transferred files between a Radio Shack Model II and my trusty Kaypro 2 by simply modifying an RS-232C cable so that pins 2 and 3 are twisted (2 on one end connected to 3 on the other, etc.).

My Kaypro 2 is so old that it came with only a "dumb" terminal program. I could still transfer data files to the mainframe here at Central Michigan University by readying our CDC to receive using the "dumb" terminal, exiting to CP/M, typing the instruction

```
A>PIP PUN: = MYFILE.DAT
```

and then recalling the terminal program

(continued)

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to terminate the input mode, save the file, and sign off the mainframe.

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RODNEY C. KIRK
Mt. Pleasant, MI

THE AMIGA'S RAM LAYOUT

The collaboration of Gregg Williams, Jon Edwards, and Phillip Robinson resulted in an essentially excellent preview of the Amiga computer (August, page 83). But if anyone had scrutinized the hardware coldly, the RAM layout might have received the assessment it deserves.

How can a true 16-bit computer possibly have just 256K bytes of dynamic RAM in this day and age?

With the eight dynamic RAM chips in your fine photograph of the main circuit board, it would make electronic sense only if these chips were 64K by 4-bit dynamic RAMs. With the 16 chips in another magazine's corresponding (but lesser) photograph, it would make electronic sense only if those chips were 128K by 1 bit. Neither of these schemes makes production sense.

If the other magazine's 16 chips were 256K by 1 bit, that would make production sense. But then the standard on-board memory would be 512K bytes, not 256K, and the optional (extra cost) memory-expansion cartridge would raise the total to 1 megabyte, not 512K. This would make a great deal of production sense. And assuming the boards, main and expansion, were wired in a sensible manner, simply replacing those hypothetical 256K by 1-bit chips with next year's 1M by 1-bit chips would bring total expanded in-box RAM to 4 megabytes. All very straightforward, no particular problems, but that's not how the Amiga is set up!

Why, logically, will an expensive external expansion cabinet be necessary to get that kind of RAM capacity for the Amiga? Why is an optional cartridge necessary just to get 512K in the first place? Is it possible that the Amiga's makers deliberately crippled the machine's memory scheme in order to squeeze some extra pesos out of its sales?

Had you all not been quite so dazzled by the Amiga's clearly great features, you might have noticed this not-so-great feature. It's really a dog. But then, no one else noticed it, either.

I appreciate the Amiga for what it does in its price range, even if the range seems just a trifle steeper than it needs to be; and I appreciate the way it does it, thanks to BYTE's analytic preview. But I resent a RAM implementation that needlessly cheats its customers.

JIM HOWARD
Project City, CA

Gregg Williams replies:
Mr. Howard caught one point that I had entirely overlooked, but I must add that I find his opinions to be rather extreme. I, for one, am glad to be offered a machine with color, greater speed, and twice the memory and disk storage of the Macintosh, all for considerably less ($900 less, if you use an existing television set) than the Macintosh itself. I applaud Commodore's decision to use 256K bytes in its basic machine (the company had orig-

(continued)

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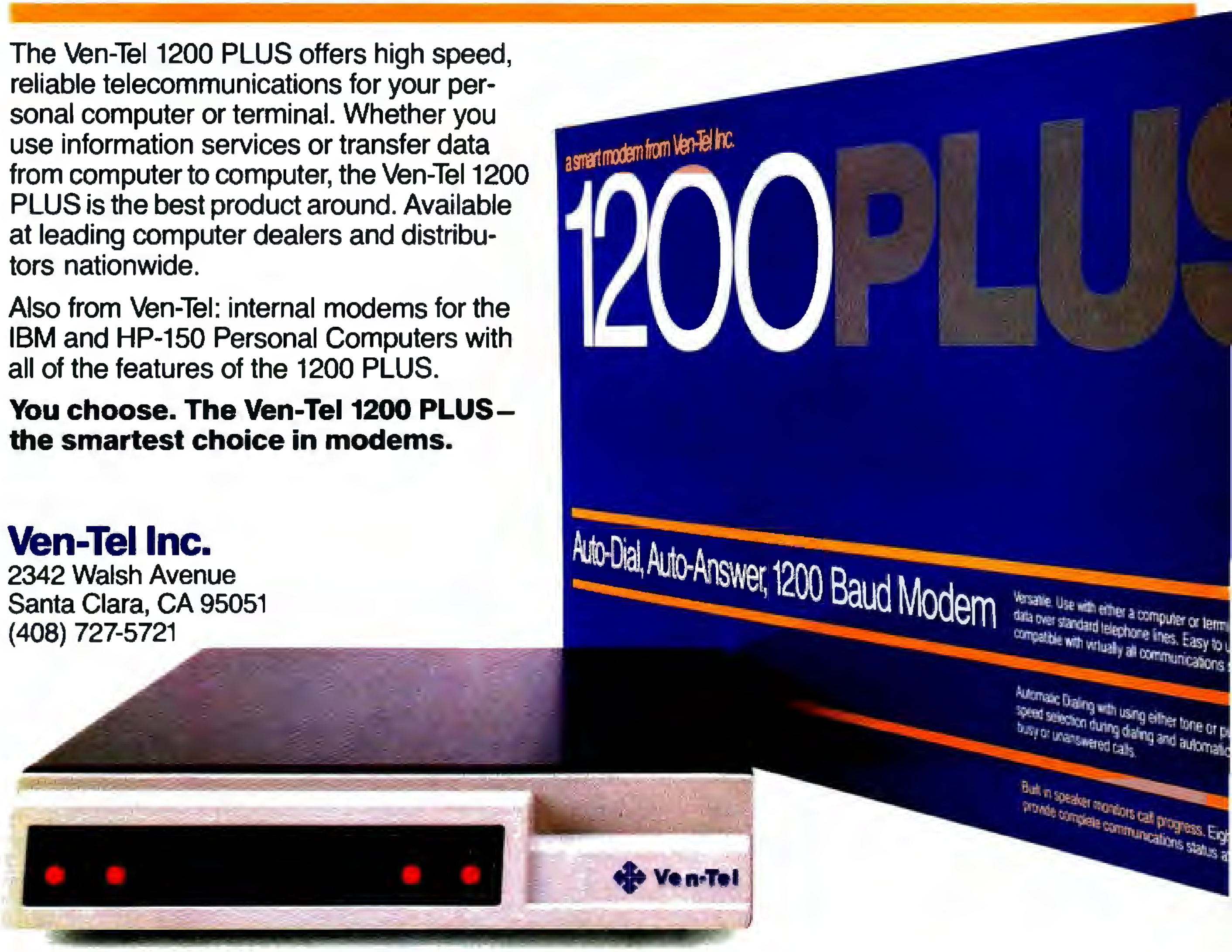

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inally designed a 128K-byte machine with a 128K-byte add-on cartridge) and to have an expansion bus (Jay Miner, who designed the custom chips, said he had to fight very hard to keep the bus in the design). You do not need an "external expansion cabinet" to get to 512K of memory—the 256K cartridge plugs into the front of the machine, replacing a hollow panel.

Mr. Howard's objections, though, draw attention to a fact of life that keeps showing up in the microcomputer industry: the effect of marketplace constraints on the engineering design of products. It's true that it would have been nice to have put more memory on the Amiga motherboard, but that would have caused the price of the basic unit to increase by, say, $300. The key fact is this: It's entirely possible that, in the same market, a $1295 computer would be successful, while a $1595 computer would sell too few units to survive at all. Because of this admittedly illogical impulse that makes people buy a product at $9.95 more often than they would at $10.00, manufacturers tend to design products to sell at the lowest possible "basic" price. This practice, called unbundling, *has been around as long as people have had products to sell, and it shows no signs of disappearing now.*

Getting on to answering some of Mr. Howard's questions, the eight memory chips on the Amiga motherboard (see page 83 of the August issue) are, in fact, 64K by 4-bit RAM chips; four of these in a row allows the Amiga's memory bus to be a full 16 bits wide (unlike the IBM PC, which is slower than an equivalent 16-bit data bus design because of its 8-bit data bus). The 16-chip design he saw on a motherboard in another magazine was a 128K-byte Amiga prototype that used sixteen 64K by 1-bit RAM chips.

I'll conclude by adding three pieces of information that were left out of the motherboard photo in the August article. The edge connector at the bottom of the photo is for the 256K-byte expansion cartridge (this connects to the front of the Amiga), and the connector on the right is the Amiga's expansion bus.

Also, the first Amigas to be shipped (which hasn't yet happened at the time I am writing this) are to have 192K bytes of write-protected RAM instead of ROM; users will start these Amigas with a special "kick-start" disk that loads a copy of the ROM software into the 192K of RAM. This will give Commodore more

(continued)

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time to find and correct bugs before it creates the final version of the Amiga ROMs.

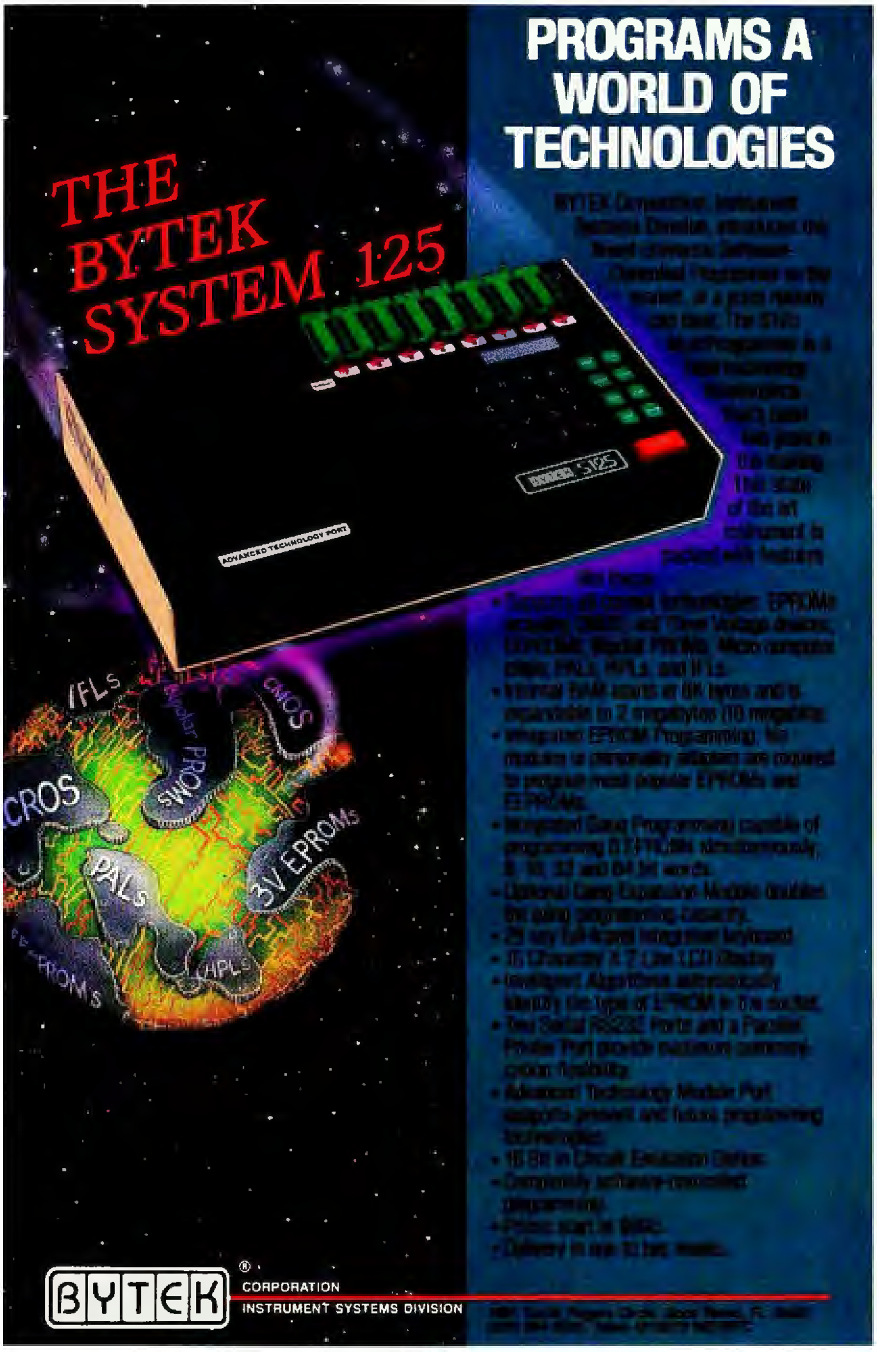
Given Mr. Howard's feelings about the Amiga, I'll be the first to come to his rescue if someone forces him to buy one.

THE getNum FUNCTION

"Context-Free Parsing of Arithmetic Expressions" by Jonathan Amsterdam (August, page 138) was clear and informative. There are, however, two points of further interest to the reader. They both concern the function getNum. First: By making this integer-valued, you are necessarily limited to numbers not exceeding MAXINT (32767 on most machines). This can create problems since, in some Pascals, entering a larger number will result in getNum producing either a negative value (because of two's complementing) or even a nonsense result. What is even worse, if this parser is extended to deal with real-number entries by having it parse the digits before and after the decimal point separately, then even an innocent number such as 3.45670 will have "3" and "45670" both subjected to the tender mercies of getNum—the result will be ridiculous!

Which brings me to the second point. Several years ago I wrote a parser very similar to the one in this article except that it parses any algebraic expression: It will accept real numbers and transcendental functions (e.g., sine, log, etc.). I placed this parser in the public domain and it is available on a disk from the Boston Computer Society's PC User Group. Unfortunately, it too contains a GetInteger function that has the same limitations as Mr. Amsterdam's! The problem is easily corrected, in either case, by simply changing the value of the function from Integer to Real.

MARK BRIDGER
Newton Upper Falls, MA



INSIDE MAC

In response to the letter from Mr. Singer in the September issue ("Paying Extra for Manuals," page 428), I must say that I agree that Apple should have made errors more clear to the user. However, I disagree that *Inside Mac* was overpriced or, for that matter, that it would have been of use to anyone but a serious programmer. I have read *Inside Mac* and found it to be a treasure chest for the serious Mac programmer, but I am relatively sure that it would have been 90 percent incomprehensible to the average user. I paid $25 for my copy, which is still the going rate, I believe, and it would have been worth far more than four times that amount.

I agree that the end user should not have to figure out what ERROR#10 means. Instead, Apple should have had some generic "A serious problem has developed. . ." type of message. I guarantee you that the real meaning of error #10 would not be very enlightening to most users—it is "F emulator" trap, also known as DSLineFErr. I hope that helps Mr. Singer, but I doubt it will.

I would like to point out in closing that the Mac is far more complex to "hack" than the IBM because of the immense power of the toolbox. Comparing the relative merits of *Inside Mac* to the IBM technical manual is comparing apples to dinosaurs.

SCOTT BERFIELD
Northbrook, IL ■

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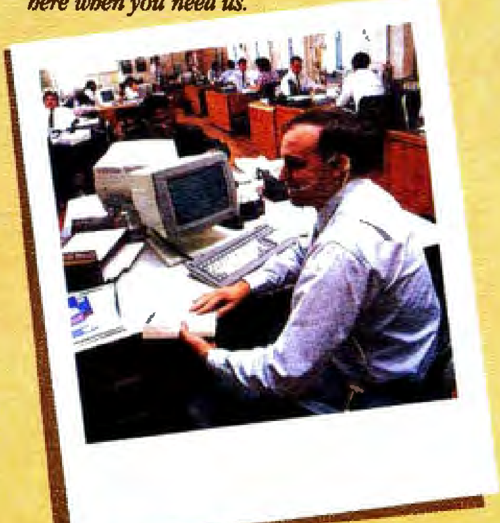

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BYTE'S BUGS

RAMDISC Corrections

A "What's New" writeup supplied an incorrect price for Beck-Tech's RAMDISC software. (See July, page 408.) The RAMDISC software alone is $49.95. With your purchase of a MacMegabytes memory-expansion board, Beck-Tech provides you with the RAMDISC package. A MacMegabytes memory-expansion board gives your 128K- or 512K-byte Macintosh more than 1 megabyte of internal memory.

In addition, RAMDISC does not have a slide-show utility. However, a demonstration of Beck-Tech's animation software package, MacMovie, is provided with each disk.

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For your copy of *Writing for BYTE*, send a self-addressed stamped business-size envelope to BYTE Author's Guide, BYTE/McGraw-Hill, POB 372, Hancock, NH 03449.

New Number for BYTEnet Listings

BYTEnet Listings has a new telephone number. Call (617) 861-9764. When you receive a carrier tone, enter three or four carriage returns so that our software can determine your operating parameters. Optimal parameters are 8 bits, 1 stop bit, no parity, full duplex, and either 300 or 1200 bps. You can download programs with the following protocols: ASCII, XMODEM, XMODEM with error checking, TeleLink, TeleLink with error checking, MiniTel, MODEM7, and MODEM7 with error checking. BYTEnet Listings does not support 2400-bps transmissions at the present time.

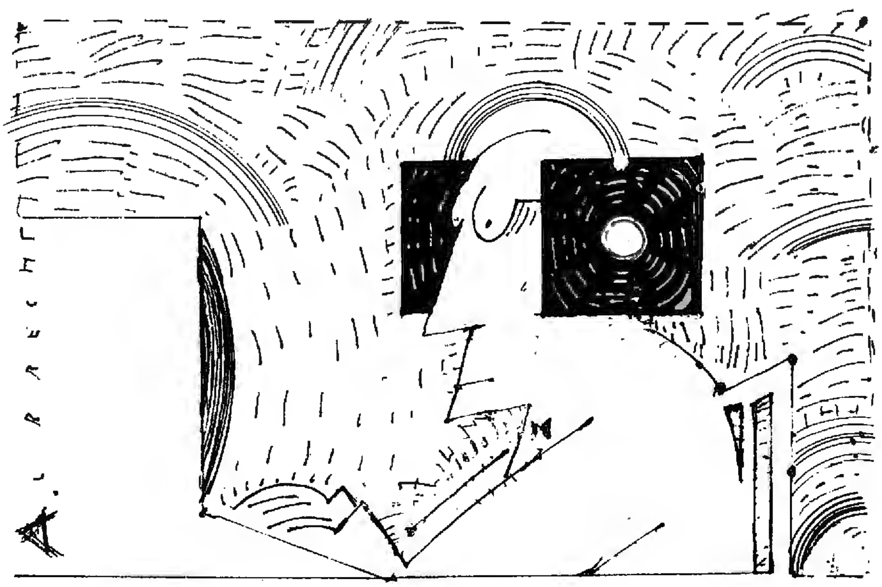
BYTEnet Listings Goes On Line in the United Kingdom

BYTE readers in the United Kingdom can now download the programs mentioned in BYTE from the Compulink Fido bulletin-board system in Woking Ferry, Surrey, England.

Compulink is a public-access bulletin-board system featuring a variety of public-domain software. It is independent of BYTE magazine, and BYTE listings are provided through the volunteer services of Compulink.

The BYTEnet Listings library comprises more than 140 programs from the September 1984 BYTE to the issue you're reading now. Bug reports, program enhancements, and all questions related to the listings in BYTE magazine should be directed to BYTE's offices in the United States and not to Compulink. The proper address for inquiries about BYTEnet Listings is BYTE/ McGraw-Hill, POB 372, Hancock, NH 03449, U.S.A., Attn: BYTEnet Listings.

Frank Thornley, the Compulink sysop, reports that the system is up and running 24 hours a day at 300, 1200, and 2400 bps. CCITT protocols are the norm. In the United Kingdom, call 04867 6535.



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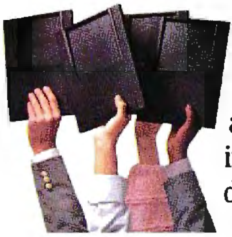
DATA INDEPENDENCE
MUCH SMALL



The Age of Data Independence™ dawned about two years ago when IOMEGA introduced a revolutionary mass storage device called The Bernoulli Box® Featuring a unique technology that uses rugged, removable 10-megabyte cartridges, it freed companies to work more productively and economically—and was soon recognized as the decade's biggest step forward in business data storage.

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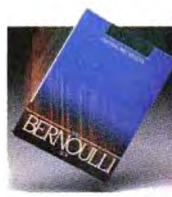
Free yourself from the limitations of system capacity. If you need more, you expand by buying slim, inexpensive cartridges, not bulky and costly hardware.



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ER FOOTPRINTS.

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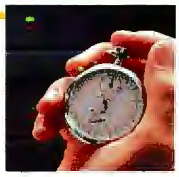
For the dealer nearest you, call 1-800-556-1234, ext. 215. In California, call 1-800-441-2345, ext. 215.



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The amazing speed of The Bernoulli Box—with access times and transfer rates that rival and often surpass the best hard disk drives—translates into the best freedom of all: the freedom of time. And now The Bernoulli Box offers users the option of booting from The Bernoulli Box cartridge with any of the IBM PC or compatible computers.

*The Bernoulli Box for Macintosh is available in a 5-megabyte single-drive version and a 20-megabyte dual-drive version for AppleTalk.™

The Bernoulli Box is a registered trademark of IOMEGA Corporation. Data Independence is a trademark of IOMEGA Corporation. Macintosh is a trademark licensed to Apple Computer, Inc. AppleTalk is a trademark of Apple Computer, Inc.

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Inquiry 199

Three Expert-System Generators

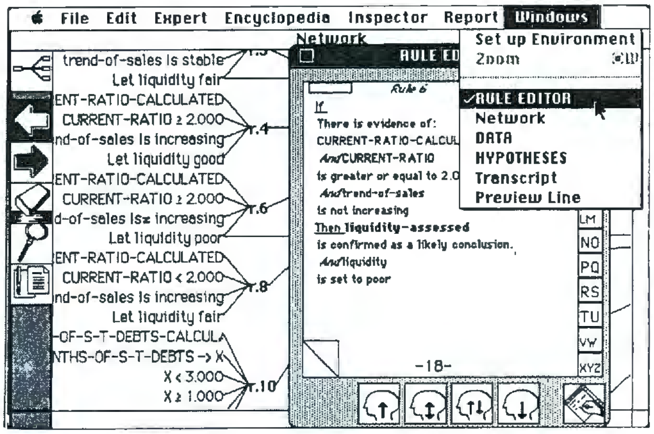
Neuron Data's Nexpert is a software package that lets Macintosh users build rule-based expert systems. It conforms to the Macintosh user interface by employing multiple windows and a series of pull-down menus.

Nexpert uses an interpreted Knowledge Editor that consists of a Rule Editor, a Category Editor, and a Text Editor. Because it is interpreted, the system can rapidly integrate new or changed knowledge into the stored body of rules. You can link knowledge that Nexpert has stored to either text or graphics images.

The rule-editing screen has a form with spaces so that you can fill in the components of an IF...THEN rule. Pull-down menus note the options available at any given time. You can either type in a response or click-on to the option you would like to choose. If you would like to use a variable that has already been entered, you don't need to retype it; you can use the mouse to copy the entry instead. This reduces the chances of semantic or syntactic errors by cutting down the amount of typing necessary.

Once you enter rules, you can retrieve them through Nexpert's Encyclopedia or Network. The Encyclopedia catalogs the rules in alphabetic order, so you can find them by scrolling through an organized listing. The Network is an interactive graphics representation of the knowledge base, much like a block diagram or flowchart. You can visually track which decisions lead to which conclusions and which rules played a role. Modifications made to the Network chart will be reflected in the structure of the expert system.

Nexpert's inference engine, Knowcess, combines backward- and forward-chaining search strategies. You can specify the reasoning path the program is to follow or let it determine the most efficient strategy. You can change data, enter new data, or suggest a new hypothesis at any time. You can run "what if" simulations at the end of a session; cases can be recorded and rerun.



Sample screen from Neuron Data's Nexpert package for the Macintosh.

Sample screen from Radian's RuleMaster programming tool.

Nexpert requires a 512K-byte Macintosh and costs $5000. Contact Neuron Data Inc., 444 High St., Palo Alto, CA 94301, (415) 321-4488. **Inquiry 600.**

RuleMaster from Radian Corporation is a programming tool for building and running expert systems on the IBM PC XT or AT and the AT&T UNIX PC. On the IBM machines, it requires either XENIX or DOS 3.0.

RuleMaster has two parts: RuleMaker is a facility for inducing rules from examples and Radial is a high-level language for expressing rules. You enter a series of examples in any order on a spreadsheet-like table, from which RuleMaker induces rules and generates Radial code.

You can write expert systems directly in the Radial language or edit Radial code into a program generated by RuleMaker. Radial is a structured language with only 14 keywords. It provides both forward and backward chaining as well as a combination of the two.

When responding to an inquiry, RuleMaker might ask for more information. Because the program organizes the rules in what it has determined to be the most efficient order, the first questions asked are those that yield the most information.

An explanation facility within RuleMaster lets you type WHY at any point to get either an explanation of a response or a justification of a question.

(continued)

For the IBM PC AT and the AT&T UNIX PC, Rule-Master costs $5000. A less powerful subset of Rule-Master for the IBM PC XT is $995. A four-day training session is available at Radian for an additional $500. Contact Radian Corp., 8501 Mo-Pac Blvd., POB 9948, Austin, TX 78766, (512) 454-4797.
Inquiry **601.**

Aion Corporation is offering the Aion Development System/PC for constructing and using rule-based expert systems on the IBM PC, XT, and AT. The program uses a series of interactive editors and a multiwindow interface to provide a structured programming environment.

The first editor you encounter is the state editor, which works much like an outline processor. It lets you outline your problem, inserting and deleting headings as desired. You can expand or compress the outline or selected portions of it at any time.

When a portion of the outline is fully expanded, you can enter rules relating to it by using the rule editor. The rule-editing screen prompts you for relevant information about the rule. It also finds semantic and syntactic errors.

Although the outline helps you organize a problem, it has no bearing on the order in which the inference engine processes the rules. The program chooses its own path by using a combination of backward and forward chaining, unless you control it by using the step editor to declare sequences. You can also give rules entry conditions to ensure which rule is fired first.

An options window is always available for querying the system. Through this window you can ask why a question is being asked, how a value was determined, or what the implications of an answer will be. You can also back up and change answers, and you can save sessions and begin them again later where you left off.

The Aion software allows direct access to DOS commands and includes graphics features for custom-designing screens.

The Aion Development System/PC requires an IBM PC, XT, AT, or compatible with 512K bytes of RAM, two disk drives (a hard disk is recommended), and PC-DOS 2.0 or higher. The execution system requires only 320K bytes of RAM. The development and execution software, documentation, and a two-day instruction course for two people costs $7000. Contact Aion Corp., 101 University Ave., Palo Alto, CA 94301, (415) 328-9595.
Inquiry **602.**

—*Brenda McLaughlin*

FORTH Development System for Atari's 520ST

The Dragon Group's 4xFORTH is a series of 32-bit FORTH development systems for Atari's 520ST computer. The compiler also includes an assembler and editor and provides full support for multitasking, multiuser access, and file-system access, as well as for RAM disks, serial disks, and printer drivers. Two versions of the compiler are planned. Level 1, available since August at a price of $99.95, supports Atari's A-line graphics; Level 2, planned for October release at $149.95, provides support for the GEM user interface. A $75 accelerator package enhances the execution speed of code generated by either level compiler.

A complete Developer's System, which includes the Level 2 compiler, accelerator, targetter, and a royalty-free license to distribute programs written with 4xFORTH, is priced at $500. Complete source code for 4xFORTH is also available for $2500. You can upgrade any version of 4xFORTH to another by paying the retail price difference plus $10.

Contact the Dragon Group, 148 Poca Fork Rd., Elkview, WV 25071, (304) 965-5517.
Inquiry **603.**

Ansa's Paradox Database

Ansa Software has introduced its first product, Paradox, a relational database-management program for the IBM PC and 100-percent compatibles. Paradox incorporates some algorithms from the field of artificial intelligence for speed and ease of use.

You pose questions to Paradox by typing an example of the information you want; this is the QBE (query by example) method. Then the two artificial-intelligence concepts—program synthesis and heuristic query optimization—enter the picture. Paradox writes a program (program synthesis) that will produce the answer in the least time (heuristic query optimization). You don't need to know anything about the data's organization or about the best structure for algorithms.

PAL (Paradox Application Language) comes with the program. This language allows development of applications based on Paradox. Another Paradox function called "scripts" records the series of operations that you perform. You can then play back scripts so they can fulfill much of the use of macros.

Ansa has built Paradox around a rows-and-columns user interface that resembles that of Lotus 1-2-3. Paradox can import or export 1-2-3, Symphony, dBASE II, dBASE III, pfs:File, ASCII, or DIF files.

Paradox works with tables, forms, queries, and reports. Tables can contain up to 260 million characters consisting of 65,000 rows (records), 255 columns (fields), 4000 characters per row, and 255 characters per column. Forms display information about a single record and can be custom-designed. Any change in a form is immediately reflected in the related table. Queries are used to retrieve, select, or perform calculations on the information in tables. The report generator lets you print (to screen or paper) the results of Paradox questions and answers. It can work with both standard and custom-designed report formats.

Paradox requires an IBM or compatible, two floppy-disk drives or one hard disk and one floppy disk, 512K bytes of RAM, and MS-DOS 2.0 or above. Its suggested list price is $695.

Contact Ansa Software, 1301 Shoreway Rd., Belmont, CA 94022, (415) 595-4469.
Inquiry **604.**

(continued)

60-DAY MONEY BACK GUARANTEE

Borland's SuperKey And SideKick Work So Well Together, You'll Hardly Work At All.

AN UNBEATABLE TEAM AT AN UNBEATABLE PRICE! We've teamed the best with the best to make the greatest. The best keyboard enhancer, SuperKey®. The best desktop organizer, SideKick®. The dynamic duo working hand in hand to let you do many different things at once. A way that cuts down the keystrokes, so you're working instead of just typing. A way that wasn't possible until we paired the electronic wizardry of SuperKey with the practical efficiency of SideKick. SuperKey brings the magic. SideKick does the details. The "S-Team" works beautifully together because we designed them that way.

GET SUPERKEY AND SIDEKICK TODAY and you'll have an unbeatable team at an unbeatable price — and a $15 rebate back in the mail.

SIDEKICK INCLUDES: * Calculator * Notepad * Auto dialer & phone directory * ASCII table * Perpetual calendar & datebook * Help window * Full-screen editor with word-wrap, paragraph editing and much much more. (Chances are that once you have SuperKey and SideKick working together for you, you'll never need to use a word-processing program again).

SUPERKEY INCLUDES: *Encryption to keep confidential files confidential * Programmable keys that let you turn a thousand keystrokes into one * Keyboard lock * Automatic turn-off of your screen after a pre-set time so the expensive phosphorus in your monitor's screen isn't etched or ruined * Secret Password protection and more.

IF YOU USE SIDEKICK, YOU NEED SUPERKEY. BECAUSE SUPERKEY AND SIDEKICK CAN MAKE YOUR DAY GO SOMETHING LIKE THIS:

8:00 am. You got to work on time, despite the 44-mph turkey ahead of you in the fast lane. It's spreadsheet time. You hit one key. Lotus 1-2-3 (or whatever) is up and running. (One key, because SuperKey has recorded all the CD\123 <ENTER >123< ENTER> <ENTER>/ F <ENTER> R <ENTER> SALES <ENTER> <PgDn> foolishness and your one keystroke played all that back instantly. One keystroke instead of a minuet).

8:03 am. You're into the spreadsheet. Phone rings. You kick in SideKick's Notepad—without leaving your spreadsheet. You talk. You listen to Frank. You make notes that tell you that Frank is upping the numbers from yesterday's order and he needs a new price and delivery date. He wants a meeting. Fast, but when? You have SideKick fire up your Calendar. Time agreed and noted—in SideKick's NotePad. Conversation ends. Your spreadsheet is still there.

8:07 am. You're watching the spreadsheet but you're thinking about the new bid you have to figure out. So you have SideKick's Calculator pulled up on the screen—over a small piece of the spreadsheet—which doesn't go away.

8:08 am. SideKick is coming up with new numbers. SuperKey keeps the spreadsheet on a roll. Satisfied with the numbers, you have SideKick auto-dial Frank's number. Talk. Talk. Hang up.

8:09 am. Spreadsheet about done. You're watching it, but thinking about what Frank just said on the phone. He liked your numbers. He ordered. He said, "That was fast. We won't need that meeting. (SideKick cancels it from your Calendar). And he also said, "How did you get all that done so quickly?" And you said, "I've got a couple of new guys working for me."

IF YOU DON'T USE SIDEKICK YET, YOU GET THEM BOTH AND FOR A LIMITED TIME, A $15.00 CASH-BACK! Because SuperKey and SideKick are so compatible, we let them move in together. Into their own blister-pack. With the $15.00 cash-back coupon and the manuals. Which is what you get for $139.90 instead of the usual $154.90. You need to fill-in the cash-back coupon, along with your registration cards and proof of purchase, and mail it back. We'll rush you your $15.00 rebate right away. Rebate offer ends March 31, 1986. (PS: You can still buy SuperKey and SideKick separately. SuperKey **$69.95.** SideKick **$84.95.** Not copy-protected.)

THE CRITIC'S CHOICE

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SuperKey SIDEKICK

SuperKey and SideKick require DOS version 2.0 or later.
Software for your IBM®PC, XT, AT, 3270, PCjr and true compatibles.

Available at better dealers nationwide. Call (800) 556-2283 for the dealer nearest you. To order by Credit Card call (800) 255-8008, CA (800) 742-1133.

Yes, I want the Best!

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The SideKick-SuperKey Team $154.90 ______
$15 cash-back ONLY when purchased together. Both come not copy protected

SuperKey $69.95 ______

SideKick $54.95 (copy protected) ______

SideKick $84.95 (not copy-protected) ______

Subtotal ______

(CA res. add 6% tax) ______

Amount Enclosed ______

Payment VISA MC BankDraft Check

Credit Card Exp. Date ____/____

Card # ______

$15.00 Cash Back

SuperKey only—Outside USA and Canada: Due to US Government restrictions of export or technology, purchase of SuperKey (without DES) can only be made through authorized distributors.

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$15 cash-back rebate upon receipt of signed license agreement and cash-back coupon. Your $15 cash-back rebate includes tax when applicable. These prices include shipping to all U.S. cities. All foreign orders add $10 per product ordered.

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COD's and Purchase Orders WILL NOT be accepted by Borland. California residents add 6% sales tax. Outside USA add $10 and make payment by bank draft payable in US dollars drawn on a US bank

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Inquiry 44 for End-Users. Inquiry 45 for DEALERS ONLY.

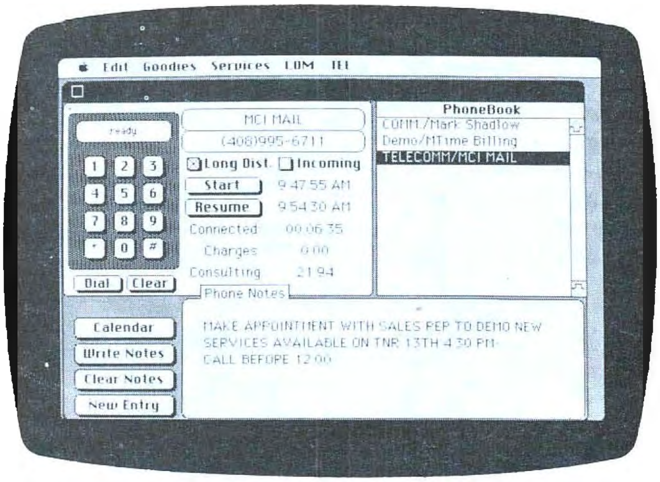
Banker Board Gives Color Computer 256K Bytes

The Banker is a 256K-byte memory expansion for the TRS-80 Color Computer. Available in assembled or kit forms, the Banker board is installed in the Color Computer's SAM socket. In addition to installing the Banker board, you must replace the 64K-byte chips with eight 41256 (256K by 1-bit) chips and a jumper attached to pin 1 of each of the 41256 chips.

The Banker is designed to be compatible with other software and hardware, but you can add a switch to make it emulate the 64K-byte system. Included with the Banker board is software (on disk or cassette) to use the extra memory for a RAM disk, fast disk copying, and print spooling. Patches are also provided to access the extended memory from Telewriter-64, BASIC, and OS-9.

A number of versions of the Banker are available. A bare board with software and documentation is $29.95; the same package with all necessary parts except memory is $54.95. An assembled and tested board is $69.95, or $99.95 with the 256K bytes of RAM. A new $24.95 SAM chip might also be necessary for some versions of the Color Computer; you might need an adapter to use the Banker with newer Korean-made Color Computers.

Contact J&R Electronics, POB 2572, Columbia, MD 21045, (301) 987-0578 or 788-6540.
Inquiry **605.**



An example of SideKick running on the Macintosh.

SideKick for the Macintosh

Borland International has enhanced SideKick, its desktop organizer, to run on the Macintosh computer. Dubbed the Macintosh Office Manager, the package contains the usual SideKick accessories and features concurrent capabilities.

You can run your preferred word processor, spreadsheet, or graphics program in the background and bring up SideKick's notepad to jot a reminder. At the same time, you can use the program's telecommunications utility; a phone dialer logs your calls and tracks the length of the call in order to calculate the charges.

As a desktop organizer, SideKick for the Mac has a calendar, notepad, print spooler, and calculator. For information management, the package offers a filing system that maintains data in index-card fashion; all files are integrated with other accessories at all times. Background communications features include a phone log and area-code lookup. An add-on called PhoneLink provides automatic telephone dialing; it plugs into the Mac's sound port.

The Macintosh version of SideKick runs on either the 128K- or 512K-byte machine. It works with Macmodem or Hayes-compatible modems. The package costs $84.95. PhoneLink is $45. Contact Borland International Inc., 4585 Scotts Valley Dr., Scotts Valley, CA 95066, (408) 438-8400.
Inquiry **606.**

Bubble-Memory Subsystem from Intel

Intel's BPK 70AZ-6C bubble-memory component kit with bias compensation provides an operating temperature range of −40 to +85° Celsius. The kit contains a 1-megabit bubble-memory component (the 7110AZ with an internally packaged Z-coil) and five ICs.

An important feature of the BPK 70AZ-6C kit is the Z-coil, which allows instantaneous erasure of the bubble memory's contents. Intel supplies you with complete instructions and applications support.

The BPK 70AZ-6C is a modular building block for designing bubble-memory systems. In a complete system, a 7220 BMC (bubble-memory controller) interfaces the BPK 70AZ-6C subsystem to the host processor. One 7220 BMC can interface up to four 1-megabit subsystems to create a ½-megabyte system.

The BPK 70AZ-6C sells for $955 in quantities of 100. Contact Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051, (408) 987-8080.
Inquiry **607.**

Multitasking Operating System Toolbox for IBM PC

Three operating-system products from Wendin let IBM PC users add custom operating-system features to MS-DOS or emulate the UNIX and VMS mainframe operating systems.

The Operating System Toolbox provides a number of tools to enhance or rewrite MS-/PC-DOS. The Toolbox kernel traps and executes MS-DOS calls directly. Four process privilege levels exist, with low-privilege processes requesting services from the kernel or Record Management System. Multitasking capabilities and paged memory-management features are also included. The C source code and user-interface examples in C, Pascal, and assembly language are provided.

Wendin also announced two operating-system shells for MS-DOS developed using the Operating System Toolbox (which is not required to run them). PC-UNIX emulates many of the

(continued)

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There are four integral drive positions for hard and floppy disks plus a tape backup. Mix and match to suit your needs. And no PC offers more expansion slots (eight in all).

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And no matter how big you get, you'll never outgrow NCR's support. We're big in 120 countries, with 1,200 service support offices.

So if you're a small businessman with big ambitions, take on the new NCR PC6. It's as anxious to grow as you are.

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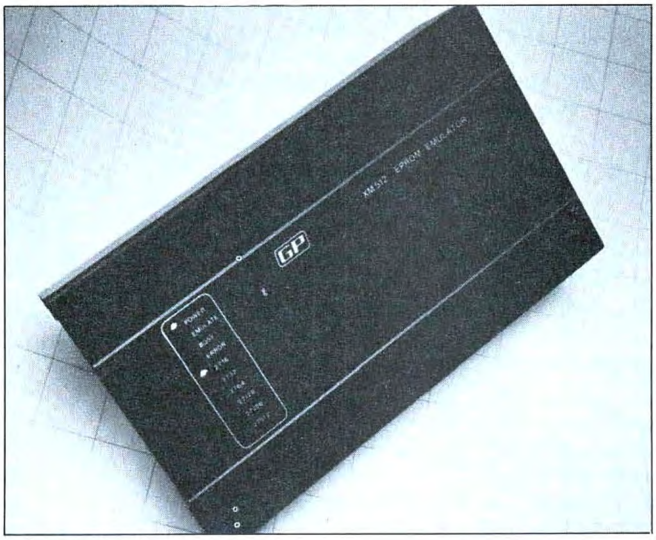
NCR

Inquiry 278

functions and utilities found in AT&T's UNIX operating system. PCUNIX uses about 20K bytes of RAM and its utilities take about 100K bytes on disk. PCVMS emulates Digital Equipment Corporation's VAX/VMS operating system.

The Operating System Toolbox is priced at $99. PCUNIX and PCVMS are $49 each. All three products include complete C source code. For more information, contact Wendin, Box 266, Cheney, WA 99004, (509) 235-8088.
Inquiry 608.



GP *Industrial Electronics'* XM512 EPROM *Emulator.*

Hewlett-Packard's LaserJet Plus

HP's LaserJet Plus is an enhanced version of the popular LaserJet laser printer. Enhancements include a new formatter board (that has more memory and new firmware) and a Centronics parallel interface option.

The improved formatting board gives the LaserJet Plus more flexibility in fonts. The printer can download fonts from 6 to 30 points, store up to 32 fonts, and employ up to 16 fonts per page. Cartridge fonts are still an option and the user can choose either portrait- or landscape-printing orientation.

The board contains 512K bytes of RAM that yields 395K bytes of user memory for improving the printer's graphics capability. The LaserJet could print a full page of 75-dpi graphics, a half-page at 150 dpi, and approximately a sixth-page at 300 dpi. The LaserJet Plus can print a full page of 150-dpi graphics and a half-page of 300-dpi graphics.

The formatter board also allows downloadable forms and letterheads; rules, patterns, and shading for forms creation; and storage of up to 32 forms in the printer's memory.

The LaserJet Plus is priced at $3995 and is 100 percent compatible with the LaserJet (both use HP's PCL printer command language). The formatter is available as an upgrade for LaserJet owners at a price of $1495 until December 31, 1985, and for $1995 after that. The parallel interface option is not available as an upgrade.

Contact Hewlett-Packard Co., 1820 Embarcadero Rd., Palo Alto, CA 94303.
Inquiry 609.

EPROM Emulator

GP Industrial Electronics has introduced the XM512 EPROM Emulator, which is capable of emulating all EPROMs in current use. It is intended to help microsystem designers and development engineers speed up the process of combining software and hardware. Typical address access time for writing data to or reading it from the XM512 is 200 nanoseconds.

This emulator connects to the target system via supplied 24-/28-pin cables. An LED provides status and error information. If you wish, you can emulate 16-bit systems by connecting two units.

Pricing for the XM512 EPROM Emulator is set at £795. Contact GP Industrial Electronics Ltd., Unit E, Huxley Close, Newnham Industrial Estate, Plymouth PL7 4JN, England, tel: (752) 342961; Telex: 42513.
Inquiry 610.

Fast 20-megabyte Backup Tape

Genoa Systems Corporation is offering the Galaxy Models 3120 (internal) and 3220 (external) 20-megabyte, half-height, streaming, digital, cassette-tape drives. The 3120 and 3220 are fully IBM-compatible, run under DOS 2.x and 3.x using the standard QIC-02 interface, and require an IBM PC, XT, AT, or compatible with 256K bytes of RAM, one floppy-disk drive (to install the backup software), and two expansion-card slots. The drives transfer data at 86.3K bytes per second (at a 90-inches-per-second tape speed) and can back up a full 20-megabyte disk in 4.3 minutes.

The 3120 and 3220 use the same software as the Galaxy Model 3160 (internal) and 3260 (external) 60-megabyte, half-height, streaming-cartridge drives. The Genoa software has a multiple-window interface, menus, a batch option, and on-line help. A time/percentage bar chart shows the time left to execute a backup function.

The software offers full restoration or file-by-file backup. File-by-file can be organized by directory or subdirectory; by time, date, and last-modified files; or by file appending and exclusion. Reports of backup activity and directories are automatically saved and can be printed.

A DOS toggle lets you run other applications or DOS commands without terminating any backup program. You can also employ the drives as a system resource: They are compatible with 3Com, PCnet, and Novell networks.

Suggested prices are $995 for the Model 3120 and $1145 for the Model 3220. Contact Genoa Systems Corp., 73 East Trimble Rd., San Jose, CA 95131, (408) 945-9720.
Inquiry 611.

continued on page 452

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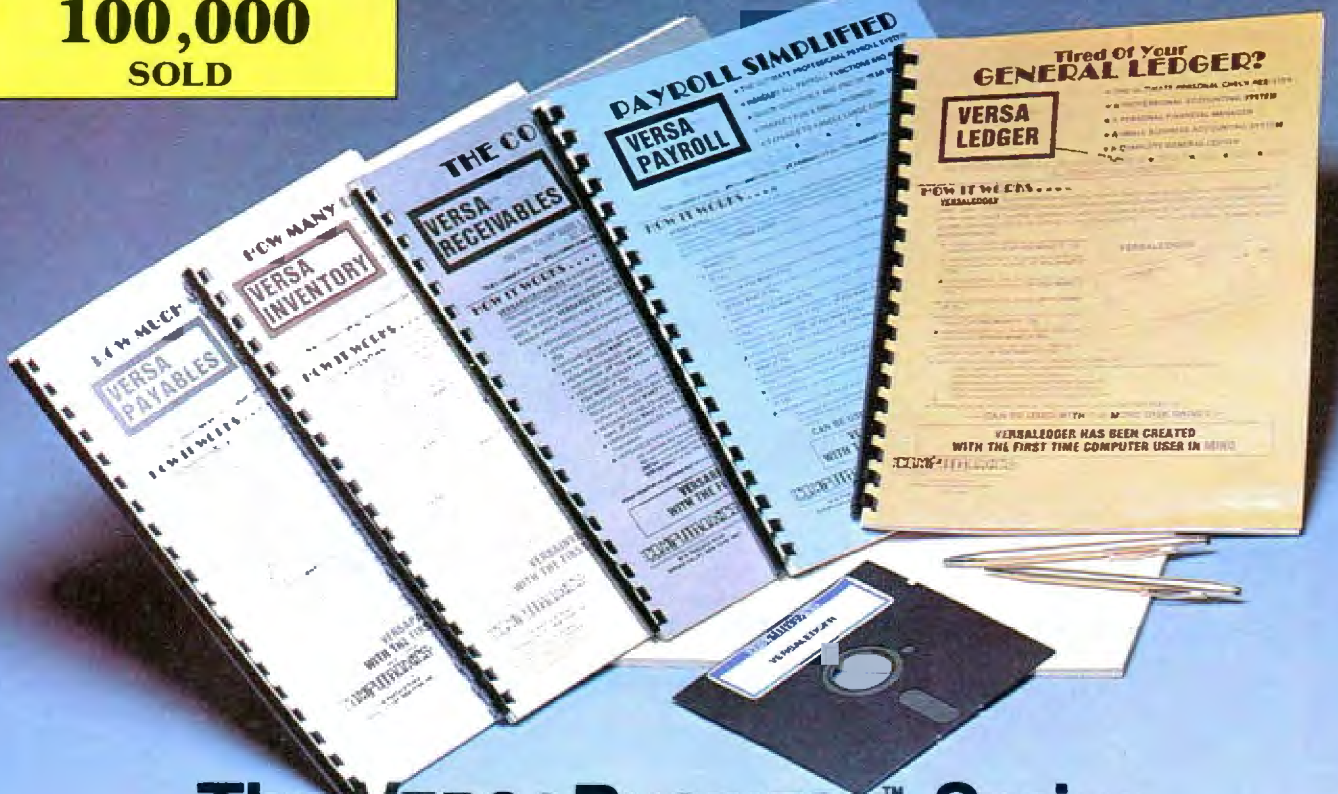

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Conducted by Steve Ciarcia

Business Hardware

Dear Steve,

I am a university student majoring in management information systems. Most of the concepts are software-oriented, but I would like to enhance my knowledge by learning about computer hardware, especially systems used in business. Could you recommend a few books?

ZAAHIR SALAAMAH
Saint Laurent, Quebec, Canada

A good reference book that lists and rates other books about microcomputers is Reader's Guide to Microcomputer Books *by Michael Nicita and Ronald Petrusha (Golden Lee, 1984). It includes sections on all the popular microcomputers, microprocessors, and operating systems.*

You should probably concentrate on books about MS-DOS, UNIX, and the 8086 family of microprocessors. I suggest the following books: From Chips to Systems: An Introduction to Microprocessors *by Rodnay Zaks (Sybex, 1981),* Modern Computer Concepts *by Joseph Giarratano (Howard W. Sams & Co., 1983),* Microprocessor Operating Systems, Vol. 2, *edited by John Zarrella (Microcomputer Applications, 1982), and* 8086/8088 16-Bit Microprocessor Primer *by Christopher Morgan and Mitchell Waite (BYTE Books, 1982).*—Steve

Good-bye Monitor

Dear Steve,

Is it possible for software to produce unwanted effects on hardware? I have an IBM PC on which I run Symphony and a few other programs. One day, I received an evaluation copy of an educational program that I decided to try. Three seconds after I booted the disk, my monochrome monitor gave the visual equivalent of the big bang. It was blown. My serviceman estimates the cost of fixing it will be about $115.

I did notice after the damage was done that the program was to be run only on the PCjr. It would appear to me almost impossible for the incompatibility of the two systems to have such a dramatic effect. Or is it?

I have a dual floppy-disk system and a Paradise modular graphics card driving the monochrome monitor. Is it an overly sensitive monitor, the graphics card, the software, some combination of these, or a coincidental event that caused my problem?

DON BERLINER
Lansdale, PA

Without knowing the actual code in the program or your precise configuration, it's hard to say what actually did happen. Nevertheless, as many others with similar experiences will testify, it is possible to "blow up" hardware with software. In particular, many people have had their monochrome monitors go up in smoke as yours did. "Safe" software should never make any assumptions about equipment. A public-domain program called SCRNSAVE caused similar problems in earlier versions.

The video-display controller chip in the PC is programmable for a variety of modes. For example, you can actually have an 80-character by 50-line display on a PC, though it is tough to read. Also, a program can send out instructions to reprogram the chip in such a way as to blow out a monitor that is expecting signals that are quite different. At this point I feel like saying, "Believe it . . . or not!"—Steve

Zenith and PC-DOS

Dear Steve,

I have a Zenith Z-150 with which I am pleased. I want to run a few application programs that were written for the IBM PC, but they cause problems on my machine. The trouble lies, I believe, with the differences in the DOS, but I don't know enough to tell for sure. I have Zenith's MS-DOS 1.25 and 2.11 and IBM's PC-DOS 2.0 and 2.1.

If I format a disk in any DOS that is 2.0 or higher, will a disk made under another DOS copy to my disk? An attempt to copy (under MS-DOS 2.11) a program written for PC-DOS 2.1 netted me extensive damage to the data on both disks. However, I have Word for the Zenith, and it seems to run fine under PC-DOS 2.0 and 2.1. When I asked Zenith about the problem, I got the stock company answer: "PC-DOS has not been tested, and the results are unpredictable."

Can you shed a little unbiased light on the possible pitfalls of using PC-DOS on the Z-150?

ROBERT HAWKINS
Greenville, MS

Even without the details of your one file-copying problem between MS-DOS 2.11 and PC-DOS 2.1, I would suspect a factor other than potential incompatibility between operating systems; it was probably a onetime occurrence. I have been using a Z-150 with a hard disk running under PC-DOS 2.1 for two months with absolutely no problems using both copy-protected software and software that isn't copy-protected. Files have been exchanged between IBM PCs, Micromint MPXs, the Z-150, and a Chameleon running PC-DOS 2.0, 2.1, and MS-DOS 2.11 with nary a problem. However, you could run into a problem trying to mix MS-DOS 1.25 and DOS 2.xx disks; avoid this combination if you can.

There may be a small number of programs (particularly games) that will not run properly on the Z-150, but I am not aware of any in particular. The Z-150 seems to be a very compatible PC clone, and PC-DOS 2.1 should run fine.

One word of caution. A problem may exist if you boot your system with one operating system and switch disks to the other operating system that uses a different version of COMMAND.COM. It is best to try to standardize on one version.—Steve

PC Problems

Dear Steve,

How can I upgrade my IBM PC to XT compatibility? I went through a year's worth of "Ask BYTE" and didn't find anything on the subject.

As hard-disk prices come down, I'd like to install one in my PC. Which one do you recommend? Do you recommend an internal or an external drive, and should I get a 130-watt power supply? Also, do you know which hard disks have tape-drive backup capability that I can add later?

With so many advertisements, I believe

(continued)

the consumer is lost in this sea of information.

GLENN DAIL
Annapolis, MD

I can appreciate your confusion about upgrading to a hard disk. Although BYTE has not published an article specifically on this topic, a few other publications have. [Editor's note: See "Four Hard Disks for Under $1000" by Richard Grehan in the Fall 1985 BYTE special issue Inside the IBM PCs.*]*

The September 18, 1984, issue of PC *magazine has several articles reviewing hard disks, tape backup units, and about installing your own hard disk.*

The November 1984 PC Tech Journal *reviews 10 hard disks for the PC and also addresses the problem of power supplies.*

The March 1985 PC Tech Journal *has an article that shows how to convert a PC into an XT.*

Unfortunately, I have not evaluated any of the hard disks, so I can't make any specific recommendations. My own preference is for an external unit with its own power supply, unless you upgrade your regular PC power supply to 130 watts.

Most tape units have their own interface cards, although a few will operate from the floppy-disk controller. Again, with no direct experience, I can't make any recommendations.—Steve

MAC UPGRADE

Dear Steve,

I am a recently graduated civil engineer. Although I don't know much about electronic design, I am an avid reader of your projects.

I bought a Macintosh in March because I needed it for writing my thesis, but I have since come to regret the hasty purchase. I'm very upset that Apple demanded $995 for the 512K-byte upgrade.

It is my opinion that quite a number of Mac owners would like to have the option of upgrading the RAM chips to the 256K-bit versions on their own. I would be grateful if you would show the necessary modifications for the RAM multiplexers and any other rewiring.

VINCENT CHEW
Bellmore, NY

"Fatten Your Mac" by Tom Lafleur and Susan Raab in the January 1985 issue of Dr. Dobb's Journal *gives step-by-step instructions on removing the 64K-bit chips and replacing them with new 256K-bit chips. Be sure to check the addendum on page 4 of the same issue, which discusses differences between early- and late-model Macs. An erratum in the March 1985 issue mentions an error in the text that refers to pin 7 of the memory-select IC being soldered, while the figure shows pin 8. Pin 8 is the correct one.*

Back issues of Dr. Dobb's Journal *can be obtained by writing to 2464 Embarcadero Way, Palo Alto, CA 94303. They are $3.50 each. The one you need is #99.*
—Steve

BUBBLES

Dear Steve,

The January and February 1984 issues of BYTE featured the two-part article "Bubbles on the S-100 Bus" by Louis Wheeler. It was an interesting project and I hoped to see more on the subject of bubble memory, particularly if someone had adapted it to something other than the S-100 bus (I have an Osborne).

I would like to build this project as a separate unit with its own power supply to interface with my Osborne through the RS-232C port. Would this be reasonable? One of the really critical parts of the project is the wiring. Has anyone come up with a PC board to simplify this problem?

JOHN T. COUGHLIN II
Westlake, OH

Building a bubble-memory board to interface with an RS-232C serial port is not out of the question but could wind up being quite expensive. The reason is that the bubble-memory devices themselves are relatively expensive and do not lend themselves to homebrew construction techniques. This means that you will have to purchase a prefabricated bubble-memory board, like the one described in the article. These boards take care of all the critical wiring and let you supply the interface circuitry. Again, these boards are usually relatively expensive.

There is no technical reason why you cannot build a bubble-memory device to interface to your serial port. In fact, Fujitsu America Inc. offers just such a device, an RS-232C interface that lets you use Fujitsu's bubble-memory plug-in cassettes. You can get more information about these devices from

Fujitsu America Inc.
Component Sales Division
910 Sherwood Drive-23
Lake Bluff, IL 60044
(312) 295-2610

(continued)

The design criteria for building your own RS-232C bubble-memory interface go beyond what I could describe here. But the project will, in general, involve an intelligent microcontroller to receive instructions from the RS-232C port, process the instructions to determine the direction of data transfer, and perform the actual transfer.—Steve

ASCII CODES

Dear Steve,

I am using a daisy-wheel typewriter as a printer for my Kaypro 10. It is the Brother Model CE 50, and it has bidirectional printing capabilities and a Centronics interface with a buffer.

I have a problem that I need some help on. I would like to use more ASCII codes with WordStar than were foreseen with the version 3.3 I am running.

First, my printer has special characters like the German umlaut, the English pound sign, the sign for Dutch guilders, and some special accent symbols. I can print these from a BASIC program using a CHR$( ) function (ASCII 14 to 22). I would like to be able to print them from WordStar.

Second, I would like to be able to type Arabic on my printer. Using WordStar, I could enter the Arabic in the phonetic transcription standardized by the United States Foreign Service Institute of the Department of State. Then I could run a BASIC program that would translate the data to Arabic characters to print on my printer (the Arabic daisy wheel fits in my printer).

You may remember that Arabic is written from right to left. This is no problem for my printer since I can change the print

(continued)

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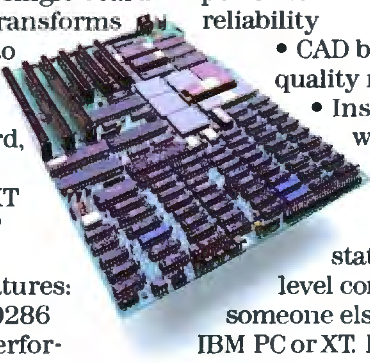

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Inquiry 326

direction with an optional switch.

I do hope that you can provide me with some useful information.

CHRIS LEISS
Hilversum, The Netherlands

You can type characters for the ASCII codes 14 to 22 in WordStar by using the keystrokes Control-O to Control-W. WordStar adds 128 to the ASCII codes for the last letter in many words, so your BASIC program will have to compensate. An easy way is to run each character through a filter to set the high bit to 0. A Microsoft BASIC statement to do this is

```
10 A$ = CHR$(ASC(A$) AND &H7F)
```

Reversing the direction on the printer motor is possible, but consider reversing the order of the characters in your translation program. This is pretty easy in BASIC, and you can shift the lines to the right margin by adding spaces to fill all lines either before or after the character order is reversed. A Microsoft BASIC program to reverse the character order is

```
9  REM Get a line of text
10 LINE INPUT B$
19 REM Find out how many characters
20 X = LEN(B$)
30 C$ = ""
40 FOR J = 1 TO X
49 REM Read last character
50 A$ = RIGHT$(B$,1)
59 REM Skip if CR
60 IF A$ = CHR$(13) GOTO 80
69 REM Add to end of new string
70 C$ = C$ + A$
79 REM Remove character from old string
80 B$ = LEFT$(B$,LEN(B$) - 1)
89 REM . . .and do it again
90 NEXT J
```

The line can then be right-justified by adding spaces to the front of the string.
—Steve ■

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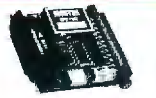

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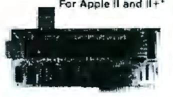

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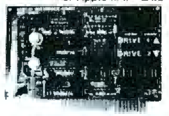

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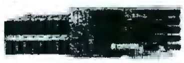

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JE883 (P/S Buffer). $79.95

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EPROM PROGRAMMERS

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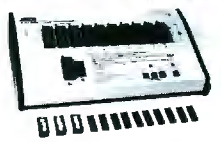

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JM G16A	2716 Intel, TMS2516 TI, NEC, etc	$19.95	JM G64C	MCM68764, MCM68766 Motorola	$19.95
JM G32A	2732A Intel, NEC, TI, etc.	$19.95	JM G128A	27128 Intel, TI, NEC, etc	$19.95
JM G32B	2732 Intel, NEC, National, etc	$19.95	JM G256A	27256 Intel, NEC, Hitachi, etc	$19.95
JM G32C	MCM2532 Motorola, TI, National, etc	$19.95	JM G512A	27512 Intel, AMD, etc	$19.95
JM G64A	2764 Intel, NEC, TI, etc	$19.95	JM G513A	27513 Intel	$19.95
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JM GE16A	2816A Exel, Intel, Rockwell, Xicor, etc	$19.95	JM GE64A	X2864A, X2864B, X28C64 Xicor	$19.95
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JM32A	TMS2532	25V	Motorola, TI, Hitachi, OKI	$14.95
JM32B	2732	25V	AMD, Fujitsu, NEC, Hitachi, Intel, Mitsubishi, National	$14.95
JM32C	2732A	21V	Fujitsu, Intel	$14.95
JM64A	MCM68764, MCM68L764, MCM68766	25V	Motorola	$14.95
JM64B	2764	21V	Intel, Fairchild, OKI	$14.95
JM64C	TMS2564	25V	TI	$14.95
JM64E	2764A	12.5V	Intel, AMD, etc	$14.95

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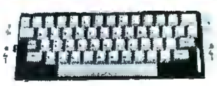

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NEWS COMPUTING JOURNAL, Department of Journalism, Central at Yale, University of New Mexico, Albuquerque, NM 87131. Quarterly journal on microcomputer use in journalism. Annual subscription: $30.

YALE MACINTOSH USERS' GROUP (YMUG), Philip Rubin, Box 220 Yale Station, New Haven, CT 06520. Monthly meetings, *The Desktop Journal* (monthly), public-domain software library. Membership: $20.

PORTLAND COMPUTER SOCIETY (PCS), POB 5494, Portland, OR 97208. Monthly educational meetings, SIGs, 24-hour BBS at (503) 775-4838, semimonthly newsletter. Annual dues: $15.

SOUTH BAY APPLE III USER'S GROUP, Gary Fortune, POB 432, Redondo Beach, CA 90277, (213) 316-7738. Monthly meetings, classes, newsletter. Annual fee: $25.

COMMODORE INVESTOR'S NEWSLETTER, Dr. Lynn Harner, 2011 Central, Dodge City, KS 67801, (316) 227-8952. Stock-market investment news for Commodore users. Free. Send SASE.

TI PROFESSIONAL COMPUTER (TI PC) USERS GROUP OF NEW MEXICO, Lawrence Langdon, (505) 298-9876. Monthly meetings in Albuquerque and newsletter.

ICS BBS, ICS, 9601 Aero Dr., San Diego, CA 92123, (800) 621-0852, ext. 303. BBS at (619) 279-0084. *The ICS Industrial IBM PC Sourcebook* (free to qualified users).

TOLEDO APPLE USERS (TAU), POB 566, Toledo, OH 43693-0566. Monthly meetings, member-aid hotline, BBS, newsletter.

MICROCLUB, 16 Stournara Str., Athens 10682, Greece; tel: 3640.676. Contact with other European clubs welcome. *Computer and Software* magazine published regularly.

OSBORNE KOMPUTER OWNERS KLUB (OKOK), Lionel Soracco, POB 40429, Pasadena, CA 91104, (818) 794-3243. Monthly meetings, hands-on sessions, SIGs, public-domain library, newsletter.

COMPUNEWS, Anthony Polifrone, Buyers Laboratory Inc., 20 Railroad Ave., Hackensack, NJ 07601, (201) 488-0404. Computer information service, buyer's guide, newsletter, hotline. Subscription: $139.

DBASE II USERS GROUP, Federation of Computer Users and User Groups (FOCUS), Hong Kong Polytechnic, Hung Hom, Kowloon, Hong Kong; tel: 3-7396239; Telex: 38964 Polyx Hx. Monthly meetings and newsletter. Newsletter exchanges and visitors welcome.

NATIONAL NINETY-NINE'ERS, Mark Leair, 4904 Edsal Dr., Cleveland, OH 44124-2305. For TI-99/4A users. Local users groups, newsletter, BBS, public-domain library. Send SASE.

THE REST OF US, (CHICAGO AREA MACINTOSH USER'S GROUP), Tom Brodersen, Suite 1100, 134 North LaSalle, Chicago, IL 60602, (312) 641-1266. Monthly meetings, newsletter, discounts, BBS, demonstrations, public-domain software library.

CLERGY KUG, Elmer Little Jr., 3868 Centorbi Court, Florissant, MO 63034. Newsletter for Kaypro users in the ministry.

SAN FRANCISCO PC USERS GROUP, Suite 33, 4444 Geary Blvd., San Francisco, CA 94118. For users of the IBM PC and compatibles. Monthly meetings, *Blue Notes*.

FRANKLIN USERS GROUP, Douglas Trueman, Apt. L, East Wind Rd., Tecumseh, MO 65760. Newsletter, public-domain library, technical assistance for users of the Franklin and Apple-compatibles. ■

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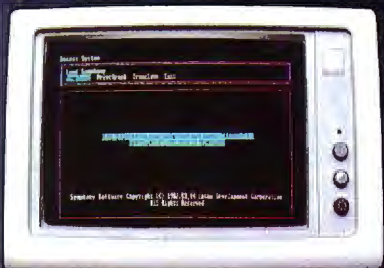

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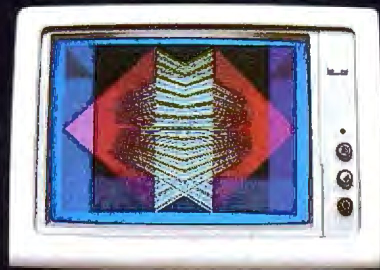

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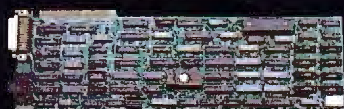
The Edge  The Plain Facts:

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MACINTOSH REVEALED, VOLUME ONE: UNLOCKING THE TOOLBOX
Stephen Chernicoff
Hayden Book Co.
Hasbrouck Heights, NJ: 1985
516 pages, $25.95

ADVANCED PROGRAMMER'S GUIDE FEATURING dBASE III AND dBASE II
Luis Castro, Jay Hanson, and Tom Rettig
Ashton-Tate
Culver City, CA: 1985
680 pages, $28.95

16-BIT MODERN MICROCOMPUTERS: THE INTEL I8086 FAMILY
George Gorsline
Prentice-Hall
Englewood Cliffs, NJ: 1985
528 pages, $32.95

STATISTICAL PROGRAMS IN BASIC
Ronald D. Schwartz and David T. Basso
Reston Publishing
Reston, VA: 1985
224 pages, $16.95

MACINTOSH REVEALED, VOLUME ONE: UNLOCKING THE TOOLBOX

Reviewed by Bonnie L. Walker

Volume One of Stephen Chernicoff's two-volume reference *Macintosh Revealed* offers more than an introduction to Macintosh menus and the mouse, and it is not simply a beginner's guide to Microsoft BASIC. The book is for serious programmers.

Macintosh Revealed resembles a polished-up edition of Apple's own *Inside Macintosh* documentation. This isn't surprising, since the author served as editor in chief of Apple Computer's publications department.

Importantly, *Macintosh Revealed*, like *Inside Macintosh*, assumes a knowledge of Pascal or 68000 assembly language. Although the book will be most useful to Pascal and assembly-language programmers, the Toolbox, the term for Mac's 64K bytes of ROM (read-only memory) routines, doesn't specify which language to use as long as you follow the proper rules and conventions. Thus, BASIC or C programmers can find useful information in Chernicoff's book.

As Chernicoff explains, when Apple first began developing Mac software, it used the Lisa (now known as the Macintosh XL); both the Lisa and the XL have since been discontinued. The Lisa programming environment, with its Pascal compiler and 68000 assembler, became the de facto standard for programming the Macintosh. Apple has since released a software-development system that includes the Pascal compiler and the 68000 assembler for Macintosh developers. It is called the Macintosh 68000 Development System. Chernicoff's book, however, was completed prior to the system's release and the discontinuation of the Lisa and the Mac XL.

Volume One presents the foundations of the Toolbox. Topics include the basic conventions for calling the Toolbox from an application program, memory management, fundamental concepts behind the QuickDraw graphics routines, how to use QuickDraw, Macintosh resources, how to start programs and load code into memory for execution, and how character text is represented inside the com-

(continued)

puter and displayed on the screen.

The second volume, *Programming with the Toolbox*, is said to cover the parts of the Macintosh user interface such as events, overlapping windows, pull-down menus, cut-and-paste text editing, controls, alert and dialog boxes, and disk input/output (I/O). [*Editor's note: A review of the second volume is forthcoming.*]

STEP BY STEP

In Volume One, each chapter (except the first) consists of an overview of one feature of the Toolbox and how to use it, followed by a reference section. Although this book is not for beginners, the author makes a remarkable effort to thoroughly explain the extremely complex nature of the innards of the Toolbox, the ROM code that ensures that "all Macintosh software shares the same easy, intuitive user interface."

Chernicoff explains the trap mechanism, the stack, the Pascal interface, stack-based and register-based routines, and other topics. He gives programming examples in Pascal form with additional information on how to use them in assembly language. He compares the memory organization of the 128K-byte and the 512K-byte Mac as well as the 512K-byte and the 1-megabyte Macintosh XL. Since memory addresses in the book may differ from those in future models of the Macintosh, programmers are cautioned to address locations by name. Throughout the text, Chernicoff provides numerous charts and figures that clarify the information.

Explanations follow on the QuickDraw graphics routines, which produce everything you see on a Macintosh screen, including text, pictures, windows, and menus. QuickDraw is also used for printing on a dot-matrix printer or preparing animation frames off screen and transferring them to the screen all at once. The book also covers the underlying principles and concepts of QuickDraw and then explains how to use it.

Another feature of the Toolbox is resources, such as menus, icons, character fonts, and dialog and alert boxes. "Summoning Your Resources" presents a thorough tutorial on this subject along with the detailed reference section. Chernicoff describes a Mac program as simply "a bundle of resources." Resources let you separate the text of menus and dialogs from the rest of the program, which makes it easy to change or edit that text. They also allow descriptive information about a program's behavior to be separated into bite-size "chunks" that do not all need to be in memory at once.

Chernicoff discusses the way in which code is loaded into memory for execution. He describes this as "curriculum enrichment," since you don't need to know it in order to write short and straightforward application programs. You *will* need this information, however, if you plan to produce stand-alone programs that can be started directly from the Finder or to define your own icons for the Finder desktop. Application code is stored in code

(continued)

BOOK REVIEWS

segments that are meaningful only for programs assembled or compiled directly into executable machine language. If you write a program in an interpreter system, the program has no machine code as such and therefore has no code segments.

A chapter entitled "Upstanding Characters" explains how text is represented internally and how to display it and control its appearance on the screen. The Macintosh character set is based on the 7-bit ASCII (American Standard Code for Information Interchange) code. There are a few control characters that can't be typed from the keyboard with special graphical representations on the Mac screen—the cloverleaf command symbol, the check mark for marking menu items, and the Apple symbol used for the menu title of desk accessories. The character codes for these screen-only characters are defined as Toolbox constants. For instance, you can refer to the Apple character as CHR(AppleMark).

HELPFUL APPENDIXES

Volume One concludes with several useful appendixes. The "Toolbox Summary" lists information by chapter. Appendix B, "Resource Formats," details each resource type. Appendix C is a summary of Macintosh memory layouts. Appendix D, "Key Codes and Character Codes," is a quick guide to the hexadecimal code for each character. Appendix E is a complete list of operating-system error codes, including those not covered in the main text. Also included is a list of "Dire Straits" errors that are reported directly to the user. These errors are so serious that recovery is impossible and the alert box (the one with the bomb icon) forces the user to restart the program. Appendix F is a summary of trap macros and trap words presented alphabetically by trap macro and then sorted again numerically by trap word. Appendix G summarizes assembly-language (global) variables whose addresses may be subject to change and should be referred to by name rather than by address. Further, *Macintosh Revealed* contains a useful and very detailed glossary as well as an unusually detailed index.

LEARNING TO LOVE PASCAL

As a "serious" Macintosh programmer in the midst of developing what will eventually be a stand-alone application program, I am looking forward to the second volume of this book. As a seasoned Apple II programmer accustomed to working with BASIC, I am beginning to resign myself to the fact that Mac development dictates either learning to love Pascal or switching to assembly language. Even though there are a growing number of high-level languages that are available for programming directly on the Macintosh (such as Microsoft BASIC, Apple's MacPascal, as well as Macintosh versions of FORTRAN, COBOL, C, LISP, Logo, and FORTH), the applications programmer seems to be better off working in the native language of the Macintosh just because the degree of support from

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Apple Computer will probably be greater.

Chernicoff's book is well written, nicely designed, and well organized. For the type of help it provides, it is the best book I've seen.

Bonnie L. Walker (4101 Woodhaven Lane, Bowie, MD 20715) *is a systems analyst/programmer. Currently she is using a* 512K Mac *to develop a nutrition self-help assessment and data-analysis system on a grant from the* National Institutes of Health.

ADVANCED PROGRAMMER'S GUIDE FEATURING dBASE III AND dBASE II

Reviewed by Paul W. Lowans

The combined nine years of dBASE programming and technical-support experience of authors Luis Castro, Jay Hanson, and Tom Rettig is evident in the information-packed *Advanced Programmer's Guide Featuring dBASE III and dBASE II*. Castro began with Ashton-Tate in 1982 and is currently project supervisor of the Software Support Center. Hanson is director of project support. Rettig is a project supervisor at the Software Support Center.

The authors present all versions of dBASE II and III. The purpose of this book is not proper syntax and explanations of commands; rather, it emphasizes programming design and technique. Commands and algorithms are grouped to provide the reader with an understanding of dBASE's programming capabilities.

An optional disk ($25) containing programs and algorithms is available but does not contain any additional information. It serves as a convenience to programmers who do not want to key in the routines.

The authors discuss a variety of topics centered around setting up a complete database system. They explain the importance of security and how to provide limited access to users by setting up passwords. They stress the importance of proper documentation, both within the program and hard copy, and they make suggestions as to the best approach. Also, they emphasize preparation before writing the first code so that coding is smoother and easier. The book explains a standard for program structure by indenting lines and distinguishing memory variables from fields. This allows prompt understanding of the program by someone other than the programmer.

Discussions of techniques in data handling, covering all types in both database and memory-variable forms, are included. *Advanced Programmer's Guide* contains suggestions on interfacing a program with a user by setting up friendly and appealing screens. Chapters are devoted to database handling, printing and form generators, and interfacing dBASE with assembly language. The coverage of debugging and optimizing techniques is very good.

Castro, Hanson, and Rettig explain software differences and problems and give special attention to programs and algorithms that work around the problems. In most cases,

(continued)

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they point out which version is being used in the examples. Most of the appendix is filled with subroutines and programs of all kinds, ranging from dBASE to assembly language (in CP/M and MS-DOS).

NOT JUST FOR DBASE

The authors cover the full array of programming subjects, including operating systems, languages, and programming concepts with emphasis on structured programming. Because the principles covered can be applied to all programming languages, not just dBASE, this book is of significant value as a programming guide for multilanguage programmers.

In the back of the book is a section titled "Curriculum for Educators." It provides guidelines for the book's use as a textbook for programmers.

Advanced Programmer's Guide is a top-notch dBASE text. It is written in easy-to-understand language and provides complete coverage of dBASE programming. It is a guide to be used with the dBASE manual and would be a valuable source for a serious beginner or an advanced programmer.

Paul W. Lowans (POB 357, Spencerport, NY 14559) is an electronics engineering technician at Xerox Corporation in Rochester, New York.

16-BIT MODERN MICROCOMPUTERS:
THE INTEL I8086 FAMILY
Reviewed by Alan Finger

The Intel 8086 has become the most widely written-about family of microprocessors. George Gorsline's *16-Bit Modern Microcomputers: The Intel I8086 Family* is one of the latest entries. Unlike the majority of such books that are targeted at the advanced user of the IBM Personal Computer, this text for software-oriented students is intended to provide a better understanding of the relationship between software and the underlying hardware environment. The author, a professor of computer science at Virginia Polytechnic Institute and State University at Blacksburg, presents an integrated picture of 16-bit microprocessor hardware and software.

BROAD TERRITORY

The book is divided into 13 chapters jumping—perhaps more than necessary—between hardware- and software-related topics. Gorsline starts with an interesting discussion of computer history and the inverse relationship between hardware and software costs over the years. This moves into a description of classic microcomputer architecture and design with comparisons of functions of some of the more common designs. A discussion of subroutine-calling methods highlights some of the low-level diversity that is so often hidden from the program-

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Jerry Pournelle discusses Multiple Choice in his *Byte* column: "I've got it here at Chaos Manor (I'm running it now on the Z-160) and it works fine. With Multiple Choice, you can have WordStar, DOS and Lotus 1-2-3 running all at the same time (with SideKick in the background already yet). Who needs Symphony? Recommended."

Pournelle later says: "Most of us might like to work on one thing at a time, but in the real world we tend to be interrupt-driven. Sit down to write, and the phone rings: Someone wants someone else's telephone number. Start to work on a spreadsheet, and you're sure to remember a phone call you ought to make. . .

"... It isn't so much that we want to be able to run more than one program at a time, but that we want to go back and forth among tasks without long waits and distractions . . ."

IN ONLY 10K OF MEMORY, MULTIPLE CHOICE LETS YOU ADD FUNCTIONS TO SIDEKICK, OR CREATE YOUR OWN SIDECLONE.

Pournelle concludes that SideKick was a good start, but: ". . . while SideKick's command structure is logical, it isn't necessarily related to the programs you want to use. I'd rather use SideKick, 123 or Supercalc, Xywrite, dbase II and MITE than any of the integrated programs I've tried."

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Thus, a guy named Loveman, out to do an encore, formed Awesome Technology (no brag, just fact). Awesome's first product: Multiple Choice, in its own way, the same kind of value represented by Springsteen tickets.

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mer of high-level languages. Likewise, the explanation of memory-addressing modes clearly illustrates the underlying relationship between software and hardware behavior.

THE 8086

The book then zeroes in on a description of the 8086's internal architecture, applying the concepts developed in a preceding chapter. This actually is the shortest portion of the book; Gorsline conveys a very concise view of the 8086.

As we begin to delve into the 8086 instruction set, the author's computer science orientation begins to show. He presents the various comparison, jump, and call instructions first, with the emphasis on implementation of proper flow of control constructs. Even their symbolic representations are included. Although the intent is laudable, I found a few missing elements in the discussion of long conditional jumps (greater than +/− 128 bytes) and the use of register and indirect jumps and calls to implement multiway, or case, transfers. A separate chapter covers various data-movement and manipulation instructions.

Gorsline covers most hardware-related topics in a single long chapter. Here we are treated to an introduction to 8086 system design detailing the bus timing and the various "glue" components required to turn an 8086 processor into a working computer. If the reader is not well versed in computer design, the timing diagrams and schematics may prove intimidating. Fortunately, a thorough understanding is not critical to the remaining material, which is devoted to the problems of moving data in and out of a computer. Intel's 8251 Programmable Communications Controller is described thoroughly, as are the principles of writing device-driver software.

Since one of the first steps in "bringing up" a microcomputer system is to establish terminal communications with it, the discussion is very appropriate. Gorsline then examines the 8086 interrupt-and-trap mechanism as a necessary component of a practical system, and for those readers not familiar with the technologies of the various peripherals used in microcomputer systems, he provides a general dissertation on various types of devices such as serial terminals, rotating storage (disks), and bubble memories.

One of the more difficult yet powerful components in the 8086 family is the 8087 Numeric Data Processor. It receives excellent treatment at the hands of Gorsline. Starting with the need for utilizing floating-point arithmetic, he provides one of the more readable explanations of the 8087 architecture and instruction set that I have seen. Some of the more esoteric but critical details, such as rounding and infinity interpretation, are also presented clearly.

It is not until we are fairly well along that the book actually deals with the 8086 assembly language itself. What the author presents serves as a good, albeit incomplete, reference to the subject. Although there are several 8086

(continued)

assembler dialects in use today, Gorsline chose to use Intel's version; while not the most widely used, it represents the language "standard" upon which Microsoft's MASM assembler is based.

At this point, I was beginning to get the impression that Gorsline wrote much of the material more than a few months before publication. Reading on, this suspicion was confirmed as the author takes us back to hardware again with a complete examination of the Intel's 8089 I/O coprocessor. The 8089 is a powerful but expensive and difficult-to-use device that combines a microprocessor and a DMA (direct memory access) controller into a single integrated circuit. It never became widely used, and anything more than a passing reference to it seems superfluous. An accompanying section on DMA technique is vital, however, and contains a significant error: Although the author says otherwise, Intel's 8257 DMA controller does *not* directly support 16-bit data transfers.

Rather abruptly, Gorsline returns to the world of software with three chapters devoted to the fundamental elements of system software design: operating systems, assemblers, and compilers. He includes a brief history of operating systems and their basic functions, with a look at three 8086-based operating systems in use today: CP/M-86, iRMX86, and UNIX. Of these three, only the last is a major player in today's 16-bit market.

Gorsline introduces assembler and linker design concepts with a series of flow diagrams. A section on the use of macros and conditional assembly for the purpose of creating structured programs is probably one of the most valuable discussions for assembly-language programmers, regardless of the processor they may be working with.

The text then moves from assemblers to high-level languages with a brief but illuminating look at language theory. As earlier, the material seems somewhat dated with its concentration on older languages such as FORTRAN and COBOL. In one of the few references to the C language, Gorsline erroneously states that it does not support dynamic strings.

So as not to overlook the more advanced processors in the 8086 family, the author takes us back again to practical matters with a somewhat sketchy description of Intel's 80186 and a more detailed description of the 80286 processor architectures and enhancements.

The final chapter, while not really coherent with earlier sections, is certainly one of the most interesting. It is devoted to communications and networking, and it is here that Gorsline truly displays his knowledge. From network topologies and the ISO Model to local-area networks, the author manages to pack a comprehensive yet readable survey into 35 pages.

Speaking from Experience?

I found *16-Bit Modern Microcomputers* to be a good book, but not on the strength of its 8086 material. It is true that a writer will be best writing from his experience. While

(continued)

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	Execution Time	Code Size	Compile/ Link Time
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Manx Aztec C86 3.3	34 secs	5,760	93 secs
Microsoft C 3.0	34 secs	7,146	119 secs
Optimized C86 2.20J	53 secs	11,009	172 secs
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Library Source Code -c	Mixed memory models -c
MAKE, DIFF, and GREP -c	Source Debugger -c
One year of updates -c	CP/M-86 Library -c

Manx offers two commercial development systems, Aztec C86-c and Aztec C86-d. Items marked -c are special features of the Aztec C86-c system.

Aztec C86-c Commercial System	**$499**
Aztec C86-d Developer's System	**$299**
Aztec C86-p Personal System	**$199**
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All systems are upgradable by paying the difference in price plus $10.

Third Party Software: There are a number of high quality support packages for Manx Aztec C86 for screen management, graphics, database management, and software development.

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MACINTOSH, AMIGA, XENIX, CP/M-68K, 68k ROM

Manx Aztec C68k

"Library handling is very flexible ... documentation is excellent ... the shell a pleasure to work in ... blows away the competition for pure compile speed ... an excellent effort."

Computer Language review, April 1985

Aztec C68k is the most widely used commercial C compiler for the Macintosh. Its quality, performance, and completeness place Manx Aztec C68k in a position beyond comparison. It is available in several upgradable versions.

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Source Editor	C-Stuff Library
MacRam Disk -c	UniTools (vi,make,diff,grep) -c
Library Source -c	One Year of Updates -c

Items marked -c are available only in the Manx Aztec C86-c system. Other features are in both the Aztec C86-d and Aztec C86-c systems.

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AMIGA, CP/M-68k, 68k UNIX	**call**

Apple II, Commodore, 65xx, 65C02 ROM

Manx Aztec C65

"The AZTEC C system is one of the finest software packages I have seen"

NIBBLE review, July 1984

A vast amount of business, consumer, and educational software is implemented in Manx Aztec C65. The quality and comprehensiveness of this system is competitive with 16 bit C systems. The system includes a full optimized C compiler, 6502 assembler, linkage editor, UNIX library, screen and graphics libraries, shell, and much more. The Apple II version runs under DOS 3.3, and ProDOS, Cross versions are available.

The Aztec C65-c/128 Commodore system runs under the C128 CP/M environment and generates programs for the C64, C128, and CP/M environments. Call for prices and availability of Apprentice, Personal and Developer versions for the Commodore 64 and 128 machines.

Aztec C65-c ProDOS & DOS 3.3	**$399**
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Aztec C65-p Apple Personal system	**$99**
Aztec C65-a for learning C	**$49**
Aztec C65-c/128 C64, C128, CP/M	**$399**

Distribution of Manx Aztec C

In the USA, Manx Software Systems is the sole and exclusive distributor of Aztec C. Any telephone or mail order sales other than through Manx are unauthorized.

Manx Cross Development Systems

Cross developed programs are edited, compiled, assembled, and linked on one machine (the HOST) and transferred to another machine (the TARGET) for execution. This method is useful where the target machine is slower or more limited than the HOST. Manx cross compilers are used heavily to develop software for business, consumer, scientific, industrial, research, and educational applications.

HOSTS: VAX UNIX ($3000), PDP-11 UNIX ($2000), MS-DOS ($750), CP/M ($750), MACINTOSH ($750), CP/M-68k ($750), XENIX ($750).

TARGETS: MS-DOS, CP/M-86, Macintosh, CP/M-68k, CP/M-80, TRS-80 3 & 4, Apple II, Commodore C64, 8086/80x86 ROM, 68xxx ROM, 8080/8085/Z80 ROM, 65xx ROM.

The first TARGET is included in the price of the HOST system. Additional TARGETS are $300 to $500 (non VAX) or $1000 (VAX).

Call Manx for information on cross development to the 68000, 65816, Amiga, C128, CP/M-68K, VRTX, and others.

CP/M, Radio Shack, 8080/8085/Z80 ROM

Manx Aztec CII

"I've had a lot of experience with different C compilers, but the Aztec C80 Compiler and Professional Development System is the best I've seen."

80-Micro, December, 1984, John B. Harrell III

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BOOK REVIEWS

Statistical software seems to hold a fascination that is out of proportion to the number of people who need to use it.

Gorsline writes very well about general computer science subjects, he seems much less comfortable with the 8086-specific topics. I came away with the distinct feeling that his knowledge of the device is limited.

I found two errors that, although minor, reappeared throughout the book. Gorsline consistently refers to members of the Intel processor family with the prefix "I" as in I8086. This designation is reserved for Intel's industrial temperature range parts and is distinct from the marketing department's affectation of "iAPX286," which is sometimes seen. The second error is in referring to Texas Instruments' 16-bit microprocessor, the TMS9900, as the TI-99/4; the ill-fated home computer that happened to contain one.

The author made a very serious omission from a book intended as a text. Student exercises are nowhere to be seen. This will leave either the instructor with a major task or the students with no way of reinforcing the material presented.

All in all, *16-Bit Modern Microcomputers* is a very good intermediate textbook for computer science students. Would-be hackers will have to look elsewhere.

Alan Finger is president of Cytek Inc. (805 Turnpike St., Unit 202, North Andover, MA 01845), *a consulting company specializing in personal computer technology.*

STATISTICAL PROGRAMS IN BASIC
Reviewed by David W. Hopper

Statistics and statistical software seem to hold a fascination for computer users that is out of proportion to the number of people who actually need to use these tools on a regular basis. The fascination seems to be greatest when the source code for the statistical operations is available, particularly when it is in BASIC.

The stated purpose of *Statistical Programs in BASIC* is "to provide an innovative approach to the traditional lecture method of statistics instruction." Ronald D. Schwartz and David T. Basso present short and easily understood programs to take the place of "canned statistical programs." These short programs allow students to follow the programming logic, to understand the computational formulas used, and to see how problems are set up for computer solution.

The programs are highly commented. For example, the

(continued)

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first one is 70 statements long, 10 of which are executable. This ratio seems to hold throughout the book. In my opinion, this is excessive commenting, particularly for such simple code. The authors use a very plain BASIC that should execute with just about any BASIC compiler or interpreter. The problem with this approach is that the code is restricted to the very simple forms of the available BASIC dialects. Thus, we are left with such things as two-character variable names, INPUT statements without explanatory prompts, and very simple PRINT statements. These factors reduce the readability of the code and hamper the user interaction and quality of the output, but they do not affect the mathematical calculations carried out by the code.

The book is organized into nine major chapters concerned with progressively more difficult topics. The beginning chapters are very simple, as befits a book designed to complement a first course in statistics.

The first sections deal with basic concepts such as summation notation and simple averaging routines. The text includes routines to sum a group of numbers, to sum a group of numbers using subscripted variables, and to sum a group of squared numbers.

A section entitled "The Analysis of Data" deals with the calculation of various means, standard deviations, and variances. The calculation of the arithmetic mean is straightforward. However, to calculate the median of a data set, the data set must be sorted to start with. If the data is already sorted, then determining the median is a trivial exercise. The standard deviation and variance are calculated using a two-pass procedure, thereby reducing potential errors associated with arithmetic round-off. The geometric mean calculation uses the obvious product of a data-point method, which will seriously limit the range and quantity of data that can be processed.

The sections covering the calculation of factorials, permutations, combinations, and five probability distributions provide straightforward algorithms for these calculations. The use of simple algorithms makes the calculations easier to understand but limits their usefulness because of overflow problems.

Simple routines are interspersed in the sections dealing with estimation theory and hypothesis testing. In the programs presented, the reader is prompted for all the required information (sample mean, standard deviation, number of data points, confidence level, and corresponding values of the standard normal variables); the program carries out the relatively trivial math. The programs for small sample sizes (less than 30 data points) prompt for the data one point at a time and calculate the mean and standard deviation on the fly. In the interest of simplicity in these calculations, the authors fall into the trap of using the sum-of-squares procedure for calculating the standard deviation rather than the more accurate updating method. This has been repeatedly shown to be a source of numerical precision errors. (See Peter A. Lachenbruch's

(continued)

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MAIL TO: The Source, PO Box 1305, McLean, VA 22102 article "Statistical Programs for Microcomputers" in the November 1983 BYTE, page 560.) The other problem with this section is that the reader is required to input the values of the Z score or T or F statistic. This would be acceptable if tables of these statistics were included in an appendix, but they are not. It would be much better if a simple subroutine to calculate these numbers were included. Later sections deal with the acceptance or rejection of the assumption of independence for (R×C) and (2×2) contingency tables. As before, the reader is required to input the test statistics.

Regression and Correlation

Regression and correlation seem to hold a great deal of fascination, as evidenced by the prevalence of these functions on scientific and business calculators. Schwartz and Basso provide simple linear and exponential regression programs that use the sum-of-squares expansions to calculate the parameters of the equations. They also include elementary routines to calculate Pearson's product moment correlation coefficient and Spearman's rank correlation coefficient. The Pearson calculation uses the sum-of-squares expansion; the Spearman calculation assumes that the paired data sets are in ranked order. There's also a short program to evaluate the significance of the calculated correlation coefficients.

The book contains a series of short programs to carry out analyses of variance programs. As with all the programs in this book, they are heavily commented, and the program structures and calculation procedures used are straightforward and easy to follow. A series of short routines to aid in the evaluation of nonparametric statistics completes the book. The Runs test, the Mann-Whitney U test, the Kruskal-Wallis test, and the Friedman test are featured.

In general, *Statistical Programs in BASIC* deals with very elementary statistical procedures in a very elementary manner. The authors use a version of BASIC that should be very easy to transport to any computer system. However, the procedures are so simple that a reader with a good statistics text and a decent calculator would not need a computer.

The major flaws in the programs are the lack of subroutines to calculate Z, F, or T statistics and the lack of even a simple sorting subroutine. Schwartz and Basso make no mention of the problems of numerical accuracy and precision and, in many cases, do not use robust routines even when simple versions of such exist. Overall, *Statistical Programs in BASIC* is a good introductory text, but not one on which to base any sort of analysis dealing with difficult or large data sets. ■

David W. Hopper (109-896 Eglinton Ave. E., Toronto, Ontario M4G 2L2, Canada) is associate editor of the newsletter of the Personal Computer Club of Toronto and a member of the board of referees for Dr. Dobb's Journal. *He has published work on atmospheric turbulence and diffusion.*

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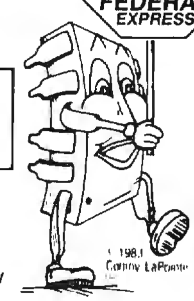

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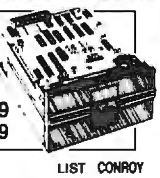

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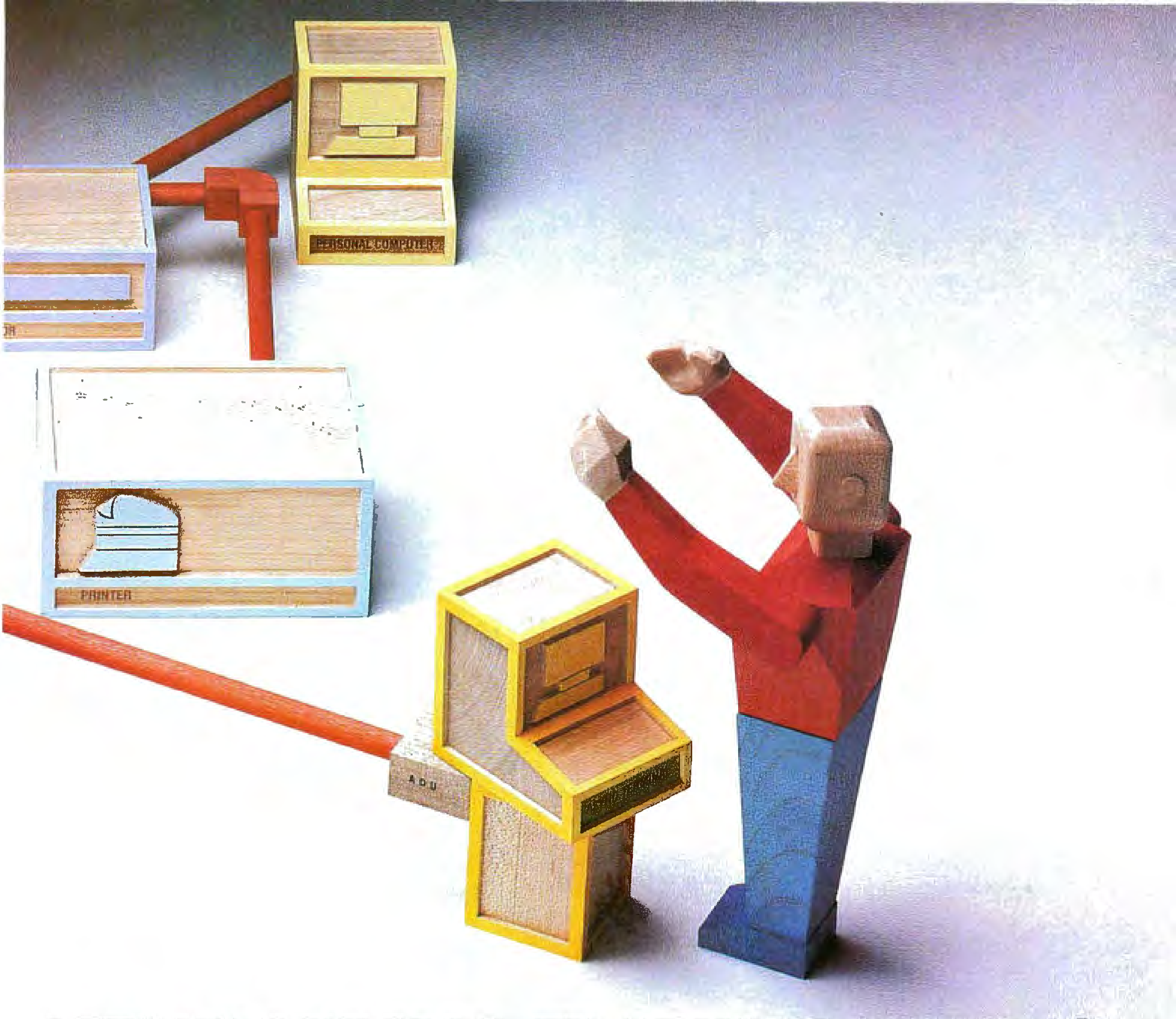

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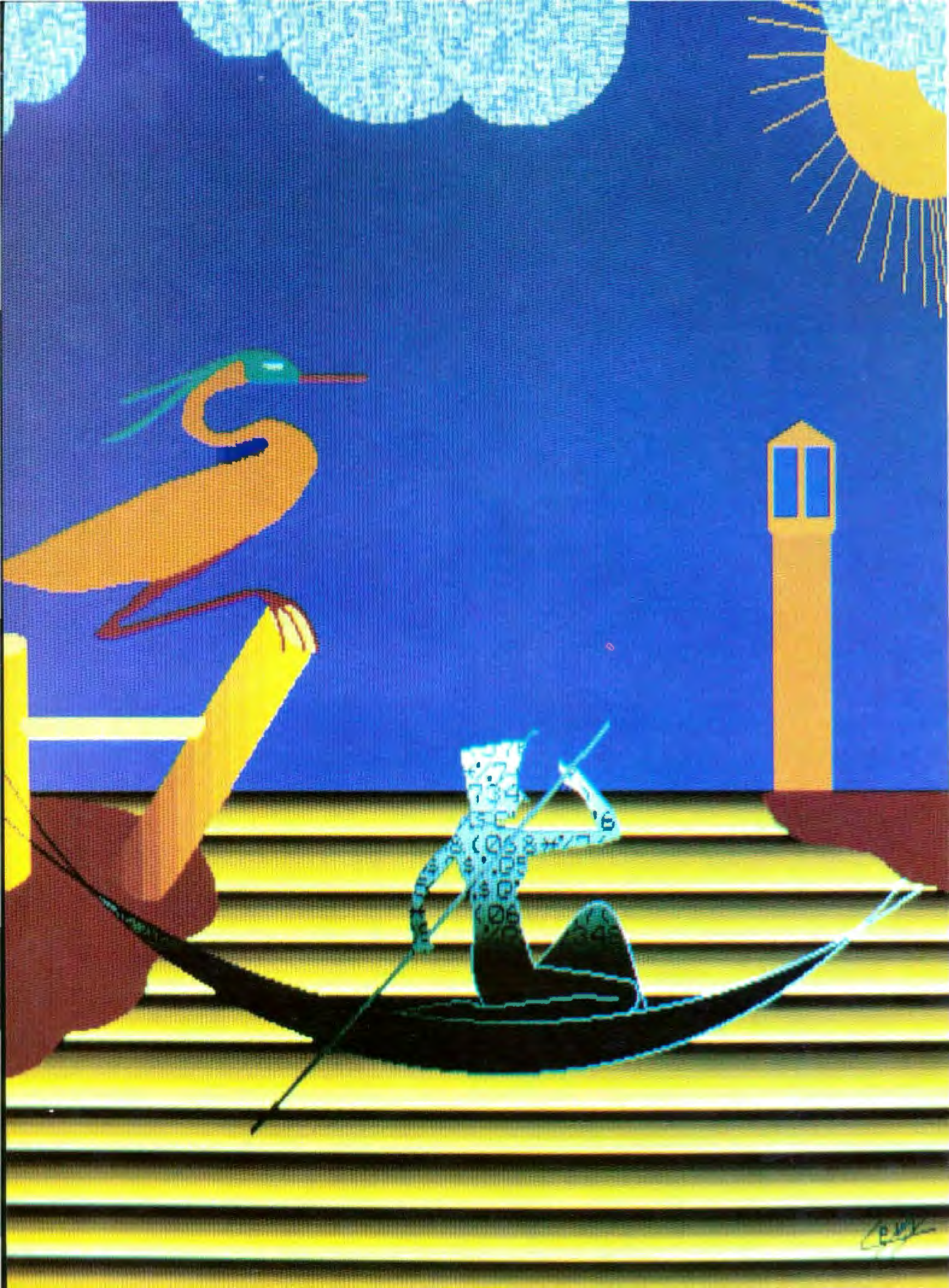

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THIS MONTH'S CIRCUIT CELLAR is slightly different. Steve does not show how to build the world's smallest 1200-bps modem. This powerful one-chip device, the MOSART, is already available from Xecom. Instead, Steve uses the MOSART in three applications he has developed—as a dumb terminal, an answering machine, and an input system with voice response.

In the first of November's two Programming Projects, Jonathan Amsterdam describes the assembler he wrote for his VM2 virtual machine (see "Building a Computer in Software," October BYTE, page 112). This assembler will let you write programs using instruction mnemonics as well as symbolic names for data. It will also automatically translate these programs into a sequence of numbers that can then be loaded into VM2's memory and run. This project will provide a stepping-stone to Jonathan's ultimate project—the construction of a high-level-language compiler—which he will present in a three-part series beginning next month.

In the second Programming Project, Bruce Webster examines five small libraries he designed to customize Turbo Pascal. These libraries extend predefined procedures and functions of the language.

As users have demanded more speed and capacity in data storage, storage media have gone from paper tape to cassette tape to floppy disk to hard disk. Now optical storage devices can be added to the list. In "CD-ROMs and Their Kin," Richard Shuford explores the basics of various optical storage devices, the advantages of their great storage capacity, and how they might be used in the future.

Michael Kilian's "Highs and Lows of Parameter Passing" deals with techniques that interface assembly language with higher-level languages, such as Pascal and FORTRAN. With these techniques, you can control devices, such as the horizontal timing of a screen; you can use the speed of assembly language for certain calculations, such as pseudorandom-number generation; and you can perform other tasks that expand the use of high-level languages beyond their original design.

In the Programming Insight, Marvin De Jong shows you how to use the game-paddle inputs on an Apple II to measure physical properties like resistance, capacitance, temperature, and light intensity.

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THE WORLD'S SMALLEST 1200-BPS MODEM

BY STEVE CIARCIA

The essential ingredient in the turnkey bulletin board

Before you get too excited about building the world's smallest modem, I must state in advance that there is nothing to build per se. Such a device already exists, and I intend to use it as the basis for my project.

Generally speaking, Circuit Cellar projects involve taking some hot new chip and pasting it together with some other components to satisfy a novel application. When that chip becomes the only component in the design, however, it can't exactly be called a construction project. In those cases, I have to demonstrate real purpose for the pages I take up rather than simply waft solder flux fumes in the general direction of my usually adamant supporters.

For a long time I have been receiving letters asking when I was going to design and present a 1200-bps (bits per second) modem (Bell-212A). Readers also ask whether I have ever thought of building a complete interactive computer-messaging system beyond the presentation alluded to in my March project, "Build the Touch-Tone Interactive Message System," which also incorporated a 1200-bps modem.

In truth, such a project has always been in the works. On two separate occasions I sketched out schematics for a 1200-bps modem using the (then) latest available chip set or single-chip modem. In both cases, these "single chips" required piles of extra ICs (integrated circuits) and interfacing components that would have resulted in relatively large and expensive printed-circuit boards. When you can buy a stand-alone Hayes-compatible smart modem for $249, it hardly makes sense to spend three times as much merely to say you built it yourself.

This continuously negative build-versus-buy price comparison seemed to be an insurmountable obstacle. Fortunately, on my last trip to California I met a couple of people from Xecom who had just what I needed to break the logjam.

I WANT MORE THAN A MODEM

Getting personal computers to communicate with each other over the telephone network has become a relatively ordinary task for computer users. Many hardware and software products let your machine exchange information with other machines. However, selectively communicating with both people and other machines is not so simple.

(continued)

Steve Ciarcia (pronounced "see-ARE-see-ah") is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, and product development. He is the author of several books about electronics. You can write to him at POB 582, *Glastonbury,* CT 06033.

Modem Interface
- Support for standard 300- and 1200-bps modems
- External audio interfaces for acoustic coupling where direct connection is not feasible

Telephone Interface
- DTMF generator and pulse dialer
- Call-progress monitoring
- Externally accessed audio inputs and outputs to items like support speakers, headphones, and microphones
- Multiple line control

Voice Interface
- Some form of voice synthesis
- Ability to store incoming voice on tape or as digitized speech

Computer Interface
- Simple physical interface
- USART built in for serialization, data framing, parity checking, flag insertion and deletion, and speed selection
- Smart command set with character-coded error and status codes

Miscellaneous
- On-board control of all device functions as well as the implementation of the smart command language
- Built-in diagnostics for the board as well as the telephone line
- FCC-registered direct-connection capability with the appropriate protective circuits
- Simple power requirements

Figure 1: *A wish list for the ultimate computerized interactive communication system.*

- Fully Bell-212A- and Bell-103-compatible
- DTMF or pulse dialing
- Call-progress monitoring
- DTMF reception and decoding
- 8251A software compatibility
- Parity generation/checking
- Sync-byte detection/insertion
- Synchronous: 1200 bps; asynchronous: 1200, 300, 110 bps
- Software-controlled audio input and output interface for voice communication or acoustic coupling
- Voice synthesis, LPC-coded
- Extensive built-in diagnostics
- Phone-line diagnostics
- FCC-registered direct connection; Tip and Ring input
- Operates on +/−5-volt power supply
- ASCII command and error/status codes

Figure 2: *Features of the* XE1203.

Sure, you can dial numbers with your modem. You can even answer the phone with it. But that's about as far as the low-cost units go. Performance beyond simple auto-dial answer/originate functions is reserved for expensive, commercially available phone-handler systems with single and multiple line-control boards.

The equivalent functions can be emulated with multiple expansion peripheral boards, but such configurations tend to be used in areas like maintaining address books, flash dialing, automatic redialing, or emergency notification calls. Few configurations combine modem functions, phone-handling flexibility, and human caller interaction at a cost that any of us could afford.

This seemingly unattainable system configuration leads us to speculate what the ultimate computerized interactive communication system would include. The feature list might look something like figure 1. Using off-the-shelf peripheral devices and doing the hardware and software yourself, you can satisfy most of these requirements. You will also end up using three or four slots in your computer and could possibly spend more than $1000 (see table 1).

Keep in mind that most commercial modems like the Hayes Smartmodem don't allow audio inputs and that any voice or DTMF (dual-tone, multiple-frequency) I/O (input/output) must be performed through a separate DAA (data-access arrangement). This configuration doesn't provide phone-line diagnostics, single (nonhost) point of control for all devices, or any way to route the audio signals around. Still, it might be worth trying if you have a few months of free evenings.

What Is a MOSART?

Of course, I wouldn't be running you around this much if I hadn't found a simpler and cheaper method. It turns out that all the functions shown in figure 1 (except the tape recorder) are available on one chip. No, not a board, just one chip! This marvel is the XE1203 hybrid IC from Xecom (374 Turquoise St., Milpitas, CA

95035, (408) 943-0313).

The chip is called a MOSART (modem synchronous/asynchronous receiver/transmitter) and is shown in photo 1. It comes with voice synthesis as the XE1203 or without voice synthesis as the XE1201. I'll be describing the XE1203, which has the features shown in figure 2.

All of this power is packed into a 2¼- by 1- by ½-inch hybrid circuit that plugs into a standard 40-pin DIP (dual in-line pin) socket. (The pin-out diagram of the XE1203 is shown in figure 3.)

Functionally, the MOSART can be divided into six sections: host interface, modem, analog circuits, DAA, speech synthesizer, and microprocessor (see figure 4). Basically, the MOSART can be viewed as a separate communication interface that looks to the host computer like an 8251A USART (universal synchronous/asynchronous receiver/transmitter) chip, including the appearance of registers and interrupt lines (shown in figure 5, it functions as an 8251A but is not pin-compatible with an 8251A). It is not a "dumb" device, like the other single-chip components I've mentioned. Instead, it is a board-level communication system that has been reduced to the size of a hybrid IC. As a Z8-based system, it is intelligent and uses a high-level command protocol between it and the host in much the same way the Hayes Smartmodem does (it is not Hayes-compatible).

The modem is capable of providing both Bell-103 and Bell-212A mode synchronous or asynchronous operation. The analog section consists of switching circuits for routing data among the speech synthesizer, modem, audio inputs and outputs, phone line, and both modulator and demodulator.

What's really impressive, though, is that the XE1203 includes an FCC-registered DAA on chip that provides 1500 volts (V) of isolation from the phone line, protection for the phone company's line, on/off hook control, and ring indication. To use the MOSART, you simply connect it to Tip and Ring on the phone line.

Table 1: A *possible bill of materials if you do it yourself.*

Hayes Smartmodem	$349
Speech-synthesis board	$349
DTMF receiver board	$60
Tape recorder	$59
DAA	$95
Relay-control board	$150
Total	$1062

Finally, the speech synthesizer, which is only on the XE1203, is an LPC (linear predictive coding) natural voice synthesizer. Data, in the form of ASCII (American Standard Code for Information Interchange) and binary strings from a word table, is fed to it (as if it were an 8251A) by the host computer. Custom vocabularies can be designed and implemented for special applications, but the package from Xecom presently includes a vocabulary of 145 words, letters, numbers, and phrases.

What We're Not Building

For the first time, a single-chip modem actually can be built with only a single 40-pin DIP hybrid chip. (It would have been smaller, but they had to leave some room to fit the DAA transformer.) The only additional circuitry necessary is for the address decoding typically required of any 8251A interface.

Since I have only one hot new chip and can't justify lots of interface glue, it hardly makes sense for me to reinvent the wheel. Instead of a purely hardware Circuit Cellar project, this month will be spent discussing how to use the XE1203 MOSART and how to design the interactive communication system suggested earlier.

Xecom manufactures an XE12XX evaluation board that plugs into the IBM PC, and I have chosen to use that board as a simple vehicle for demon-

(continued)

Photo 1: A *close-up of the* MOSART *module as a 1200-bps modem (and more) on a chip.*

Plugging the MOSART *into an* IBM PC *requires only the inclusion of address-decoding logic.*

stration rather than hand-wire a prototype of the same thing (after all, how many ways are there to hook up one chip?). The MOSART evaluation board is IBM PC-compatible simply for convenience (see photos 2 and 3).

In addition to Xecom's evaluation software, I have included programs that accomplish the major elements of human/computer interaction. The software provided in this article is written primarily in BASIC, so it is transportable to virtually any system. If you want to use the MOSART on an Apple or CP/M system, little would have to be changed.

Some of the applications that might be possible with the MOSART board are found in figure 6.

A Note of Caution

I must caution you about one significant point regarding this article. This demonstration board and the XE1203 are not Hayes-software-compatible. While the MOSART has an intelligent command structure, the codes themselves are different. This article is intended to present and make available what I consider to be the world's smallest modem. It is not a cheaper alternative to a Hayes-compatible modem but a design alternative for OEMs and industrious experimenters. For it to be used instead of a Hayes-compatible modem, the communication driver routines must be modified.

Also, since the evaluation board was designed primarily as an engineering evaluation tool and not specifically as a Circuit Cellar project, its documentation is aimed at the experienced programmer or engineer and does not contain the usual broad spectrum of supporting materials that aid beginners.

With that out of the way, I'll introduce you to the XE1203 MOSART and hope it will solve some of your communication problems. I'll demonstrate in software how to program it as a simple dumb terminal, a smart answering machine, and as a DTMF/voice interactive communication device.

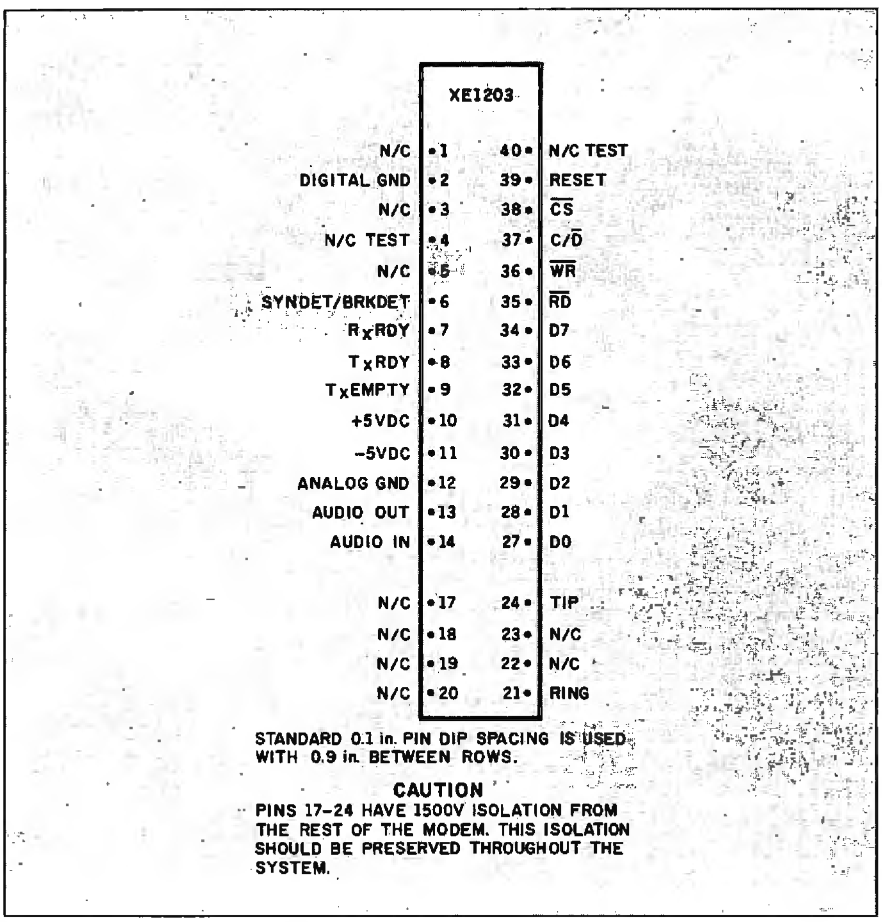

Figure 3: *The pin-out diagram of the* XE1203 MOSART.

Putting the MOSART into an IBM PC

Interfacing to the MOSART is simple since it looks like an 8251A to the host computer and the phone lines merely connect to the Tip and Ring inputs on the chip. Plugging the MOSART into an IBM PC requires only the inclusion of address-decoding logic (see figure 7). The simplest circuit requires only a 74LS02 and a 74LS30. Use of the interrupt lines is optional since the same signals are available from the MOSART's control register.

You simply wire the phone line to the Tip and Ring pins of the MOSART. Connecting a headset and microphone to let you hear or talk directly to the connected party involves the use of three resistors and one capacitor.

Exchanging data and command/status information with the MOSART is straightforward. You initialize the device via a hardware reset line on power-up or by writing the initialization bit of the control register. The MOSART initializes similarly to the 8251A device it emulates (see figure 8). After writing several bytes of hexadecimal 0s to ensure the MOSART is not stuck between initialization states, the initialization bit is written to the control register. The mode byte is written next, followed by 1 or 2 sync bytes if you are using synchronous transmission. Lastly, the control byte is written. Once the MOSART is initialized, a new control byte can be set at any time by simply writing to the control register.

All communication takes place through the MOSART's data port. An RTS bit in the control byte allows the MOSART to differentiate between command function codes and data. Setting RTS to a logic 1 indicates that the information is to be accepted as data and sent either to the modem or the speech synthesizer. An RTS bit of logic 0 indicates that the information written to the data port is to be interpreted as a MOSART command function code.

The MOSART outputs both data and status codes to the host computer over the same port. The host computer interrogates a DSR bit in the control register to determine if the received information is data or a status code.

The command function codes the MOSART recognizes are divided into four categories: modem connection, configuration, telephone control, and tests.

Modem-connection functions include answering and originating modem connections and monitoring for modem carrier or voice. The configuration functions allow speed, framing, and parity selection; rotary or DTMF dialing; and switching control over the synthesizer, external audio, and phone lines.

Telephone-control functions handle dialing and DTMF. The commands consist of line hold, DTMF receive, dial digits, and the */# keys. In addition, the letters a through f can be used to

The MOSART *outputs both data and status codes to the host computer over the same port.*

send the DTMF codes for the normally unimplemented last row of the keyset. (Tone dialing must have been selected previously with the configuration command.) In addition, a detailed monitor function is included that will watch the phone line and every half second give out a code that indicates the frequency heard on the

(continued)

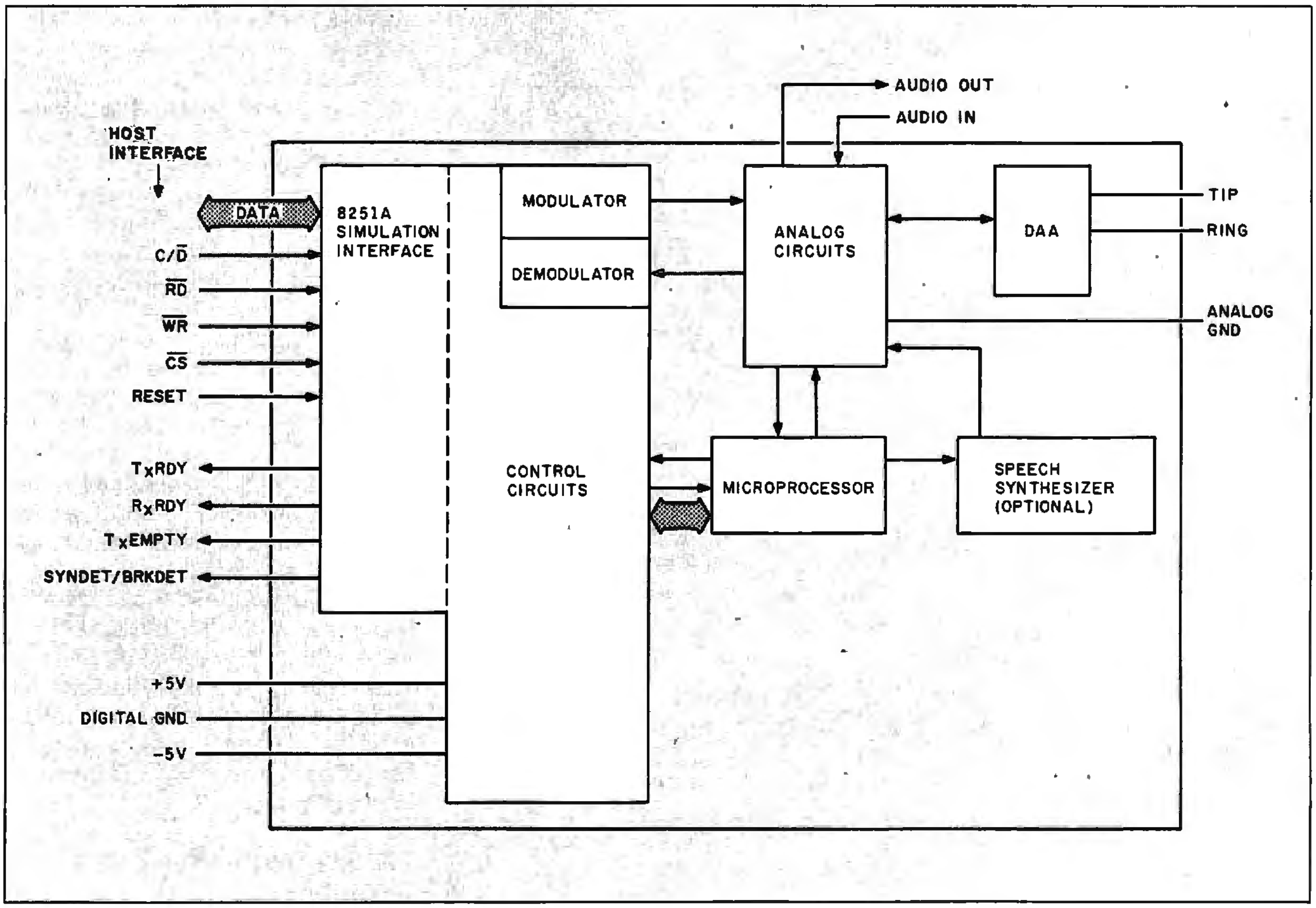

Figure 4: *The* MOSART'*s functional block diagram.*

line (in tens of hertz). Other standard control functions like pausing and waiting for dial tone are also included in the telephone-control function set.

The test functions are perhaps the most unique to the MOSART. These functions include allowing answer- or originate-mode loopbacks; a line-analysis feature that includes signal/noise, received-carrier level, and carrier-frequency error statistics; and a special analysis of 1200-bps mode phase-error information.

A detailed description of many of the important command functions is given in table 2.

APPLICATIONS

I'm sure you can think of many uses for such a flexible device. I have already developed three applications for it using the IBM PC: dumb terminal with auto-dial answer/originate capabilities, simple announce or announce-and-record answering machine, and DTMF input system with voice response.

With the exception of the speech synthesizer, which needs more speed than the usual interpreter can provide, all the applications are written in BASIC to allow you to see what is going on. In a further attempt to keep it simple, no interrupts were used. This does limit the speed of the dumb terminal to only 300 bps, however, unless you switch to a compiled BASIC. [*Editor's note: The source codes for the programs mentioned in this article are available for downloading from* BYTEnet *Listings. Call* (617) 861-9774 *before November* 1. *Thereafter, call* (617) 861-9764.]

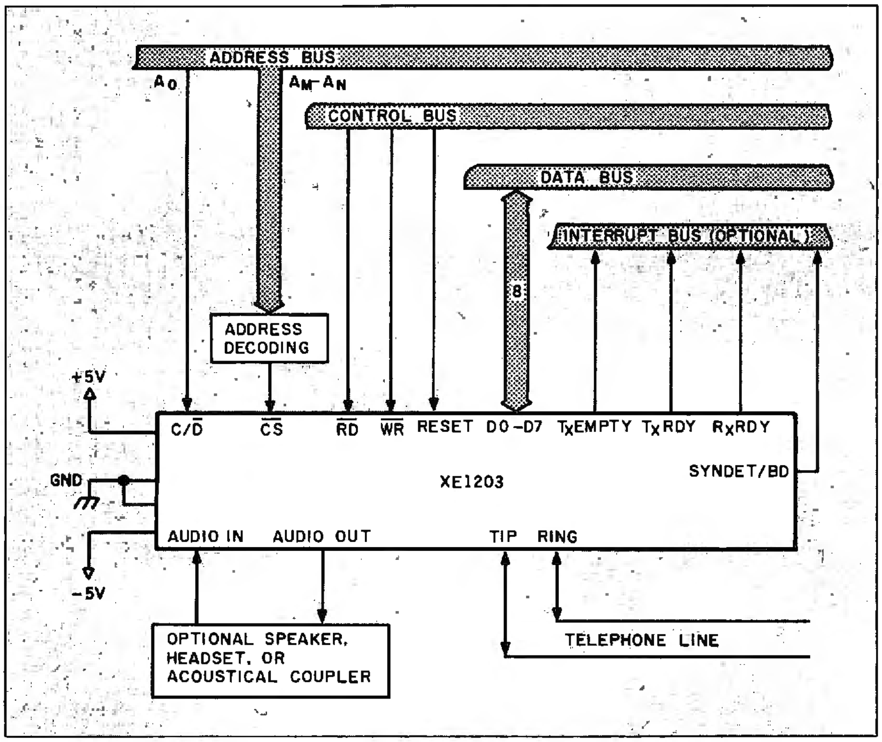

Figure 5: *Interfacing details for the* MOSART. *Notice that it provides the same signals as an* 8251A USART.

- Smart auto-dial/auto-answer modem
- Telephone dialer/directory machine
- Answering machine (simple or smart)
- Call-forwarding system
- Security modem
- Wake-up caller
- Emergency dialer
- DTMF input system with voice response
- DTMF home-control system with voice response

Figure 6: *Some possible applications for the* MOSART.

MOSTERM: DUMB TERMINAL

Listing 1 (MOSTERM) illustrates the use of the MOSART as the modem and phone handler in a dumb-terminal application. Through the use of configuration files, various modem and phone-number parameters can be stored. The program allows the computer to either originate the connection or wait for a call to be received. When either of these events is complete, the program enters the terminal emulator. The terminal emulator can be stopped at any time by entering Control-A from the keyboard.

In this program, the configuration values for speed, number of data bits, number of stop bits, and parity are used to create a mask for the MOSART-mode byte, as would be done in an 8251A-based device. The values for answer or originate mode, the type of dialing to be used (pulse or DTMF), and the digits to be dialed are saved as MOSART function codes. Lastly, the values for the support of half- or full-duplex mode (really character echo to the screen) and linefeed suppression are stored as flags for the emulator to test as it's running. A simplified flowchart of the program appears in figure 9.

MOSANSWR: ANSWERING MACHINE

The MOSANSWR program (see listing 2) shows how the MOSART can be used to implement a simple answering machine. The system can be configured to announce only or to act as an announce-and-record device. For recording, you need to add only a cassette cable and a cassette tape recorder. The IBM PC's cassette motor-control output is used to turn the cassette recorder on and off, and the audio output of the MOSART is routed to the auxiliary or line input jack of the recorder.

This application is relatively simple, but it does have some neat features. The software has the ability to give out date and time information or a call-forwarding number to the caller. These options, as well as control of the operating mode of the device (announce or announce/record), are all under user control via a setup menu when the program is started.

In addition to the initial setup, you have the ability to create, save, and load a 30-element table that can change the way the machine works based on the date and time. The system will automatically synchronize to the loaded table by executing all changes earlier than the current date and time in chronological order. This lets you program call-forwarding numbers in advance, announce or record mode, and whether or not date and time information is given out. Multiple tables can be created, each containing several "standard" operations as well as custom information for different days or situations.

The entire speech vocabulary is loaded for this program, even though only a few words and phrases were needed. This is to let you customize the messages for your own applications. Canned phrases are voiced using data statements, where the first data item is the count of words or phrases to be spoken concurrently. The rest of the numbers are pointers to the phrase table, (TB(X,Y)), which contains the offsets of the LPC codes and the lengths of the phrases.

All speech is output via a machine-language subroutine call. The starting address of the LPC codes for the phrase and the number of bytes to

(continued)

Photo 2: *The Xecom* IBM PC MOSART *evaluation board.*

Photo 3: *The* MOSART *evaluation board installed in an* IBM PC. *Directly behind the* MOSART *board is a Hayes* 1200-*bps* Smartmodem. *Note the difference in complexity between the boards, with the* MOSART *also having* DTMF *encoding/decoding and a speech synthesizer.*

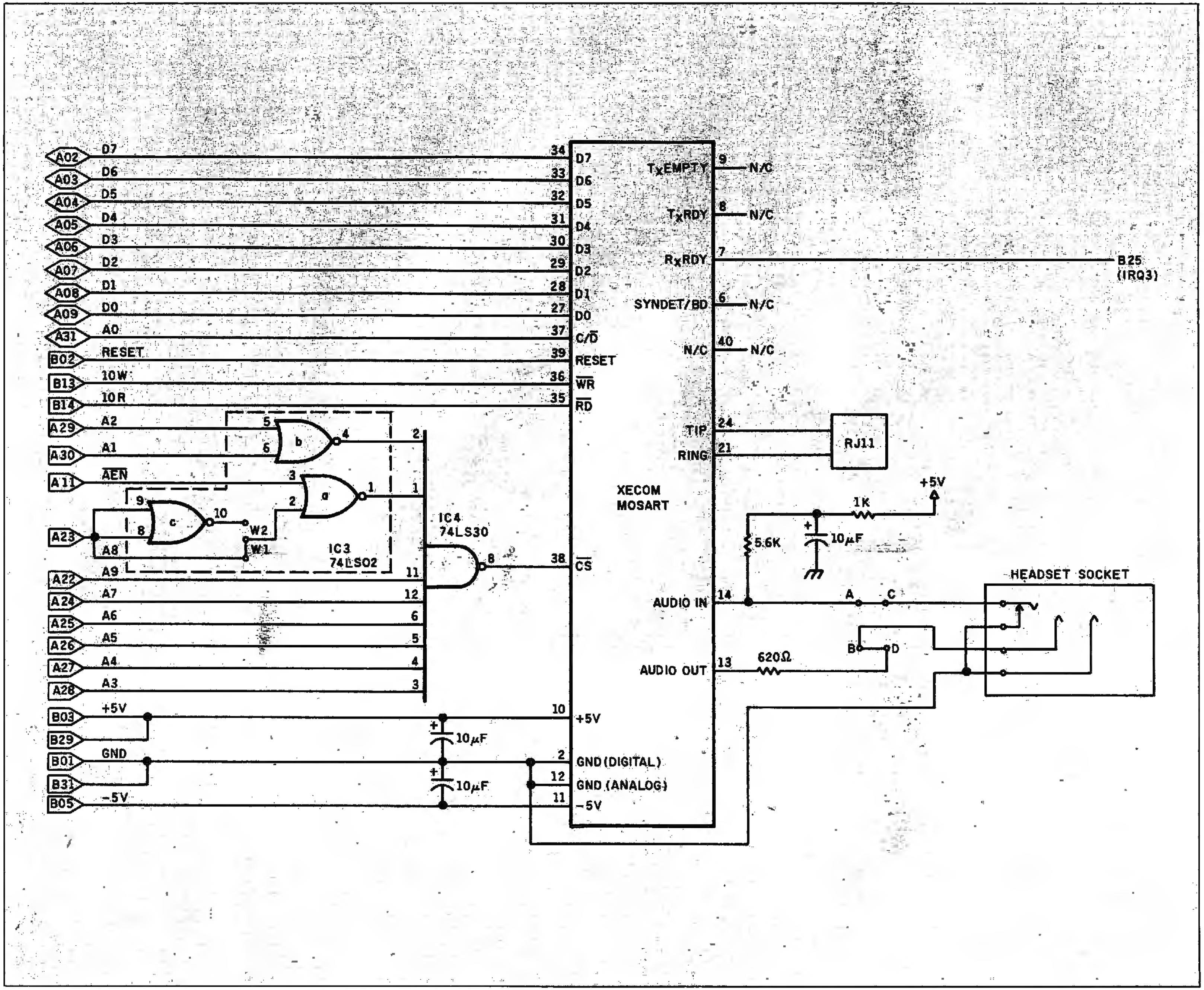

Figure 7: *Schematic diagram of the MOSART interface to an IBM PC.*

A Little Incentive

In the spirit of supporting hobbyists, I have often offered free listings or disks of software to those who built my projects from scratch. With this month's project there is nothing to build, and the software is either published here or available through BYTEnet Listings. I mentioned in the article that any commercial modem software would have to be modified to use the MOSART since it is not directly Hayes-compatible. Its use would be beneficial since it actually offers many more features.

There is no sense in trying to convert hardware folk like me, so I'd like to offer some incentive to any software gurus in the audience. I will offer a $200 prize to the person who sends in the whizbang best, most complete bells-and-whistles modification file for PC-Talk III, enabling PC-Talk III to really make full use of the MOSART board's capabilities.

PC-Talk III, a shareware communications program for the PC, while not in the public domain itself, has a fair number of customization files floating around in the public domain. These are usually supplied as BASIC ASCII files that can be merged with the source code to PC-Talk III to add enhancements or changes. A panel selected from the Connecticut Computer Club will review all software submitted by January 31, 1986, and determine the winner by March 15, 1986. I will pay the winner $200. To be eligible, all submissions may have a copyright but must carry the statement that the author is placing the software in the public domain for noncommercial use only. I will then make the winning software and any other significant entries available to users through BYTEnet or the Circuit Cellar Bulletin Board.

output are passed to the routine as parameters on the stack, as outlined in the IBM BASIC manual. The routine jams the data out to the MOSART to create the synthesized voice. (Xecom provides the LPC codes for 145 words and phrases on a disk with the evaluation package, but all the speech evaluation and demonstration code is written in FORTH. In the process of producing this article, several additional programs were written that translate these files into ASCII text. These have been added to the demonstration routines. Unfortunately, this accumulation of programs is too much to publish here. If you wish to examine the code in the unpublished portions of this software, you are welcome to download the appropriate files through BYTEnet Listings.)

It is possible to do more things with the answering-machine program. "Hooks" were left in the software for DTMF remote-control functions. After any beep during announce or announce-and-record modes, the system briefly checks to see if a DTMF "*" or "#" has been received. These would be used to tell the system to go into special mode for privileged callers or supervisory mode for the owner of the system. Currently, trying this will result in a message stating that the function is unavailable. The hooks are left there for your use in custom applications.

MOSDTMF: Input System with Voice Response

This final program (see listing 3) shows how you might use the MOSART's DTMF recognition function to develop an interactive data inquiry function. Since I had the native vocabulary of the MOSART to work with, I decided to code a sample routine that would let a remote user hear all the 145 words and phrases.

After receiving a call, the program checks for a correct identification code. In this case, I used the numbers

(continued)

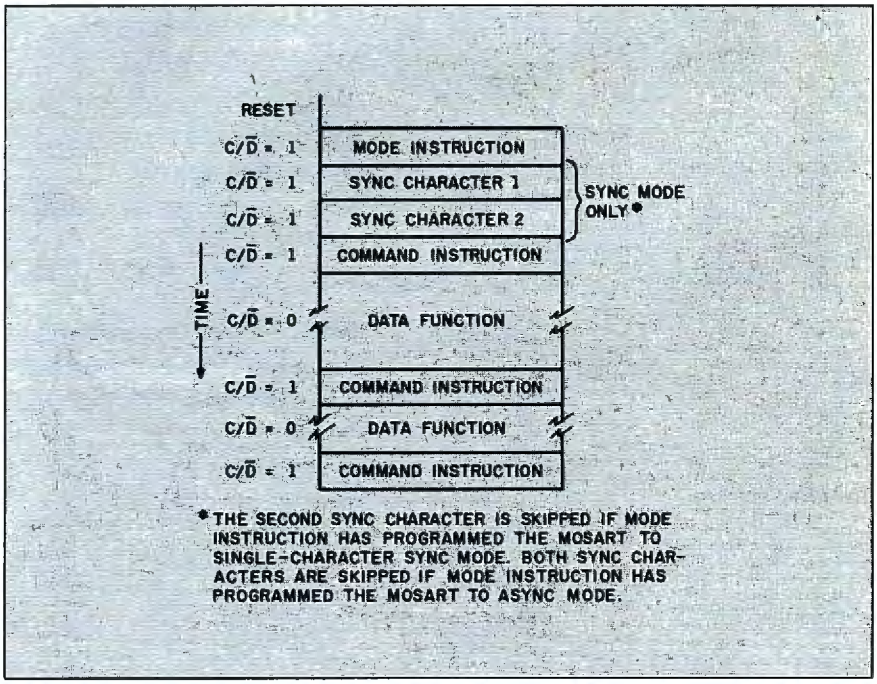

Figure 8: *The MOSART's initialization sequence.*

Table 2: *Most of the important command functions available on the* MOSART.

ASCII Code (hexadecimal)	Character	Function
41	A	Answer incoming call.
01	Control-A	Controlled answer. This function can be aborted by the caller by pressing "1" on a Touch-Tone dial or speaking. The MOSART will return a 1 or a v, respectively.
4D	M	Monitor the line and return status. MOSART returns R (ring back), D (dial tone), B (busy), V (voice), and others as appropriate.
4F	O	MOSART modem enters the originate mode.
52	R	Rotary dial.
54	T	Touch-Tone dial.
0F	Control-O	Set data-transmission rate to 110 bps.
14	Control-T	Set data-transmission rate to 300 bps.
08	Control-H	Set data-transmission rate to 1200 bps.
16	Control-V	Enable voice to phone-line connection. Returns an I (inappropriate) if a modem connection exists.
56	V	Enable voice locally. The synthesizer and audio input are connected to the audio output.
76	v	Disable voice.
58	X	Enable audio-output connection to the phone line (enables you to listen to the phone line).
78	x	Disable audio-output connection to the phone line.
5A	Z	Coupler on. The modulator is connected to audio-out, and the demodulator listens to audio-in.
7A	z	Coupler off.
3D	=	Parity checking/generation off.
3E	>	Even parity checking/generation.
3C	<	Odd parity checking/generation.
13	Control-S	Seven-bit character length.
05	Control-E	Eight-bit character length.
44	D	DTMF receive mode. The MOSART recognizes keys entered from a Touch-Tone phone and returns their associated ASCII codes.
48	H	Performs a logical disconnect of the modem but leaves the line in hold status.
49	I	Identify. Returns a letter corresponding to the version of the MOSART.
0D	Control-M	Detailed monitor. Every 0.05 second the MOSART returns a data byte indicating the line frequency in tens of hertz.
6D	m	Same as M.
70	p	Pause for 2 seconds.
50	P	Pause for 5 seconds.
57	W	Wait for dial tone.

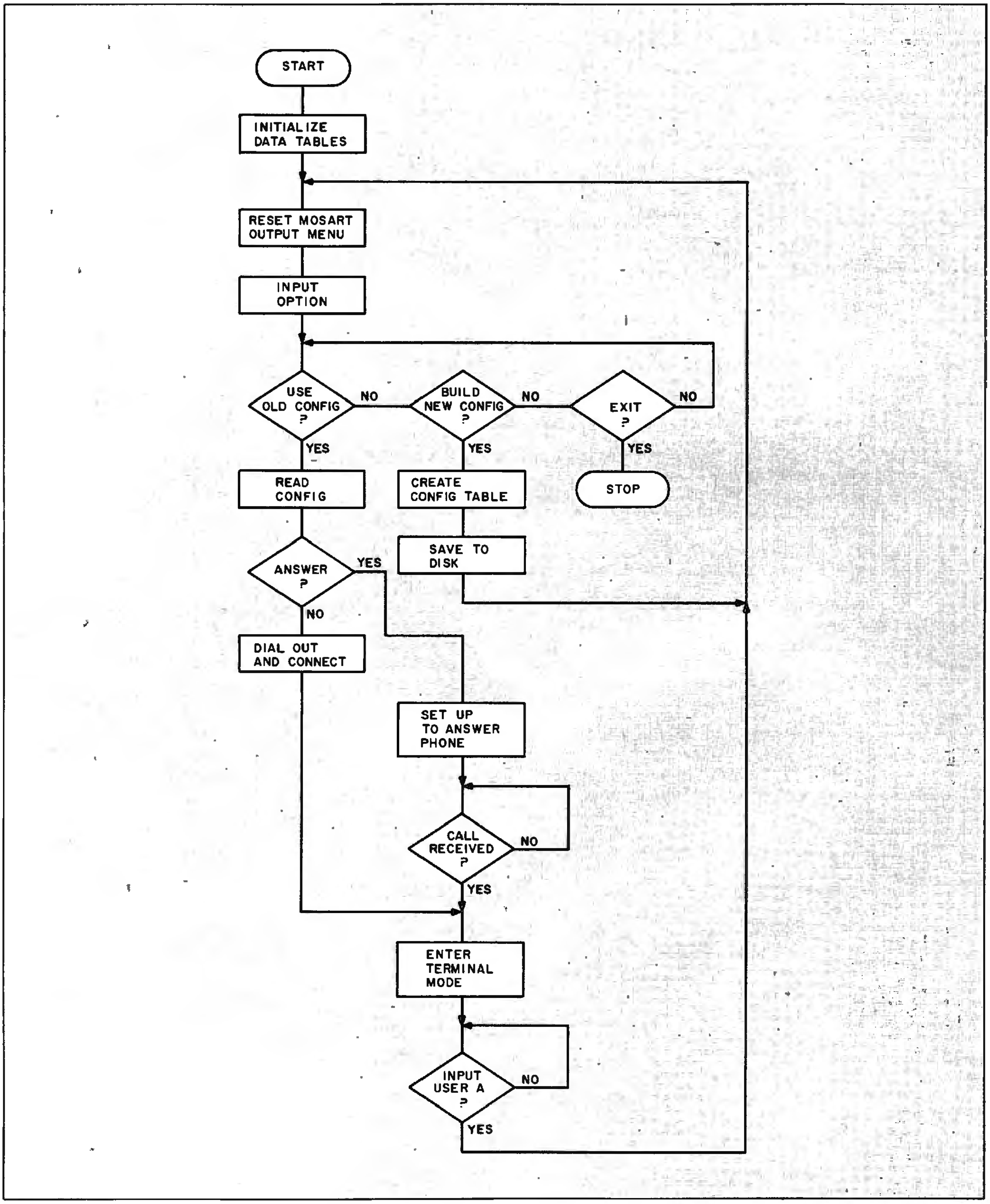

Figure 9: *Flowchart for the* MOSTERM *program (see listing* 1).

Listing 1: *Source code for the* MOSTERM *program.*

```
10 KEY OFF
20 DIM TB(4,3),P(6)
30 GOSUB 1450
40 CLS
50 PRINT "MOSTERM"
60 PRINT "MOSART routine #1, Auto-dial/Auto-answer
    Modem,"
70 PRINT "with built-in dumb-terminal driver."
80 PRINT:PRINT
90 REM reset MOSART
100 OUT &H2F9,0
110 OUT &H2F9,0
120 OUT &H2F9,0
130 OUT &H2F9,&H40
140 PRINT:PRINT
150 PRINT " Please Select an Option "
160 PRINT
170 PRINT "  1 — Use a predefined Configuration File"
180 PRINT "  2 — Create a Configuration File"
190 PRINT "  3 — Exit to BASICA"
200 PRINT
210 INPUT "please enter 1-3 ";C
220 IF C=3 THEN CLS:KEY ON:END
230 IF C<1 OR C>2 OR C<>INT(C) THEN 210
240 ON C GOSUB 260,740
250 GOTO 40
260 REM bring in a config file and start terminal emulation
270 CLS
280 INPUT "Please Enter Filename : ";F$
290 F$=F$+".cfg"
300 OPEN F$ FOR INPUT AS #1
310 M=0
320 REM get speed, # data bits, # stop bits
330 REM mask values for MOSART-mode byte
340 FOR X=1 TO 4
350 INPUT #1,Y
360 M=M+Y
370 NEXT X
380 REM get duplex and linefeed-suppression codes
390 INPUT #1,D
400 INPUT #1,L
410 REM get orig/answer mode and optional phone
     number
420 A$=""
430 INPUT #1,A$
440 IF A$<>"O" THEN 480
450 INPUT #1,A1$
460 INPUT #1,A2$
470 A$=A2$+A1$+A$
480 CLOSE #1
490 OUT &H2F9,M
500 OUT &H2F9,&H7
510 GOSUB 1280
520 PRINT "CONNECTION ESTABLISHED"
530 PRINT:PRINT "press enter key to start terminal mode"
540 PRINT "press ctrl-a to end emulation and hang up
     phone"
550 INPUT A$
560 REM quick terminal-emulation stuff
570 CLS
580 LOCATE ,,1
590 OUT &H2F9,&H27
600 IF (INP(&H2F9) AND 2) THEN GOSUB 670
610 IF (INP(&H2F9) AND &H40) THEN CLS : PRINT "line
    drop..press return" : INPUT A$ : RETURN
620 A$=INKEY$
630 IF LEN(A$)=0 THEN 600
640 IF ASC(A$)=1 THEN RETURN
650 OUT &H2F8,ASC(A$):IF D<>1 THEN PRINT A$;
660 GOTO 600
670 REM check for cr/lf and output character
680 A$=CHR$(INP(&H2F8))
690 IF L=0 THEN PRINT A$;:GOTO 730
700 IF (ASC(A$)=&HA) AND CR=1
    THEN CR=0:GOTO 730
710 IF ASC(A$)=&HD THEN CR=1
720 PRINT A$;
730 RETURN
740 REM create a config file
750 CLS
760 PRINT "Build a Configuration File "
770 PRINT:PRINT
780 INPUT "enter speed (1=110, 2=300, 3=1200) ";P
790 IF P<1 OR P>3 OR P<>INT(P) THEN 780
800 P(1)=TB(1,P)
810 INPUT "enter # of data bits (1=7, 2=8) ";P
820 IF P<1 OR P>2 OR P<>INT(P) THEN 810
830 P(2)=TB(2,P)
840 INPUT "enter # of stop bits (1=1, 2=1.5, 3=2) ";P
850 IF P<1 OR P>3 OR P<>INT(P) THEN 840
860 P(3)=TB(3,P)
870 INPUT "enter parity (1=even, 2=odd, 3=none) ";P
880 IF P<1 OR P>3 OR P<>INT(P) THEN 870
890 P(4)=TB(4,P)
900 INPUT "enter duplex mode (0=half, 1=full) ";P
910 IF P<0 OR P>1 OR P<>INT(P) THEN 900
920 P(5)=P
930 INPUT "suppress LF after CR ? (0=no, 1=yes) ";P
940 IF P<0 OR P>1 OR P<>INT(P) THEN 930
950 P(6)=P
960 INPUT "type of connection (0=originate,
     1=answer) ";P
970 IF P=0 THEN T$="O":GOTO 1000
980 IF P=1 THEN T$="A":GOTO 1000
990 GOTO 960
1000 IF P<>0 THEN GOTO 1100
1010 INPUT "type of dialing (0=rotary, 1=DTMF) ";P
1020 IF P=0 THEN T2$="R":GOTO 1050
1030 IF P=1 THEN T2$="T":GOTO 1050
1040 GOTO 1010
1050 INPUT "enter phone #, use 'p' for pauses ";T1$
1060 PRINT "you entered ";T1$;" – "
1070 INPUT "enter 0 to redo, 1 to accept ";P
1080 IF P=1 THEN 1100
1090 GOTO 1050
1100 PRINT:PRINT
1110 PRINT "enter filename for config file (drive spec
      and 8 digits max.)"
1120 INPUT F$
1130 PRINT "you entered ";F$;" – "
1140 INPUT "enter 0 to redo, 1 to accept ";P
1150 IF P=1 THEN 1170
```

```
1160 GOTO 1110
1170 F$=F$+".cfg"
1180 OPEN F$ FOR OUTPUT AS #1
1190 FOR X=1 TO 6
1200 PRINT #1,P(X)
1210 NEXT X
1220 PRINT #1,T$
1230 IF T$<>"O" THEN 1260
1240 PRINT #1,T1$
1250 PRINT #1,T2$
1260 CLOSE #1
1270 RETURN
1280 REM command process routine
1290 IF A$<>"A" THEN 1330
1300 A$="pA"
1310 PRINT :PRINT "Answer mode selected...Awaiting call"
1320 IF (INP(&H2F9) AND &H40)<>&H40 THEN 1320
1330 FOR X=1 TO LEN(A$)
1340 Y=0
1350 Y=Y+1:IF Y>2000 THEN PRINT "MOSART device
     busy error":STOP
1360 IF (INP(&H2F9) = 5 ) OR (INP(&H2F9)=&H85)
     THEN 1370 ELSE 1350
1370 T$=MID$(A$,X,1)
1380 OUT &H2F8,ASC(T$):PRINT T$;
1390 IF (INP(&H2F9) AND 2) THEN 1410
1400 IF ((INP(&H2F9) AND 5)= 5) THEN 1420 ELSE 1390
1410 PRINT:PRINT "information byte from command : ";T$;
     " was ";CHR$(INP(&H2F8))
1420 NEXT X
1430 PRINT
1440 RETURN
1450 REM initialize data tables
1460 FOR X=1 TO 4
1470 FOR Y=1 TO 3
1480 READ TB(X,Y)
1490 NEXT Y
1500 NEXT X
1510 DATA 3,2,1
1520 DATA 8,12,0
1530 DATA 64,128,192
1540 DATA 48,16,0
1550 RETURN
```

Listing 2: *Source code for the* MOSANSWR *program.*

```
10 KEY OFF
15 PRINT "MOSANSWR"
20 PRINT "MOSART ROUTINE #2, MOSART-BASED
   PHONE-ANSWERING SYSTEM"
30 REM INITIALIZE THE SYSTEM
40 GOSUB 1000
50 REM RUN THE SYSTEM
60 GOSUB 2000
70 REM STOP SYSTEM
80 STOP
1000 REM INITIALIZE
1010 PRINT "STARTING INITIALIZATION"
1020 REM SYSTEM INIT
1030 GOSUB 3000
1040 REM DO EVENTS SETUP
1050 GOSUB 4000
1060 REM LOAD SPEECH TABLES AND DRIVER
     PROGRAM
1070 GOSUB 5000
1080 PRINT "INITIALIZATION COMPLETE"
1090 RETURN
2000 REM RUN THE SYSTEM
2010 REM RESET THE MOSART
2020 GOSUB 6000
2030 PRINT "WAITING FOR CALL OR EVENT, PRESS
     ANY KEY TO END PROGRAM"
2040 REM TEST KEYBOARD
2050 REM TEST KEYBOARD
2060 IF INKEY$<>"" THEN GOTO 2160
2070 REM TEST EVENT
2080 GOSUB 9000
2090 REM CHECK FOR RING
2100 IF (INP(&H2F9) AND &H40) <> &H40 THEN GOTO
     2050
2110 IF (INP(&H2F9) AND &H40) <> 0 THEN 2110
2120 REM CHECK MODE AND DO IT
2125 PRINT "RING DETECTED"
2127 PRINT "ANSWERING PHONE"
2129 C$="HxDV"
2130 GOSUB 29000
2135 SP=0
2140 ON MO GOSUB 7000,8000
2150 GOTO 2000
2160 RETURN
3000 REM SYSTEM INITIALIZATION
3010 PRINT "SYSTEM INITIALIZATION STARTING"
3020 REM CHECK DATE AND TIME
3030 GOSUB 10000
3040 REM INITIALIZE THE MOSART
3050 GOSUB 6000
3060 REM GET SYSTEM MODE, DATE/TIME, AND CALL-
     FORWARD FLAGS
3070 GOSUB 11000
3080 PRINT "SYSTEM INITIALIZATION COMPLETE"
3090 RETURN
4000 REM EVENTS SETUP
4005 DIM E$(30,3)
4010 PRINT:PRINT:PRINT "TIME-BASED SYSTEM MODE
     CHANGES"
4020 PRINT
4030 PRINT "1 — BUILD NEW TABLE"
4040 PRINT "2 — MODIFY TABLE IN MEMORY "
4050 PRINT "3 — LOAD TABLE FROM DISK"
4060 PRINT "4 — SAVE TABLE TO DISK"
4070 PRINT "5 — CLEAR TABLE IN MEMORY"
4080 PRINT "6 — EXIT THIS ROUTINE"
4090 PRINT
4100 PRINT "ENTER YOUR CHOICE (1-6) "
4110 INPUT C
4120 IF C=6 THEN GOTO 4160
```

(continued)

```
4130 IF C<1 OR C>5 OR C< >INT(C) THEN GOTO 4090
4140 ON C GOSUB 12000,13000,14000,15000,31000
4150 GOTO 4010
4160 RETURN
5000 REM LOAD SPEECH TABLES AND DRIVER
     PROGRAM
5005 DIM TB%(146,2)
5010 DEF SEG=0
5020 X=PEEK(&H510)+(256*PEEK(&H511))
5030 X=X+&H1000
5040 DEF SEG=X
5050 PRINT "STORING SPEECH ROUTINE"
5060 BLOAD "SPEECH.BIN",0
5160 PRINT "LOAD OF SPEECH TABLES"
5170 OPEN "SPEECH.TBL" FOR INPUT AS #1
5180 FOR X=1 TO 145
5190 INPUT #1,W$,TB%(X,1),TB%(X,2)
5260 NEXT X
5290 PRINT "SPEECH AND DRIVER LOAD COMPLETE"
5295 CLOSE #1
5297 CLOSE #2
5300 RETURN
6000 REM MOSART INITIALIZATION
6010 PRINT "RESETTING MOSART"
6020 OUT &H2F9,0
6030 OUT &H2F9,0
6040 OUT &H2F9,0
6050 OUT &H2F9,&H40
6053 FOR X=1 TO 100: NEXT X
6055 OUT &H2F9,&HFA
6057 OUT &H2F9,&H7
6060 X=0
6070 X=X+1:IF X>3000 THEN PRINT "MOSART HUNG
     UP":STOP
6080 IF (INP(&H2F9) AND 5) < >5 THEN GOTO 6070
6100 C$="xv"
6110 GOSUB 29000
6120 PRINT "MOSART RESET COMPLETE"
6123 PRINT "BRIEF PAUSE TO ALLOW LINE TO QUIET"
6125 FOR X=1 TO 3500:NEXT X
6130 RETURN
7000 REM ANNOUNCE-ONLY MODE
7010 PRINT "ANNOUNCE MODE ENTERED"
7020 REM MAKE CANNED ANNOUNCEMENTS"
7030 GOSUB 33000
7040 IF SP< >1 THEN GOTO 7070
7050 GOSUB 34000
7060 GOTO 7090
7070 IF SP< >2 THEN GOTO 7090
7080 GOSUB 16000
7090 PRINT "EXITING ANNOUNCE MODE"
7100 RETURN
8000 REM RECORD A CALL
8010 PRINT "RECORD MODE ENTERED"
8020 REM ANNOUNCE FIRST AND CHECK
     SPECIAL/SUPER
8030 GOSUB 17000
8040 IF SP< >1 THEN GOTO 8070
8050 GOSUB 34000
8060 GOTO 8090
8070 IF SP< >2 THEN GOTO 8090
8080 GOSUB 16000
8090 PRINT "EXITING RECORD MODE"
8100 RETURN
9000 REM CHECK EVENTS
9010 IF EI=0 THEN GOTO 9270
9020 REM BUILD CURRENT TIME VARIABLES
9030 D1$=DATE$
9040 T1=TIMER
9050 REM BUILD DATE NUMERIC CODE FOR COMPARE
9060 D1=VAL(MID$(D1$,4,2))
9070 D1=D1+(VAL(MID$(D1$,1,2))*100)
9080 D1=D1+(VAL(MID$(D1$,9,2))*1000)
9090 REM T1=SECS AFTER MIDNIGHT, D1=DATE
     NUMERIC CODE
9100 REM CHECK OUT EVENTS TABLE FOR EVENT
     TO DO
9110 REM EI POINTS TO NEXT CHRONOLOGICAL
     EVENT
9130 REM BUILD COMPARISON NUMBERS
9140 D2$=MID$(E$(EI,2),1,10)
9150 T2$=MID$(E$(EI,2),11,8)
9160 D2=VAL(MID$(D2$,4,2))
9170 D2=D2+(VAL(MID$(D2$,1,2))*100)
9180 D2=D2+(VAL(MID$(D2$,9,2))*10000)
9190 T2=VAL(MID$(T2$,7,2))
9200 T2=T2+(VAL(MID$(T2$,4,2))*60)
9210 T2=T2+(VAL(MID$(T2$,1,2))*3600)
9220 IF D2<D1 THEN GOTO 9270
9230 IF D2>D1 THEN GOTO 9250
9240 IF T2>T1 THEN 9270
9250 REM DO EVENT
9260 GOSUB 30000
9270 RETURN
10000 REM CHECK DATE/TIME
10010 PRINT:PRINT "CURRENT DATE IS : ";DATE$
10020 INPUT "ENTER NEW DATE OR PRESS ENTER TO
      USE THIS DATE : ";D1$
10030 IF D1$=" " THEN GOTO 10060
10040 DATE$=D1$
10050 GOTO 10010
10060 PRINT:PRINT "CURRENT TIME IS : ";TIME$
10070 INPUT "ENTER NEW TIME OR PRESS ENTER TO
      USE THIS TIME : ";T1$
10080 IF T1$=" " THEN GOTO 10110
10090 TIME$=T1$
10100 GOTO 10060
10110 RETURN
11000 REM SET MODES
11005 MO=1:DT=0:CF=0:CN$=" "
11010 PRINT:PRINT "SET OPERATING MODE"
11020 PRINT:PRINT "1 — ANNOUNCE ONLY"
11030 PRINT "2 — ANNOUNCE AND RECORD"
11040 PRINT "3 — GIVE DATE AND TIME TO CALLER"
11050 PRINT "4 — DON'T SAY DATE AND TIME"
11060 PRINT "5 — GIVE OUT A FORWARDING
      NUMBER"
11070 PRINT "6 — DON'T SAY A FORWARDING
      NUMBER"
11080 PRINT "7 — SET FORWARDING NUMBER"
11090 PRINT "8 — EXIT THIS ROUTINE"
11100 PRINT:PRINT "CURRENT SETTINGS ARE :"
```

```
11110 PRINT "ANNOUNCE ";
11120 IF MO=2 THEN PRINT "AND RECORD MESSAGE"
      ELSE PRINT
11130 IF DT=1 THEN PRINT "GIVE OUT DATE AND
      TIME" ELSE PRINT "NO DATE/TIME"
11140 IF CF=1 THEN PRINT "GIVE FORWARDING
      NUMBER TO CALLERS" ELSE PRINT "NO
      FORWARDING NUMBER GIVEN OUT"
11150 IF CN$=" " THEN PRINT "NO FORWARDING
      NUMBER SET" ELSE PRINT "FORWARDING
      NUMBER IS : ";CN$
11160 PRINT
11170 INPUT "PLEASE ENTER CHOICE (1-8) : ";C
11180 IF C=8 THEN RETURN
11190 IF C<1 OR C>7 OR C<>INT(C) THEN
      GOTO 11160
11200 ON C GOSUB 11210,11220,11230,11240,11260,
      11250,11270
11205 GOTO 11010
11210 MO=1:RETURN
11220 MO=2:RETURN
11230 DT=1:RETURN
11240 DT=0:RETURN
11250 CF=0:RETURN
11260 CF=1
11270 PRINT "ENTER CALL-FORWARDING NUMBER "
11280 PRINT "NO SPECIAL PUNCTUATION EXCEPT FOR
      - ( ) / OR SPACES "
11290 INPUT CN$
11300 RETURN
12000 REM BUILD EVENTS TABLE
12010 GOSUB 31000
12020 FOR X=1 TO 30
12025 PRINT "THERE IS ROOM FOR ";31-X;
      " MORE EVENTS"
12030 PRINT:PRINT "ENTER EVENT DATE, OR PRESS
      ENTER TO STOP INPUT"
12040 INPUT "USE FORMAT MM-DD-YYYY : ";D1$
12050 IF D1$=" " THEN X=30:GOTO 12076
12060 IF LEN(D1$)<>10 THEN GOTO 12040
12065 E$(X,1)="E"
12070 E$(X,2)=D1$
12072 GOSUB 12080
12074 NEXT X
12075 GOSUB 31000
12076 RETURN
12080 PRINT "ENTER EVENT TIME"
12090 INPUT "USE FORMAT HH:MM:SS : ";T1$
12100 IF LEN(T1$)<>8 THEN GOTO 12090
12105 E$(X,2)=E$(X,2)+T1$
12110 PRINT "ENTER 1 TO ANNOUNCE ONLY, 2 TO
      ANNOUNCE AND RECORD "
12120 INPUT T$:IF T$<>"1" AND T$<>"2" THEN
      GOTO 12110
12130 E$(X,3)=T$
12140 PRINT "ENTER 1 TO GIVE OUT DATE/TIME, 0 NOT
      TO SAY "
12150 INPUT T$:IF T$<>"0" AND T$<>"1" THEN
      GOTO 12140
12160 E$(X,3)=E$(X,3)+T$
12170 PRINT "ENTER 1 TO GIVE OUT FORWARDING
      NUMBER, 0 NOT TO SAY "
12180 INPUT T$:IF T$<>"0" AND T$<>"1" THEN
      GOTO 12170
12190 E$(X,3)=E$(X,3)+T$
12200 PRINT "ENTER FORWARDING NUMBER "
12210 INPUT T$
12220 PRINT "FORWARDING NUMBER IS NOW : ";T$;"
      PRESS ENTER TO CONFIRM, OR ENTER NEW
      NUMBER"
12230 INPUT T1$
12240 IF T1$<>" " THEN T$=T1$:GOTO 12220
12250 E$(X,3)=E$(X,3)+T$
12260 RETURN
13000 REM MODIFY EVENTS TABLE
13010 PRINT:PRINT "MODIFY EVENTS TABLE"
13020 PRINT:PRINT "1 — ADD AN EVENT"
13030 PRINT "2 — DELETE EVENT"
13040 PRINT "3 — DISPLAY EVENTS TABLE"
13050 PRINT "4 — EXIT THIS ROUTINE"
13060 PRINT:PRINT "PLEASE ENTER CHOICE (1-4)"
13070 INPUT C
13080 IF C=4 THEN GOTO 13530
13090 IF C<1 OR C>3 OR C<>INT(C) THEN 13060
13100 ON C GOSUB 13120,13270,13360
13110 GOTO 13010
13120 REM ADD EVENT
13130 PRINT "SEARCHING FOR OPEN TABLE ENTRY"
13135 Y=0
13140 FOR X=1 TO 30
13150 IF E$(X,1)<>" " THEN 13240
13160 Y=1
13170 PRINT "ENTER EVENT DATE OR PRESS ENTER
      TO STOP"
13180 INPUT "USE FORMAT MM-DD-YYYY : ";D1$
13190 IF D1$=" " THEN X=30 : GOTO 13240
13200 IF LEN(D1$)<>10 THEN GOTO 13180
13210 E$(X,1)="E":E$(X,2)=D1$
13220 GOSUB 12080
13230 X=30
13240 NEXT X
13250 IF Y=0 THEN PRINT "NO OPEN TABLE
      ENTRIES...DELETE SOME FIRST"
13260 RETURN
13270 REM DELETE AN EVENT
13280 PRINT "PLEASE ENTER EVENT NUMBER TO BE
      DELETED"
13290 INPUT "ENTER 0 TO ABORT ";C
13300 IF C=0 THEN 13350
13310 IF C>0 AND C<31 AND C=INT(C) THEN GOTO
      13340
13320 PRINT "EVENT NUMBER MUST BE 1-30"
13330 GOTO 13280
13340 E$(C,1)=" "
13350 RETURN
13360 REM PRINT OUT TABLE
13370 FOR X=1 TO 30
13380 PRINT X;"-";
13390 IF E$(X,1)<>" " THEN GOTO 13420
13400 PRINT "OPEN"
13410 GOTO 13460
```

(continued)

```
13420 PRINT MID$(E$(X,2),1,10);" ";MID$
      (E$(X,2),11,8);" ";
13430 PRINT MID$(E$(X,3),1,3);" ";
13450 IF LEN(E$(X,3))>3 THEN PRINT
      MID$(E$(X,3),4,LEN(E$(X,3))-3)
13460 IF X=15 THEN INPUT "PRESS ENTER TO
      CONTINUE ";T$
13510 NEXT X
13515 INPUT "PRESS ENTER TO CONTINUE";T$
13520 RETURN
13530 REM EXIT ROUTINE
13540 GOSUB 32000
13550 RETURN
14000 REM LOAD EVENTS TABLE
14010 PRINT:PRINT "ENTER NAME OF TABLE TO BE
      LOADED (8 CHARS MAX)"
14020 INPUT "OR PRESS ENTER TO ABORT : ";T$
14030 IF T$=" " THEN GOTO 14130
14040 IF LEN(T$)>8 AND MID$(T$,2,1)<>":" THEN
      GOTO 14010
14050 T$=T$+".EVT"
14060 OPEN T$ FOR INPUT AS #1
14070 FOR X=1 TO 30
14080 INPUT #1,E$(X,1),E$(X,2),E$(X,3)
14090 NEXT X
14100 PRINT "TABLE LOADED":CLOSE #1
14110 REM BUILD INDEX POINTER
14120 GOSUB 32000
14130 RETURN
15000 REM SAVE EVENTS TABLE
15010 PRINT:PRINT "ENTER NAME OF TABLE TO BE
      SAVED (8 CHARS MAX)"
15020 INPUT "OR PRESS ENTER TO ABORT : ";T$
15030 IF T$=" " THEN GOTO 15130
15040 IF LEN(T$)>8 AND MID$(T$,2,1)<>":" THEN
      GOTO 14010
15050 T$=T$+".EVT"
15060 OPEN T$ FOR OUTPUT AS #1
15070 FOR X=1 TO 30
15080 PRINT #1,E$(X,1)
15090 PRINT #1,E$(X,2)
15100 PRINT #1,E$(X,3)
15110 NEXT X
15120 PRINT "TABLE SAVED":CLOSE #1
15130 RETURN
16000 REM SPECIAL ACCESS
16010 GOSUB 40000
16020 RETURN
17000 REM RECORD MODE
17010 REM DO CANNED MESSAGE FOR RECORD
17020 GOSUB 25000
17030 REM DO DATE/TIME IF DESIRED
17040 IF DT=1 THEN GOSUB 19000
17050 REM DO CALL-FORWARD NUMBER IF DESIRED
17060 IF CF=1 THEN GOSUB 20000
17070 REM PUT OUT RECORD MESSAGE AND BEEP
      TONE
17080 GOSUB 38000
17090 REM DO RECORD A MESSAGE (INCLUDES
      SUPER/SPECIAL TEST)
17100 GOSUB 26000
17110 RETURN
18000 REM CANNED ANNOUNCEMENT
18010 REM DATA FOR CANNED PHRASE BUILD
18020 DATA 4,55,46,57,89
18030 REM SPEAK STUFF
18040 RESTORE 18020
18050 READ P
18060 FOR P1=1 TO P
18070 READ S
18080 GOSUB 36000
18090 NEXT P1
18100 RETURN
19000 REM SPEAK DATE AND TIME
19010 REM DO TIME FIRST
19020 S=79
19030 GOSUB 36000
19035 S=93:GOSUB 36000
19040 T1$=TIME$
19050 T1=VAL(MID$(T1$,1,2))
19060 IF T1>20 THEN GOTO 19090
19070 S=T1:IF S=0 THEN S=91
19080 GOTO 19120
19090 S=20
19100 GOSUB 36000
19110 S=T1-20
19120 GOSUB 36000
19125 S=93:GOSUB 36000
19130 T1=VAL(MID$(T1$,4,2))
19140 IF T1>20 THEN GOTO 19170
19150 S=T1:IF S=0 THEN S=91
19160 GOTO 19220
19170 T1=VAL(MID$(T1$,4,1))
19180 S=18+T1
19190 GOSUB 36000
19200 T1=VAL(MID$(T1$,5,1))
19210 S=T1:IF S=0 THEN 19230
19220 GOSUB 36000
19230 REM DO DATE NOW
19232 S=93
19234 GOSUB 36000
19240 S=64
19244 GOSUB 36000
19246 S=93
19250 GOSUB 36000
19260 D1$=DATE$
19270 D1=VAL(MID$(D1$,1,2))
19280 S=D1
19290 GOSUB 36000
19295 S=93:GOSUB 36000
19300 D1=VAL(MID$(D1$,4,2))
19310 IF D1>20 THEN GOTO 19340
19320 S=D1
19330 GOTO 19390
19340 D1=VAL(MID$(D1$,4,1))
19350 S=18+D1
19360 GOSUB 36000
19370 D1=VAL(MID$(D1$,5,1))
19380 S=D1:IF S=0 THEN GOTO 19400
19390 GOSUB 36000
19395 S=93:GOSUB 36000
19400 D1=VAL(MID$(D1$,7,2))
```

```
19410 S=D1
19420 GOSUB 36000
19430 D1=VAL(MID$(D1$,9,2))
19440 IF D1>20 THEN GOTO 19470
19450 S=D1:IF S=0 THEN S=28
19460 GOSUB 36000
19470 D1=VAL(MID$(D1$,9,1))
19480 S=18+D1
19490 GOSUB 36000
19500 D1=VAL(MID$(D1$,10,1))
19510 S=D1:IF S=0 THEN 19530
19520 GOSUB 36000
19530 RETURN
20000 REM GIVE CALL-FORWARDING NUMBER
20010 DATA 4,66,90,45,93
20020 RESTORE 20010
20030 READ P
20040 FOR P1=1 TO P
20050 READ S
20060 GOSUB 36000
20070 NEXT P1
20080 FOR Z=1 TO LEN(CN$)
20090 T$=MID$(CN$,Z,1)
20100 IF T$="-" OR T$="/" OR T$=
      " " OR T$="(" OR T$=")" THEN S=95:GOTO
      20130
20110 T1=VAL(T$)
20120 S=T1:IF S=0 THEN S=91
20130 GOSUB 36000
20140 NEXT Z
20142 S=93
20144 GOSUB 36000
20150 RETURN
25000 REM RECORD ANNOUNCE #1
25010 REM DATA FOR CANNED PHRASE BUILD
25020 DATA 4,55,46,57,89
25030 REM SPEAK STUFF
25040 RESTORE 25020
25050 READ P
25060 FOR P1=1 TO P
25070 READ S
25080 GOSUB 36000
25090 NEXT P1
25100 RETURN
26000 REM RECORD A CALL
26010 REM FIRST SET UP MOSART AND START
      RECORDER
26020 C$="XD"
26030 GOSUB 29000
26040 MOTOR 1
26045 GOSUB 35000
26050 IF SP<>0 THEN 26140
26060 REM RECORD UNTIL TIMER GONE OR HANG-UP
26070 T1=TIMER
26080 T1=T1+90:IF T1>86400! THEN T1=T1-86400!
26090 IF T1>90 THEN 26120
26100 IF TIMER>T1 AND TIMER<100 THEN 26140
26110 GOTO 26135
26120 IF TIMER>T1 THEN 26140
26130 C$="M":GOSUB 29000
26132 IF CHR$(INP(&H2F8))="T" OR
      CHR$(INP(&H2F8))="D" THEN GOTO 26140
26135 GOTO 26090
26140 MOTOR 0
26150 RETURN
29000 REM PROCESS MOSART COMMANDS
29010 REM C$=COMMAND STRING
29020 FOR X=1 TO LEN(C$)
29025 OUT &H2F9,&H7
29030 Y=0
29040 Y=Y+1:IF Y>5000 THEN PRINT "MOSART
      LOCKED UP":STOP
29050 IF (INP(&H2F9) AND 5) = 5 THEN 29060 ELSE
      29040
29060 T$=MID$(C$,X,1)
29070 OUT &H2F8,ASC(T$)
29080 IF (INP(&H2F9) AND 2) = 2 THEN 29100
29090 IF (INP(&H2F9) AND 7) = 5 THEN 29110 ELSE
29080
29100 PRINT:PRINT "INFO BYTE FROM COMMAND
      ";T$;" WAS ";CHR$(INP(&H2F8))
29110 NEXT X
29130 RETURN
30000 REM DO EVENT
30005 PRINT "EVENT IN PROGRESS ";DATE$,TIME$
30010 E$(EI,1)=" "
30020 MO=VAL(MID$(E$(EI,3),1,1))
30030 DT=VAL(MID$(E$(EI,3),2,1))
30040 CF=VAL(MID$(E$(EI,3),3,1))
30050 IF LEN(E$(EI,3))=3 THEN CN$=" ":GOTO 30070
30060 CN$=MID$(E$(EI,3),4,(LEN(E$(EI,3))-3))
30070 GOSUB 32000
30075 PRINT "EVENT COMPLETED"
30080 RETURN
31000 REM CLEAR EVENTS TABLES
31010 EI=0
31020 FOR X=1 TO 30
31030 FOR Y=1 TO 3
31040 E$(X,Y)=" "
31050 NEXT Y
31060 NEXT X
31070 PRINT "EVENTS TABLE CLEAR COMPLETE"
31080 RETURN
32000 REM SET UP EVENT INDEX POINTER
32010 REM SET TEST VALUES TO HIGH VALUES
32020 EI=0:D1=999999!:T1=99999!
32030 REM LOOP THROUGH TABLE AND GET NEXT
      CHRONOLOGICAL EVENT
32040 FOR X=1 TO 30
32050 IF E$(X,1)=" " THEN GOTO 32180
32060 REM BUILD COMPARE NUMBERS
32070 D2$=MID$(E$(X,2),1,10)
32080 T2$=MID$(E$(X,2),11,8)
32090 D2=VAL(MID$(D2$,4,2))
32100 D2=D2+(VAL(MID$(D2$,1,2))*100)
32110 D2=D2+(VAL(MID$(D2$,9,2))*10000)
32120 T2=VAL(MID$(T2$,7,2))
32130 T2=T2+(VAL(MID$(T2$,4,2))*60)
32140 T2=T2+(VAL(MID$(T2$,1,2))*3600)
32150 IF D2>D1 THEN GOTO 32180
32160 IF D2<D1 THEN D1=D2:T1=T2:EI=X:GOTO
```

(continued)

```
      32180
32170 IF T2<T1 THEN D1=D2:T1=T2:EI=X
32180 NEXT X
32190 RETURN
33000 REM ANNOUNCEMENT ONLY
33010 REM DO CANNED MESSAGE FOR ANNOUNCE
33020 GOSUB 18000
33030 REM DO DATE/TIME IF DESIRED
33040 IF DT=1 THEN GOSUB 19000
33050 REM DO CALL-FORWARD NUMBER IF DESIRED
33060 IF CF=1 THEN GOSUB 20000
33065 REM SAY GOODBYE LIKE NICE FELLOW
33067 S=93:GOSUB 36000
33068 S=54:GOSUB 36000
33069 S=93:GOSUB 36000
33070 REM TEST TO SEE IF SPECIAL OR SUPER
      REQUESTED
33075 REM OUTPUT TONE
33077 S=96:GOSUB 36000
33080 GOSUB 35000
33090 RETURN
34000 REM SPECIAL ACCESS
34010 GOSUB 40000
34020 RETURN
35000 REM WAIT A BIT AND CHECK SPECIAL/SUPER
35010 SP=0
35015 C$="XD"
35017 GOSUB 29000
35020 FOR X=1 TO 500
35030 IF (INP(&H2F9) AND 2) = 0 THEN 35060
35040 IF INP(&H2F8)=&H2A THEN SP=1:X=300:GOTO
      35060
35050 IF INP(&H2F8)=&H23 THEN SP=2:X=300:GOTO
      35060
35060 NEXT X
35065 IF SP< >0 THEN PRINT "SPECIAL ACCESS
      REQUESTED"
35070 RETURN
36000 REM SPEECH OUTPUT
36010 REM S=POINTER TO PHRASE IN TABLE TB(X,Y)
36020 REM ASSUMES CONNECT IS ESTABLISHED
      ALREADY
36030 C$="x"+CHR$(22)
36040 GOSUB 29000
36050 OUT &H2F9,&H27
36060 REM WRITE OUT SPEECH DATA
36070 SYNTH%=0
36080 START%=TB%(S,1):COUNT%=TB%(S,2)
36090 CALL SYNTH%(START%,COUNT%)
36100 OUT &H2F9,&H7
36110 C$="v"
36120 GOSUB 29000
36130 RETURN
38000 REM RECORD ANNOUNCE #2
38010 REM DATA FOR CANNED PHRASE BUILD
38020 DATA 7,39,67,88,93,77,94,96
38030 REM SPEAK STUFF
38040 RESTORE 38020
38050 READ P
38060 FOR P1=1 TO P
38070 READ S
38080 GOSUB 36000
38090 NEXT P1
38100 RETURN
40000 REM SUPERVISORY AND SPECIAL FUNCTIONS
      ARE NOT YET IMPLEMENTED
40010 DATA 10,57,93,115,52,117,53,58,63,93,93
40020 RESTORE 40010
40030 READ P
40040 FOR P1=1 TO P
40050 READ S
40060 GOSUB 36000
40070 NEXT P1
40080 RETURN
```

Listing 3: *Source code for the* MOSDTMF *program.*

```
10 KEY OFF
20 CLS
30 PRINT "MOSDTMF"
40 PRINT "MOSART ROUTINE #3, DTMF INPUT,"
50 PRINT "VOICE RESPONSE DEMO SYSTEM"
60 PRINT:PRINT
70 REM INITIALIZE SPEECH TABLES
80 GOSUB 770
90 REM RESET MOSART
100 PRINT "RESETTING MOSART"
110 OUT &H2F9,0
120 OUT &H2F9,0
130 OUT &H2F9,0
140 OUT &H2F9,&H40
150 OUT &H2F9,&HFA
160 OUT &H2F9,&H7
170 C$="xv"
180 GOSUB 1250
190 BAD=0
200 REM AWAIT INCOMING CALL
210 PRINT "WAITING FOR LINE TO QUIET"
220 FOR X=1 TO 2000:NEXT X
230 PRINT "AWAITING CALL"
240 IF (INP(&H2F9) AND &H40) < > &H40 THEN 240
250 IF (INP(&H2F9) AND &H40) < > 0 THEN 250
260 FOR X=1 TO 500
270 NEXT X
280 PRINT "ANSWERING PHONE "
290 REM ANSWER PHONE
300 C$=CHR$(22)+"D"
310 GOSUB 1250
320 REM ANNOUNCE FIRST MESSAGE
330 PRINT "REQUESTING ID CODE"
340 DATA 8,55,93,67,87,56,61,42,73
350 RESTORE 340
360 GOSUB 1100
370 REM INPUT ID CODE
380 TIME-OUT=0
390 GOSUB 950
400 REM TEST TIME-OUT
```

```
410 IF TIME-OUT = 0 THEN GOTO 440
420 GOTO 450
430 REM TEST ID CODE
440 IF CODE$ = "78383" THEN GOTO 490
450 REM BAD ROUTINE
460 BAD=BAD+1
470 IF BAD>=3 THEN GOTO 90
480 GOTO 320
490 REM NO TIME-OUT, AND CODE GOOD
500 BAD=0
510 REM OUTPUT MESSAGE
520 PRINT "CONNECTED MESSAGE AND REQUEST FOR
    PHRASE NUMBER"
530 DATA 21,92,49,81,74,93,67,118,61,52,91,81,1,28,22,5,
    42,73,92,83,94,72
540 RESTORE 530
550 GOSUB 1100
560 REM INPUT NUMBER
570 TIME-OUT=0
580 GOSUB 950
590 REM TEST TIME-OUT
600 IF TIME-OUT = 0 THEN GOTO 630
610 GOTO 670
620 REM TEST END CODE AND THEN
630 REM TEST GOOD-NUMBER RANGE
640 S=VAL(CODE$)
650 IF S = -1 THEN GOTO 90
660 IF S>=0 AND S<=145 THEN GOTO 710
670 REM BAD ROUTINE
680 BAD=BAD+1
690 IF BAD>=3 THEN GOTO 90
700 GOTO 510
710 REM SAY SPEECH STUFF
720 PRINT "SAYING PHRASE NUMBER ";S
730 OUT &H2F9,&H27
740 GOSUB 1200
750 OUT &H2F9,&H7
760 GOTO 510
770 REM LOAD SPEECH TABLES AND DRIVER
    PROGRAM
780 DIM TB%(146,2)
790 DEF SEG=0
800 X=PEEK(&H510)+(256*PEEK(&H511))
810 X=X+&H1000
820 DEF SEG=X
830 PRINT "STORING SPEECH ROUTINE"
840 BLOAD "SPEECH.BIN",0
850 PRINT "LOAD OF SPEECH TABLES"
860 OPEN "SPEECH.TBL" FOR INPUT AS #1
870 FOR X=1 TO 145
880 INPUT #1,W$,TB%(X,1),TB%(X,2)
890 NEXT X
900 TB%(0,1)=34:TB%(0,2)=TB%(145,1)+TB%(145,2)-35
910 PRINT "SPEECH AND DRIVER LOAD COMPLETE"
920 CLOSE #1
930 CLOSE #2
940 RETURN
950 REM GET DTMF INPUT
960 PRINT "AWAITING DTMF INPUT"
970 CODE$=" "
980 REM INPUT DTMF DIGITS UNTIL #,* OR TIME-OUT
990 REM (TIME-OUT MEANS LOOP EXHAUSTED)
1000 TIME-OUT=1
1010 FOR X=1 TO 1750
1020 IF (INP(&H2F9) AND &H2) <> 2 THEN 1040
1030 X=1750:TIME-OUT=0
1040 NEXT X
1050 IF TIME-OUT=1 THEN RETURN
1060 IF INP(&H2F8)=&H2A THEN PRINT "DTMF DATA
     INPUT  WAS : ";CODE$:RETURN
1070 CODE$=CODE$+CHR$(INP(&H2F8))
1080 IF INP(&H2F8)=&H23 THEN CODE$="-1":PRINT "#
     KEY PRESSED":RETURN
1090 GOTO 980
1100 REM CANNED ANNOUNCEMENT
1110 OUT &H2F9,&H27
1120 REM SPEAK STUFF
1130 READ P
1140 FOR P1=1 TO P
1150 READ S
1160 GOSUB 1200
1170 NEXT P1
1180 OUT &H2F9,&H7
1190 RETURN
1200 REM SPEECH OUTPUT
1210 SYNTH%=0
1220 START%=TB%(S,1):COUNT%=TB%(S,2)
1230 CALL SYNTH%(START%,COUNT%)
1240 RETURN
1250 REM PROCESS MOSART COMMANDS
1260 REM C$=COMMAND STRING
1270 FOR X=1 TO LEN(C$)
1280 OUT &H2F9,&H7
1290 Y=0
1300 Y=Y+1:IF Y>5000 THEN PRINT "MOSART LOCKED
     UP":STOP
1310 IF (INP(&H2F9) AND 5) = 5 THEN 1320 ELSE 1300
1320 T$=MID$(C$,X,1)
1330 OUT &H2F8,ASC(T$)
1340 IF (INP(&H2F9) AND 2) = 2 THEN 1360
1350 IF (INP(&H2F9) AND 7) = 5 THEN 1370 ELSE 1340
1360 PRINT:PRINT "INFO BYTE FROM COMMAND ";T$;
     " WAS ";CHR$(INP(&H2F8))
1370 NEXT X
1380 RETURN
1390 REM SPEECH OUTPUT
1400 REM S=POINTER TO PHRASE IN TABLE TB(X,Y)
1410 REM ASSUMES CONNECT IS ESTABLISHED ALREADY
1420 C$="x"+CHR$(22)
1430 GOSUB 1250
1440 OUT &H2F9,&H27
1450 REM WRITE OUT SPEECH DATA
1460 SYNTH%=0
1470 START%=TB%(S,1):COUNT%=TB%(S,2)
1480 CALL SYNTH%(START%,COUNT%)
1490 OUT &H2F9,&H7
1500 C$="v"
1510 GOSUB 1250
1520 RETURN
```

The MOSART *makes it much easier for system designers to incorporate sophisticated features at low cost.*

that correspond to Steve (7-8-3-8-3). After entering the numbers, followed by an asterisk, the program moves to the output section. Entering any number from 1 to 145 will cause the corresponding phrase to be spoken. Entering 146 will dump the whole vocabulary, and entering an asterisk will cause the program to hang up the phone line. Time-out, hang-up, and error detection are all included to allow the system to handle the phone line without attendance by an operator. Using customized vocabularies would allow the use of MOSART in both inquiry and data-collection applications.

In Conclusion

If you are dead set against writing your own software, Xecom has an application package called Xenial, which includes Dialing Directories, Auto Answer, File Transfer (using the XMODEM protocol), and Access to DOS files by drive ID and Path. It is written to run on the evaluation board, but it is intended more as support for OEMs than as a competitive communications software package.

Compatibility is a moot point when the implemented functions don't exist in the devices that you might strive to be compatible with. The MOSART sets a new standard for computer communications and makes it much easier for system designers to incorporate sophisticated features at low cost. Perhaps it will be the new pacesetter and all others will strive to be compatible with it.

Circuit Cellar Feedback

This month's feedback is on page 450.

Next Month

I'll become one of the OEMs I often refer to as I design a modem-communications expansion board for the SB180 single-board computer using the MOSART. This communications board combined with some fancy software will turn the SB180 into a turnkey bulletin-board system. ■

Special thanks to Bill Curlew for his software expertise.

Drawings and specifications of the XE12XX MOSARTs *are reprinted by permission of Xecom Inc.*

The following items are available from

The Micromint Inc.
25 Terrace Dr.
Vernon, CT 06066
(800) 635-3355 for orders
(203) 871-6170 for information

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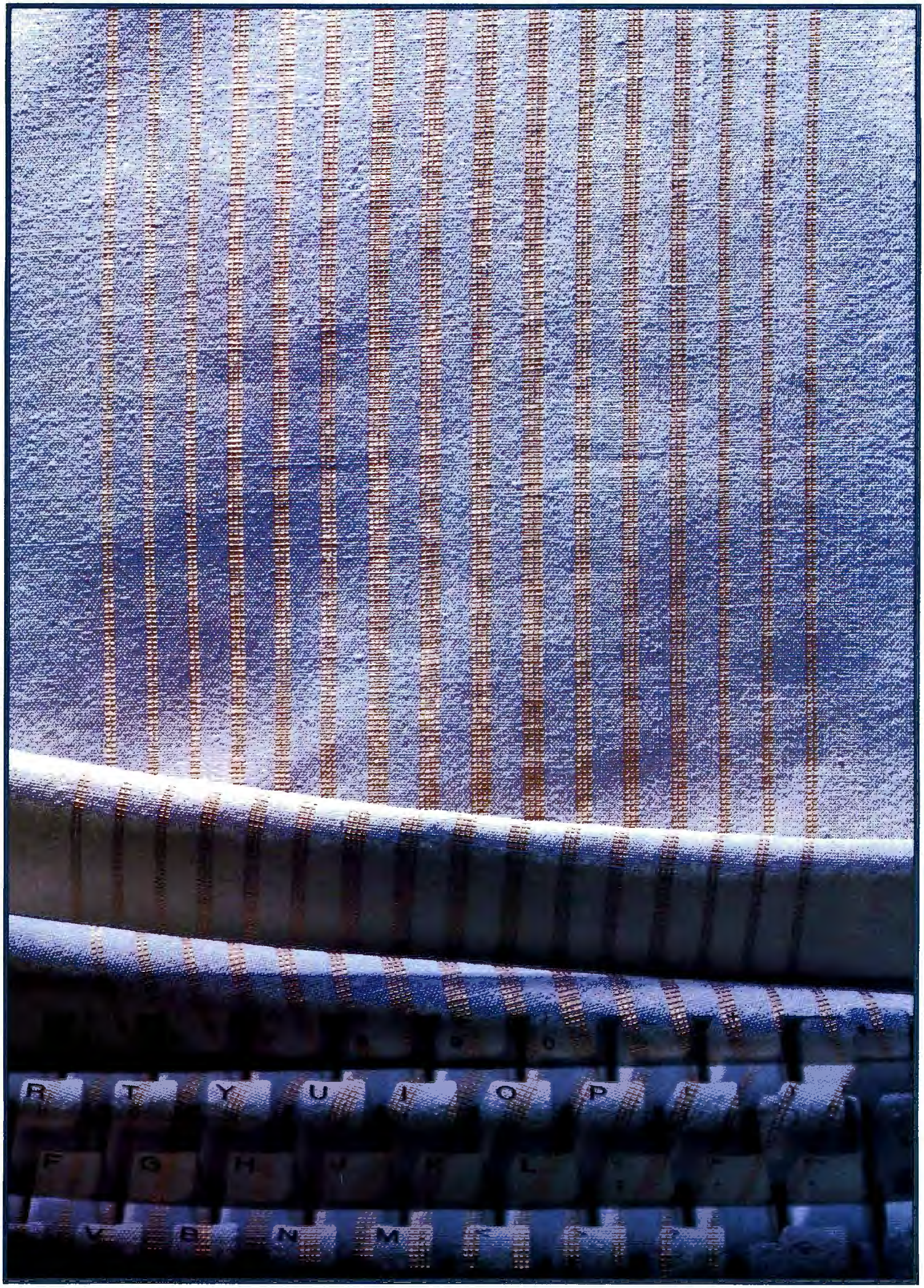

AN ASSEMBLER FOR VM2

BY JONATHAN AMSTERDAM

This assembler can ease the pain of machine-language programming

Last month I discussed my design for the VM2 virtual machine. The VM2 interpreter and a simple monitor program are available on BYTEnet Listings. (Call (617) 861-9774 before November 1; thereafter, call (617) 861-9764.)

This month I will present an assembler that will make VM2 easier to use and will provide a stepping-stone to my ultimate project—the construction of a high-level-language compiler. The assembler is written in Modula-2 and can also be downloaded from BYTEnet Listings.

You may recall that VM2 is a stack machine, which means that most of its instructions expect their arguments or place their results on the computer's stack. ADD, for example, takes the top two values off the stack, adds them, and pushes the result back on the stack. Some instructions expect their arguments to follow them directly in memory; an example is PUSHC, which pushes a constant on the stack.

As it stands now, the only way to get VM2 to do anything is to use the monitor program I described last month, which allows you to poke instructions and data one word at a time into memory. The assembler I am presenting this month will let you write programs using instruction mnemonics as well as symbolic names for data. This tool will also automatically translate these programs into a sequence of numbers that can then be loaded into VM2's memory and run.

WHAT IS AN ASSEMBLER?

An assembler is a computer program that translates other programs from one form to another. The input to the assembler is source code—human-readable text that uses symbolic names for instructions and data. The output is object code—a sequence of bit patterns (or numbers) that can be loaded directly into the machine's memory and executed. Figure 1 is a graphic description of the assembler's function.

The assembler's job is fairly easy because the level of the source code is close to the computer's actual instruction set. Consider the following VM2 program listing that adds 5 and 6, leaves the result on the top of the stack, and then stops.

```
PUSHC 5
PUSHC 6
ADD
HALT
```

Each of the assembler's instructions—

(continued)

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PUSHC, ADD, and HALT—is an actual VM2 instruction, represented in the computer as some word-long pattern of bits called an op code. Say, for example, that the op code for PUSHC is the number 1, for ADD is 2, and for HALT is 3. The object code for the short program listing just shown would then be the following:

1 5 1 6 2 3

Based on this example, you might think that something like the algorithm shown in figure 2 would serve for the assembler. It just keeps reading items from the input and translating them.

Such a program would certainly be useful, but you can improve it in two ways. First, you might want to provide some error checking. In its present form, this program will cheerfully assemble the sequence PUSHC HALT, even though PUSHC is supposed to be followed by an argument.

Second, you might want to be able to supply your own symbolic names for memory locations. This means you can name locations in which you want to store data, and it allows you to label points in your program to which you might want to branch. Listing 1 shows both of these uses of symbolic names, or labels, as they are usually called. This program counts down from 10 to 0. First the variable COUNT—that is, the contents of the memory location to which the label COUNT refers—is pushed on the stack. The BREQL instruction pops this value off the stack and, if it's 0, branches to DONE—that is, to the memory location to which the label DONE refers. If COUNT isn't 0, it is decremented and you go around the loop again.

Listing 1 also illustrates the syntax I used in my assembler. Assembly-language programmers will find it familiar; certain of its aspects are universal. The syntax can be described as follows:

- Labels appear at the beginning of the line and are followed by a colon.
- An instruction mnemonic may appear next. If the instruction takes an argument, the argument immediately follows the mnemonic.
- An argument may be a number or a label name.
- A mnemonic need not follow a label. Instead, an argument—that is, a number or label name—may follow a label (as with COUNT, above).
- Anything between a semicolon and the end of a line is a comment and is ignored by the assembler.

How are labels assembled? Well, whenever a label is defined (that is, whenever it appears at the beginning of a line and is followed by a colon), you need to associate the label name with the current memory location in some table. When the label is used (as an argument, for example), you retrieve the value from the table and output it. You can keep track of the current memory location by setting a counter to 0 before you start assembling and by incrementing it every time you assemble an item.

A revised version of my original algorithm is shown in figure 3. It keeps track of the current memory location and records labels and their values in a data structure called the label table. It also checks to see if arguments are provided for the instructions that require them.

This algorithm is closer to what I want, but it's not exactly right; it actually fails to work in some cases. In fact, it won't work in listing 1. I'll explain why in the next section.

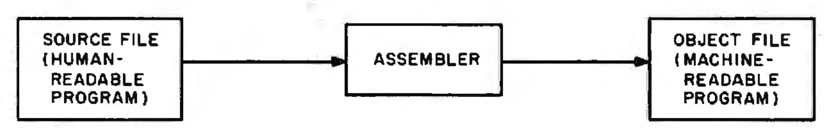

Figure 1: *The function of an assembler.*

```
Repeat until the end of input is reached:
  Read the next item from the input;
  If it is a mnemonic, find its op code and output it;
  If it is a number, just output the number.
```

Figure 2: *A first try at an assembler.*

Listing 1: *A VM2 program with labels.*

```
LOOP:   PUSH    COUNT
        BREQL   DONE     ; stop when COUNT = 0
        PUSH    COUNT
        PUSHC   1
        SUB
        POPC    COUNT    ; COUNT := COUNT - 1
        BRANCH  LOOP
DONE:   HALT
COUNT:  10
```

BACKPATCHING FORWARD REFERENCES

The second algorithm (figure 3) can't handle a situation where a label is used before it is defined. These so-called forward references are quite common. They occur twice in listing

(continued)

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Lexical analysis is the process of organizing a sequence of characters into meaningful chunks.

1: Both COUNT and DONE are used as arguments before they are defined. In listing 1 you could avoid the problem by moving the label definition to the beginning, but sometimes it's impossible.

This is a serious problem in the second algorithm. When the assembler reaches the item COUNT in the first line of listing 1, it doesn't know what the label's value is. Yet it has to output the correct value if it is to produce a proper translation of the program.

One possible solution is to read the input file twice. The first time through you just gather label definitions. The next time around you do the actual assembling. This method is reasonable, but it's time-consuming.

Instead, you could choose to reread the output file. You assemble as before, except that when you find an undefined label you output a special marker. When the input is finished, go back and read the output file, substituting the label definitions for the markers. You could read the output file faster than you could read the input file, because it has a simpler structure, but this method is still slow.

I used a third algorithm, shown in figure 4, that trades time for space. With this algorithm you don't need to reread any files, but you do need to keep the assembled program in memory. Instead of outputting an assembled value, you save it in a table I'll the program array, which is indexed by VM2 memory address. Not until you have read the whole input file do you output the program array. When you first see an undefined label, you insert it in the label table with an indication that it is undefined. Each time you encounter the label, you add the current location to a forward reference list. When you finally find the label's definition, you go *back* through the program array, *patching* each location in the forward-reference list with the correct value. This technique is called backpatching.

The algorithm shown in figure 4 is the same as the second one but it is augmented with backpatching. There are a few slight additions I want to make to this algorithm. It would be nice to be able to specify characters as well as integers so that a single quote followed by a character denotes the ASCII value of that character. For example, the instruction PUSHC '? would result in the ASCII value for a question mark being pushed on the stack. I also want to let a sequence of characters enclosed in double quotes indicate a string, so I could write "BYTE" instead of 'B 'Y 'T 'E. I also want to add a facility for assembler directives, that is, commands to the assembler that can be embedded in the source code. I'll say that a dot followed by a symbol indicates a directive. The only directive I'm going to include is .BLOCK, which reserves a chunk of memory. It's useful for specifying buffers, arrays, and tables. For example, I could write NED: .BLOCK 30 to reserve 30 words of memory and label the first word NED.

THE DETAILS

Three key sections of my assembler program need to be explained more fully: scanning the input, the organization of the label table, and backpatching.

LEXICAL ANALYSIS

The three algorithms I've presented ask us to read the next item from the input. But what constitutes an item? Obviously, the items should be chunks of input that are meaningful to the program. For the assembler, a label would be an item, as would an integer. Unfortunately, most programming languages can't help much with this job: Usually, they allow you to read the input only a character at a time. The process of organizing the sequence of characters into meaningful chunks is called lexical analysis, and usually the chunks are called tokens, not items. Successive calls on a lexical analyzer's getToken routine return successive tokens in the input stream.

If you pick up any textbook on compilers, you can find out more about lexical analysis than you probably want to know. For my purposes, a

```
Main program:
  Set the current location to zero.
  Repeat until the end of input is reached:
    Read the next item from the input;
    If it is a comment, ignore it;
    If it is a label definition, record it along with the current location
              in the label table;
    If it is a mnemonic, find and output its op code, and increment
              the current location;
      If the instruction takes an argument,
            Read the next item from the input and treat it as an argument.
    If it is not a mnemonic, treat it like an argument.

Handling arguments:
  If the item is a number, output it and increment the current location;
  If it is a label name, then
    If the label is defined, then get its value from the label table,
        output the value, and increment the current location;
    If the label is not defined, signal an error;
  If it is anything else (e.g., a mnemonic), signal an error.
```

Figure 3: *The revised assembler algorithm.*

rather simple scheme will suffice. This scheme requires that you back up over the input occasionally (which is something the fancy lexical analyzers never have to do—that's why they're faster). The first task is to provide low-level routines that allow you to read characters from the input and put them back onto the input when you need to. Since you'll never have to put back more than one character at a time, this is not difficult to implement. These two procedures, which I call getChar and ungetChar, are used by the rest of the lexical analyzer in building up tokens. The lexical analyzer consists of several different procedures, each designed to read a different kind of token. Typically, a procedure keeps getting characters until it finds one that does not belong in the token it is constructing; it then "ungets" that character and returns the token. For example, the procedure for reading an integer reads characters from the input until a nondigit is encountered, "ungets" the nondigit, and returns the integer represented by the string of digits it has read.

When called on to get a token, the lexical analyzer uses the next character of the input to decide which of these token-building procedures to call. If, for example, the next character is a digit, the number routine is called. This decision is most elegantly implemented by a dispatch table, which is an array of procedures indexed by character. The dispatch routine needs merely to get the next character, use it to index into the table and call the associated procedure. You can use this technique only if your programming language has procedure variables, as do C and Modula-2. If not, you will have to resort to a case statement.

Although the procedures using getChar are under the impression that only one character at a time is being read from the input, getChar itself doesn't have to work that way. In particular, the input can be read a line at a time, with getChar doling out characters in the line one by one. The advantage of this scheme is that the whole line is available for printing out when an error is detected, to give you some idea of where in the program the error occurred.

A lexical analyzer is a handy tool to have on your software workbench. Unfortunately, every program has its own way of carving up the input. Still, much of the guts of the lexical analyzer can be separated from the program-specific details, providing a general-purpose toolkit for building lexical analyzers. One of the modules for this project, LexAnStuff, is just such a toolkit. It provides getChar and ungetChar, a dispatch mechanism, an error-display procedure, and some useful reading routines that construct strings and integers. To build a lexical analyzer with LexAnStuff, you write your program-specific reading routines and install them in the character table. The dispatch routine does the rest.

My assembler's lexical analyzer recognizes eight different kinds of

(continued)

```
Main program:
  Set the current location to zero.
  Repeat until the end of the input is reached:
    Read the next item from the input;
    If it is a comment, ignore it.
    If it is a label definition, then
      Look it up in the label table;
      If it is not present, enter it along with the current location;
      If it is present but undefined, backpatch using the forward-
        reference list for the label;
      If it is present and defined, signal an error.
    If the item is a mnemonic, find its op code, place the op code
        in the program array at the current location, and
        increment the current location;
      If the instruction takes an argument, then
          Read the next item from the input and treat it as an argument.
    If the item is a directive, then
      If the directive is BLOCK, then
        Read its argument, which should be an integer;
        Increment the current location by the argument;
      If the directive is not BLOCK, signal an error.
  If the item is none of the above, treat it like an argument.
When the end of the input is reached,
    Check for labels that were used but not defined;
    Output the program array.

Handling arguments:
  If the item is a number, place it in the program array and increment the
      current location.
  If it is a character, place it in the program array and increment
      the current location.
  If it is a string, treat it as if it were a list of characters.
  If it is a label name, then
    If the label is defined, then
        Get its value from the label table;
        Place the value in the program array and increment the
          current location;
    If the label is not present in the label table,
      Enter it into the table;
      Start the forward-reference list by making the label-table
        entry point to the current location and placing a
        NIL in the program array at the current location.
    If the label is present in the label table but is undefined,
      Add the current location to the forward-reference list.
  If the item is anything else (e.g. a mnemonic), signal an error.
```

Figure 4: *The final assembler algorithm.*

The label table provides some sort of mapping between label names and values.

tokens: identifiers (strings of alphanumeric characters), label definitions (identifiers followed by a colon), directives (identifiers preceded by a dot), integers; character constants (a single quote followed by a character), string constants (a list of characters enclosed by double quotes), and end-of-line and end-of-file indicators. As all good lexical analyzers should do, it skips over comments, never mentioning their presence. So the callers of the lexical analyzer need not even consider comments—they can treat the program as comment-free. However, it does not distinguish mnemonics from uses of a label, although it easily could. Instead, it considers both to be identifiers, leaving the job of separating the two to higher-level functions. This was an arbitrary decision; you could do it either way.

THE LABEL TABLE

The label table provides some sort of mapping between label names and their values (the addresses at which they were defined). The simplest way to implement this mapping scheme would be to create a list of <label, value> pairs—used, perhaps, as an array or linked list of records. Searching this list for a label could take a long time, because there would be as many comparisons as there are labels. And since redefining labels is not allowed, you would need to search the whole list every time you want to insert a label to make sure it hasn't already been defined. Other schemes involving sorted lists or trees are also possible, but it is probably best in this case to use some form of hashing.

Hashing is based on the observation that, ideally, you'd like to be able to get the value of a label by just indexing into an array, using the label itself as an index. That would be extremely fast—and more importantly, the time it would take would be independent of the number of labels in the table. But such an array would have to be absurdly large, requiring one entry for every possible label; and even if you just consider, for example, seven-letter labels, there are over 8 billion possibilities.

But of course, no program has anywhere near this number of labels. Could you get by with a much smaller array by somehow compressing the labels into a smaller range of indexes? Perhaps you can take a label—indeed, any string of characters—and hash it up, turning it into a number small enough to index into your array. That's exactly the purpose of a hash function—given a string as input, it produces a number as output. The number serves as an index into an array called, appropriately enough, a hash table. There are several good choices for a hash function; one of the simplest and most effective is to add up the ASCII values of the characters in the string, divide the sum by the size of the hash table and output the remainder.

It is possible that two different strings will hash to the same spot in the table. My implementation handles these collisions by linear probing: If a label hashes to location n in the hash table and n is occupied, then locations $n+1$, $n+2$, . . . are examined until an empty one is found and the string is placed there. If I run off the bottom of the hash table, I continue searching from the top. When looking for a label in the table, I use the same technique, only now when I reach an empty hash-table entry (or when I have searched the entire table) I know that the label is not present.

THE ADVANTAGE OF BACKPATCHING

It may seem that backpatching requires space not only for the assembled program but also for the forward-reference list. But what endears backpatching to me is the fact that you need no additional storage for forward-reference lists. The forward references for a label form a linked list that is kept in the program array itself, in the very locations that would have been used to store the label values had the label been defined.

When the assembler encounters for the first time a label that hasn't been defined, it inserts that label into the label table with the current location as its value and puts a special value NIL in the program array at the current location. The value cell of the label-table record acts as a pointer into the program array, indicating the beginning of a linked list of forward references. A NIL terminates the linked list. Figure 5a illustrates this situation.

When a second occurrence of an undefined label is encountered, you link the current location onto the front of the forward-reference list. It is easy to do this: You put the contents of the label's value cell in the program array at the current location and replace the contents of the value cell with the current location. This situation is illustrated in figure 5b.

When you finally find the definition for the label, you update the label-table record to reflect this and step through the forward-reference list putting the correct value of the label into the indicated locations in the program array. You destroy the forward-reference list in the process, but so what? Its purpose has been served. Figure 5c shows what memory looks like after you have finished backpatching.

What value should NIL be? Anything that's not a valid VM2 address will do. But what, if any, word-length bit pattern can be a valid address? There's one value that can't be confused with the address of a forward reference; I leave its discovery to you.

INTERFACE TO VM2

My assembler reads in a VM2 assembly-language program and outputs a file that can be loaded by the VM2 monitor, a program I supplied with the VM2 machine simulator. The output file is actually a text file containing integers instead of some specially formatted file; this means you can read it with your friendly text editor.

Not that you'd want to do that too often—it's a little like reading punched paper tape—but I found it useful for debugging.

The loader always starts loading at location 0 and always loads consecutive memory locations. This affects the implementation of the .BLOCK directive. Basically, if a program says .BLOCK 100, you've got to output 100 zeroes (or some other value). This can make for large output files. It would be reasonable to extend the loader so that a special character in the file followed by a number *n* would result in the rest of the file being loaded from location *n*. This would solve the .BLOCK problem and also make it possible to start loading programs from a location other than 0. But be careful: The assembler assumes that the program will be loaded at a particular memory location—whatever the initial value of the current location variable is—and loading it into any other place will screw up all the program's references to memory.

EXTENSIONS

You can spiff up your assembler in a number of ways. Good assemblers allow the programmer to define symbolic constants with numeric values. So, for example, you could write

```
BUFSIZE = 30
```

at the beginning of your program and from then on use the more readable BUFSIZE instead of 30. Often you write arithmetic expressions that the assembler will evaluate for you. So if an array consists of 20 elements of two words apiece, you could write

```
NELEMENTS   = 20
ELSIZE      = 2
ARRAYSIZE   = NELEMENTS
  * ELSIZE
```

Another common addition is a macro facility. A macro instruction is a mnemonic that stands for several actual assembly-language instructions. You define the macro in your program by means of an assembler directive, and when you use it, the macro is replaced by the instructions that constitute it. Macro assemblers often have powerful features, but even a simple one will let you write macros with arguments. For example, say you are sick of writing

```
PUSH    A
PUSHC   1
ADD
POPC    A
```

every time you want to increment a variable. You'd like to just write INC A. Of course, you don't want to make the macro specific to A; any other label name should work in its place. The following macro will do the trick:

```
  .MACRO   INC   %1
; the % indicates an argument
  PUSH   %1
; argument is substituted here. . .
  PUSHC  1
  ADD
  POPC   %1     ; . . .and here
  .ENDM
; the "end macro" directive
```

All these extensions make it easier to write assembly-language code. But, except for a few test programs I wrote, I don't plan to do assembly coding. Instead, next month I'm going to tell you how to program in a high-level language and compile it into VM2 assembly language. ■

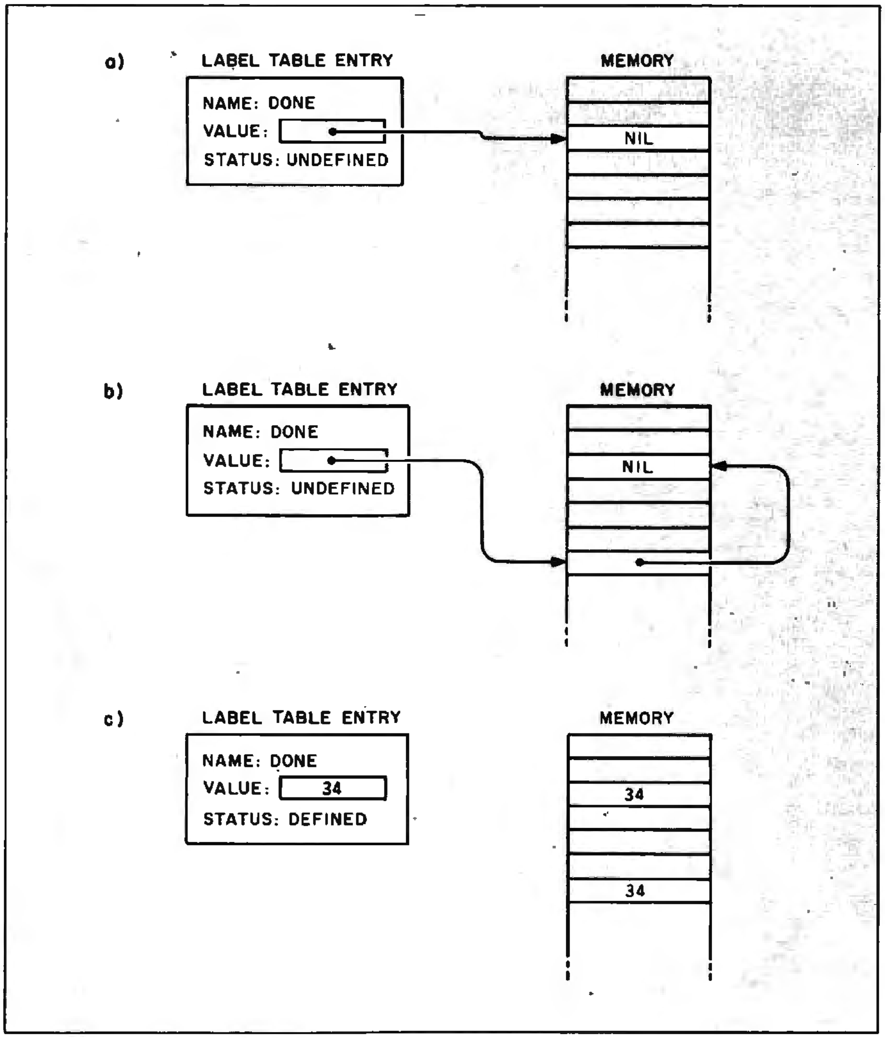

Figure 5: *The backpatching algorithm. (a) An undefined label is first encountered. (b) A second occurrence of the label is seen. (c) The label is defined at location 34.*

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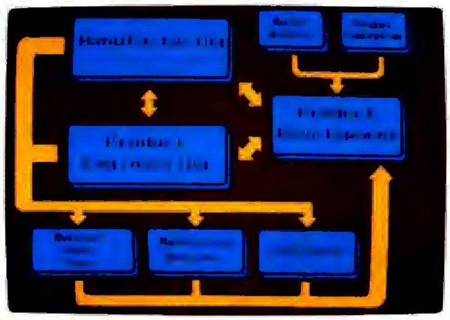

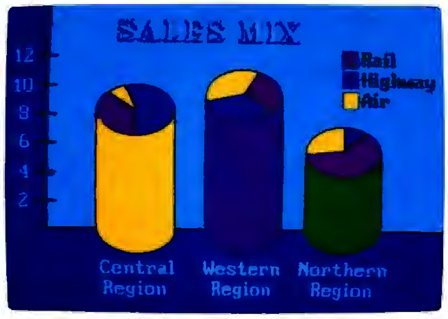

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EXTENDING TURBO PASCAL

BY BRUCE WEBSTER

Five subroutine libraries can enhance your Turbo Pascal working environment

No computer language is complete, although a few attempts have been made at creating a complete language (such as PL/I and Ada) with less-than-spectacular results. The reasons for such results are obvious. First, an attempt to include every conceivable feature in a language would result in an oversize, bloated compiler (or interpreter). Second, no matter what the language included, there would be users who would want something more or different or who would want certain features removed.

It appears that Niklaus Wirth realized these pitfalls when he designed Pascal some fifteen years ago. The language definition itself is fairly compact. Apple Computer Inc. once put out a remarkably uncrowded poster with the entire language definition on it. Wirth added a small selection of predefined procedures and functions to that definition. His latest effort, Modula-2, goes even further in that minimalist direction.

Unfortunately, Pascal (as Wirth defined it) has some annoying, if not serious, limitations. Most Pascal implementations have sought to overcome those limits by adding language features and predefined procedures and functions. Unfortunately, not all of them add the same things, and many of them drop features found in Wirth's definition or the later ISO (International Standards Organization) standard. Incompatible compilers and uncertainty about what you can or can't do are the results.

There isn't a whole lot you can do about features of the language itself, but you can add to the predefined procedures and functions by creating subroutine libraries (see my article "Subroutine Libraries in Pascal," June BYTE, page 253). Such libraries serve three purposes. First, if you're using two or more Pascal compilers, libraries can help to "standardize" them a little more by providing the same functions in each one. Next, they can help overcome deficiencies in a given implementation. And finally, they let you extend the language to suit your particular needs and help you avoid reinventing the wheel each time you program.

This article looks at five small libraries I developed specifically for Turbo Pascal (version 3.0). These libraries were developed keeping the ideas noted previously in mind. All were written on a Compaq under MS-DOS, but all should work equally well under CP/M and CP/M-86. Most of the routines could also be implemented for other Pascal compilers, such as MS-Pascal, Pascal/MT+, and Apple Pascal.

(continued)

Bruce Webster (846 East 840 N, Orem, UT 84057) is a contributing editor for BYTE.

It helps to have a set of bulletproof routines for user input/output. Having a library also gives your programs a consistent, predictable look.

Due to space limitations, complete listings aren't given here. Instead, the libraries (USERIO.LIB, INTEGERS.LIB, STRINGS.LIB, STRUCT.LIB, and LINKED.LIB) can be downloaded from BYTEnet Listings. Call (617) 861-9774 before November 1; thereafter, call (617) 861-9764.

USER INPUT/OUTPUT

Most programs you write will have a certain amount of user interaction. In particular, you'll prompt the user for commands and values. It helps to have a set of "bulletproof" routines that you can call to take care of the user I/O (input/output). Having a library also gives your programs a consistent, predictable look.

Figure 1 shows the data types and routines defined in USERIO.LIB. The two data types, MsgStr and CharSet, are needed for parameter passing because Turbo Pascal doesn't allow a string or set specification within a parameter list. Also, you might want to use the {$V−} compiler directive if you're going to be passing strings with differently defined lengths (i.e., string[30], string[255], etc.). The variables IOErr and IOCode are used by the routine IOCheck, which I will describe later.

The routine WriteStr is the basis for the rest of the library. All that WriteStr does is move to the indicated location on the screen, clear the rest of that line, write out the string passed to it, and leave the cursor sitting at the end of that string. The rest of the routines use the top line of the screen (Column = 1, Line = 1) when calling WriteStr; you, of course, are free to change that as you wish.

The routine Error writes its message on the top line, along with a beep (Control-G) and the added note (hit any key). It then waits for the user to hit any key.

GetChar puts a command prompt across the top of the screen, much like the UCSD p-System. It then waits for the user to enter a single character. That character is converted to uppercase (where appropriate) and then compared against the set OKSet. If the character is in OKSet, then GetChar returns it in Ch; otherwise, it just prompts for another character. A sample call to the function GetChar might look like this:

```
GetChar(Ch,'U)p D)own L)eft R)ight',['U','D','L','R'])
```

The Boolean function Yes makes a special call to GetChar. It appends the string (Y/N) onto the string Question and prompts for a Y or an N. Yes then returns True if Y has been entered, False otherwise. This is handy for loops and conditional statements like this:

```
repeat
  ...
until Yes('Are you finished yet?');
```

GrabInt and GetInteger both serve the same purpose. They prompt the user for an integer in the range Min..Max. Both append a string to Prompt showing Min and Max so the user can see what the limits are. The only difference between the two is that GrabInt returns the value as a function, while GetInteger passes the value back through the parameter Val. Why the difference? Well, if you've got integer subranges that are only 1 byte in size, you can't pass them as var integer parameters, but you can assign them integer values, hence the function. The procedure GetInteger isn't necessary—you could do everything with GrabInt—but it's included for those who want it. Assuming that TVal is of type Integer, the following calls have identical results:

```
TVal := GrabInt('Enter your age',0,150);
GetInteger(TVal,'Enter your age',0,150);
```

Both would write the string Enter your age [0..150]: to the top line of the screen and would continue to prompt until you entered an integer value from 0 to 150.

WriteReal writes out the real number RVal in one of two formats, fixed point (352.5) or floating point (3.525E+02). It uses fixed point if the number can fit within the fixed-point format, that is, if it has sufficient space before or after the decimal point; otherwise, it uses floating point. The parameter Width lets you specify the total field width; the parameter Digits, the number of digits after the decimal point if fixed-point format is used.

GetReal performs the same function as GetInteger, but (of course) for real variables. It calls WriteReal to print out the Min and Max values.

GetString is like the other Get routines; it writes the prompt on the top line of the screen and waits for the user to enter something acceptable. In this case, that something is a string not longer than the specified length (MaxLen) and containing only the characters specified in OKSet. GetString bypasses Turbo Pascal's string input routine and uses low-level character input to build the string itself. The only characters that GetString accepts are backspace (BS), carriage return (CR or Enter), and those in OKSet. BS deletes one character from the string and backs the cursor up a space, erasing the previous character. CR accepts the string you've entered so far. One special feature of GetString: If you hit CR without entering anything, the parameter TStr is left unchanged and is written out on the line after the prompt.

The last routine, IOCheck, is handy if you're doing any

(continued)

file I/O. To use it, you should turn off I/O error checking for your program with the compiler directive {$I−}. After each file I/O call, call IOCheck. If there's an I/O error, you'll get an error message at the top of the screen (via the routine Error), and IOErr will be set to True; otherwise, nothing happens, and IOErr is set to False. In either case, IOCode is assigned the error number so that you can take appropriate action. The following piece of code (using Turbo Pascal's structured-constant feature) shows one way of opening a file for input:

```
const
  FileSet : CharSet = ['.','0'..'9','A'..'Z','a'..'z'];
var
  FileName : string[12];
  InFile : Text;
begin
  repeat
    GetString(FileName, 'Enter input file: ',12,FileSet);
    Assign(InFile,FileName);
    Reset(InFile); IOCheck
  until not IOErr;
```

You could make several changes to this library. You could pass line and column values to most or all of the routines, allowing input (and output) anyplace on the screen. That would make it easy to set up a formatted screen with data fields. You could drop the prompts from most of the Get routines and specify a field width for all input values. The important thing is to decide what you like best and implement it. Once you've done that, you don't have to worry about it each time you start to write a new program.

```
type
  MsgStr        = string[80];
  CharSet       = set of Char;
var
  IOErr         : Boolean;
  IOCode        : Integer;
procedure WriteStr(Col,Line : Integer; TStr : MsgStr);
procedure Error(Msg : MsgStr);
procedure GetChar(var Ch : Char;
                Prompt : MsgStr; OKSet : CharSet);
function  Yes(Question : MsgStr) : Boolean;
function  GrabInt(Prompt : MsgStr;
                Min,Max : Integer) : Integer;
procedure GetInteger(var Val : Integer; Prompt : MsgStr;
                Min,Max : Integer);
procedure WriteReal(RVal : Real; Width,Digits : Byte);
procedure GetReal(var Val : Real; Prompt : MsgStr;
                Min,Max : Real);
procedure GetString(var TStr : MsgStr; Prompt : MsgStr;
                MaxLen : Integer; OKSet : CharSet);
procedure IOCheck;
```

Figure 1: *Data types and routines from the library* USERIO.LIB. *Due to space limitations, just the procedure statement for each routine is shown.*

```
function Sign(Val : Integer) : Integer;
function Min(Val1,Val2 : Integer) : Integer;
function Max(Val1,Val2 : Integer) : Integer;
procedure ISwap(var Val1,Val2 : Integer);
function ISqrt(Val : Integer) : Integer;
procedure Condition(Min : Integer; var Val : Integer;
  Max : Integer);
function AMin(var IAddr; Size : Integer;
  var Mndx : Integer) : Integer;
function AMax(var IAddr; Size : Integer;
  var Mndx : Integer) : Integer;
```

Figure 2: *Routines from the library* INTEGERS.LIB.

INTEGERS

Turbo Pascal lets you do more with integers than most Pascal implementations. In addition to the standard operations, you can use the operators and, or, xor, shl, and shr with integers. Additional procedures and functions, such as Hi and Low, are also provided. But there are, of course, those little things that you always want to do: minimum and maximum values, swapping two integers, and so on. The library INTEGERS.LIB provides some of those functions for you. The declarations for INTEGERS.LIB are shown in figure 2.

The first function, Sign, simply returns the sign (−1, 0, or +1) of the integer Val. It makes a good companion to the function Abs, which is already defined in Turbo Pascal. The next two, Min and Max, also do what you would think: return the minimum (or maximum) of the two values passed. And the routine ISwap swaps the values of Val1 and Val2.

The function ISqrt lets you find square roots without resorting to real arithmetic. It returns the integer square root of Val, that is, the real square root of Val rounded to the nearest integer. For example, this code fragment:

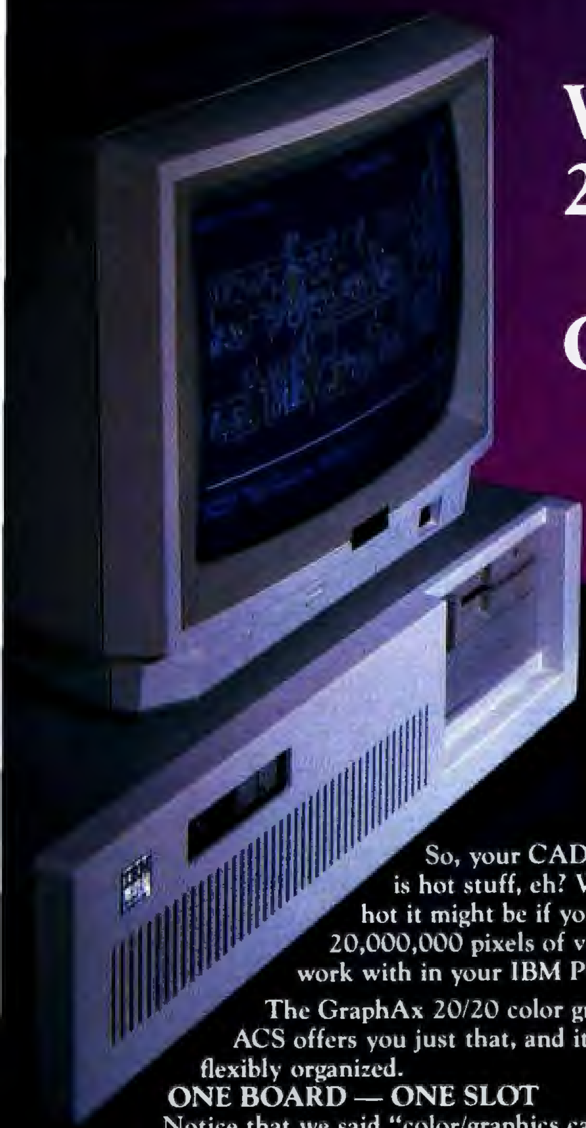
```
for Indx := 0 to 9 do'
  WriteLn('ISqrt(',Indx,') = ',ISqrt(Indx));
```

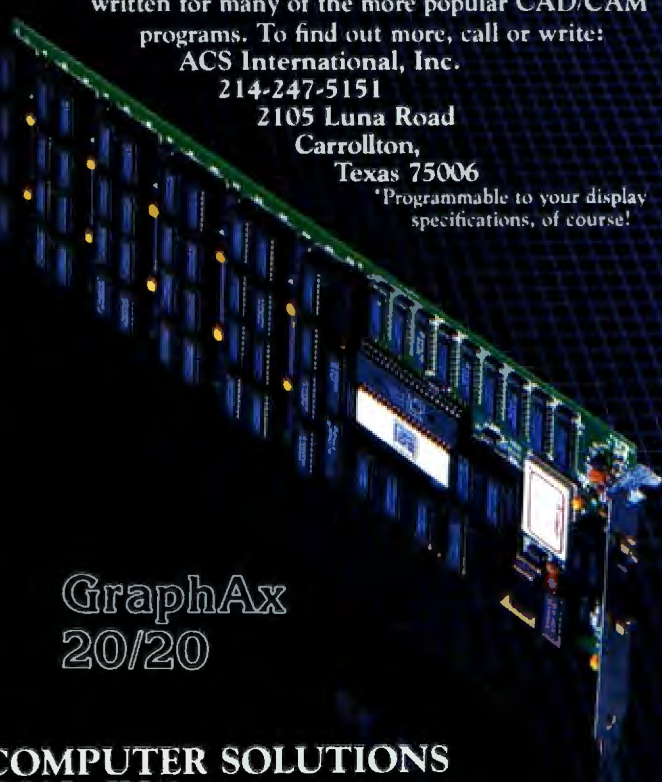
would produce this output:

```
ISqrt(0) = 0
ISqrt(1) = 1
ISqrt(2) = 1
ISqrt(3) = 2
ISqrt(4) = 2
ISqrt(5) = 2
ISqrt(6) = 2
ISqrt(7) = 3
ISqrt(8) = 3
ISqrt(9) = 3
```

The procedure Condition lets you force an integer (Val) to be in the range Min..Max. You can use this to make other routines more bulletproof; for example, a graphics routine might call Condition to force coordinates passed

(continued)

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Replace *can be thought of as the "junk mail" procedure, substituting each instance of* OldStr *with* NewStr.

to it to be within screen limits. By the way, Condition will call ISwap(Min,Max) if Min is greater than Max.

AMin and AMax provide the same functions as Min and Max, but for arrays of integers. The array can be of any length, and you can start at any point in the array. You also tell the routine how many integers to look at. You pass the array and the length (in integers), and the routine returns the minimum (or maximum) value as well as the index of that value, relative to the starting point. Given the following code:

```
const
  NumList : array[1..10] of Integer =
    (-20, 3, 523, -1, 72, 44, -10, 7, -1000, 25);
var
  Val,Indx : Integer;
begin
  Val := AMin(NumList,10,Indx);
  Write('Min: NumList[',Indx,'] = ',Val);
  Val := AMax(NumList,10,Indx);
  Write('Max: NumList[',Indx,'] = ',Val);
  Val := AMin(NumList[3],5,Indx);
  Write('Local min = NumList[',Indx,'] = ',Val)
end.
```

you'll get the following output:

```
Min: NumList[9] = -1000
Max: NumList[3] = 523
Local min = NumList[7] = -10
```

Similar routines for arrays of bytes could be written.

STRINGS

One of Pascal's greatest flaws is the lack of a standard character string type. When working in a punched-card, magnetic-tape mainframe environment, Wirth just used arrays of type Char for any string manipulation. Unfortunately, that makes for clumsy string handling.

The closest thing to a standard for Pascal strings is that found in UCSD Pascal. A string of length N (defined as string[N]) is implemented (invisible to the user) as an array[0..N] of Char, with the current length of the string stored in location 0. Several procedures and functions are provided for string manipulation. Turbo Pascal uses that standard and adds a few routines to it. The library STRINGS.LIB adds a few more.

Figure 3 shows the declarations in STRINGS.LIB. Note that the compiler directives {$R-} and {$V-} are used to turn off range checking and length checking of string parameters. The data type BigStr (which has the maximum allowable size of a string) is used for all parameters. Note that there is another definition, SetOfChar, for character sets. This is needed for parameter passing, just like the type CharSet in USERIO.LIB, but a different name has been chosen to avoid definition conflicts should you use both libraries in the same program. The two data types are equivalent so that variables of one type can be passed as parameters to routines using the other.

LowToUp is a simple routine that converts all lowercase alphabetic characters (a through z) in TStr to uppercase letters. This procedure is useful when you want to compare two strings that might have the same text but different capitalization: Just convert both to all uppercase and then compare.

The procedure Strip removes any characters from the start of Line that are found in the character set Break. This lets you remove leading blanks, punctuation, and so on. The new length of Line is returned in the variable Len.

The next routine, Parse, uses Strip to help pull off the next "word" in Line. A word is defined as a substring that doesn't contain any of the characters found in Break. Parse calls Strip to remove any leading unwanted characters, then copies the following word into Word. It then calls Strip again to clean up any trailing characters. The following code:

```
Line = 'Come here, Watson, I need you!';
BreakSet := [' ',',','!'];
while Line <> '' do begin
  Parse(Line,Word,BreakSet);
  WriteLn('Word = ',Word)
end;
```

produces the output:

```
Word = Come
Word = here
Word = Watson
Word = I
Word = need
Word = you
```

The last routine, Replace, can be thought of as the "junk mail" procedure. It goes through Target and replaces each instance of OldStr with NewStr. MaxLen specifies the maximum size of Target; once that is reached, no more substitutions take place (to avoid overflowing the string boundaries). The following code:

```
Line := 'And so, Mr. <name>, the whole <name>
  family';
Token := '<name>';
Name := 'Lemming';
Replace(Line,Token,Name,80);
WriteLn(Line);
```

results in the output:

(continued)

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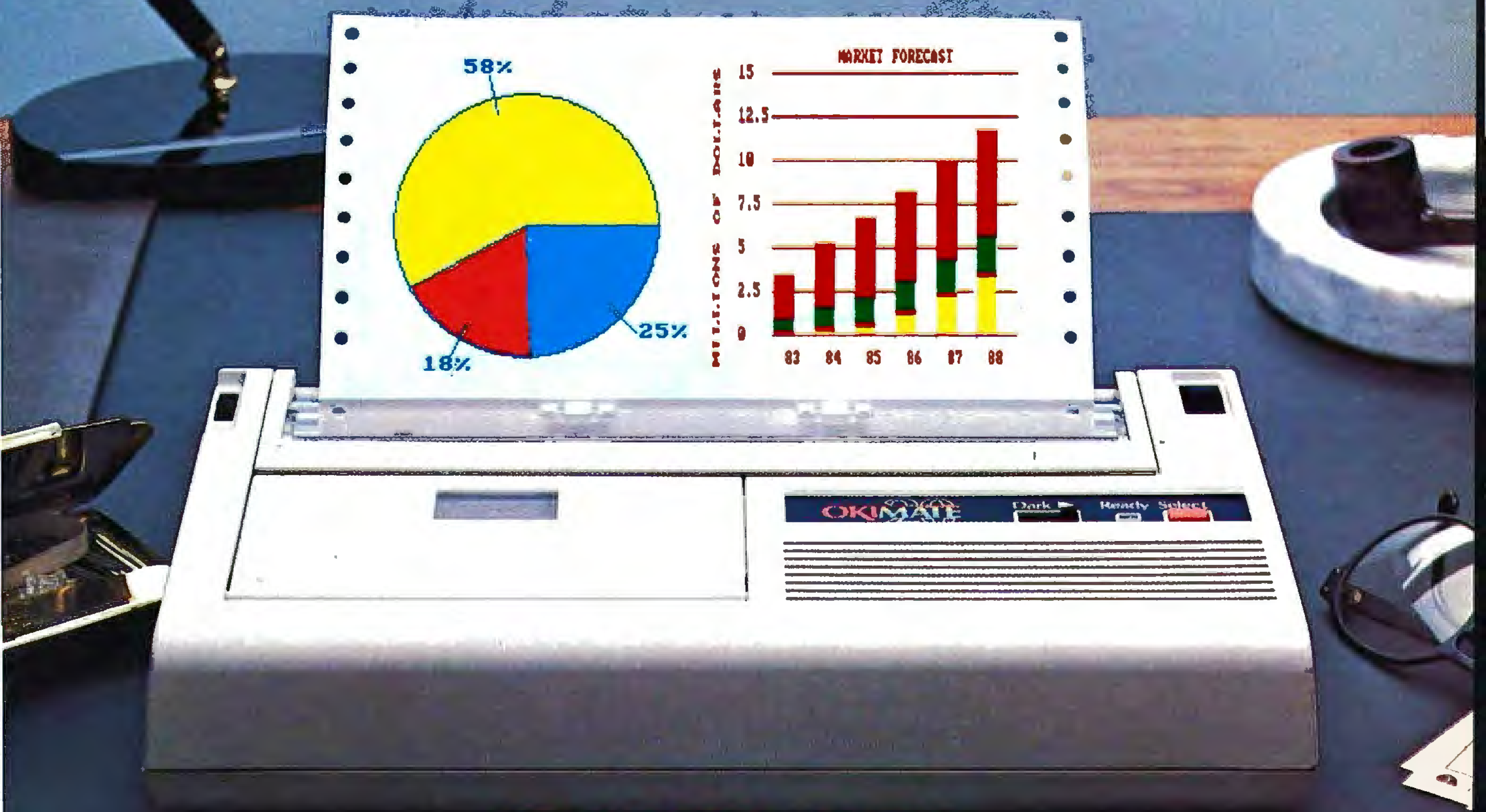

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```
{$R-} { turn off range checking (if on) }
{$V-} { turn off string parameter length checking }
type
  BigStr              = string[255];
  SetOfChar           = set of Char;
procedure LowToUp(var TStr : BigStr);
procedure Strip(var Line : BigStr;
  var Len : Integer; Break : SetOfChar);
procedure Parse(var Line,Word : BigStr; Break :
SetOfChar);
procedure Replace(var Target : BigStr;
  OldStr,NewStr : BigStr; MaxLen : Byte);
```

Figure 3: *Compiler directives, data types, and procedures from the library* STRINGS.LIB.

```
procedure ASwap(var A1Addr,A2Addr; Size : Integer);
function Identical(var A1Addr,A2Addr;
  Size : Integer) : Boolean;
function Any(var SetAddr,VAddr; Size : Integer) : Boolean;
```

Figure 4: *Routines from the library* STRUCT.LIB.

Listing 1: *This procedure from* STRUCT.LIB *shows how to use the untyped parameter and absolute address definitions to write general-purpose routines.*

```
procedure ASwap(var A1Addr,A2Addr; Size : Integer);
{
        purpose          swaps A1 <-> A2
        last update      23 Jun 85
}
type
  DummyArray          = array[1..MaxInt] of Byte;
var
  A1                  : DummyArray absolute A1Addr;
  A2                  : DummyArray absolute A2Addr;
  Temp                : Byte;
  Indx                : Integer;
begin
  for Indx := 1 to Size do begin
    Temp    := A1[Indx];
  A1[Indx]  := A2[Indx];
  A2[Indx]  := Temp
  end
end; { of proc ASwap }
```

And so, Mr. Lemming, the whole Lemming family

Now you know why it's the "junk mail" procedure.

Data Structures

Figure 4 shows the definitions in the library STRUCT.LIB. With these routines you can do certain manipulations of data structures. All are based on a feature in Turbo Pascal that lets you pass the address of a variable without passing any data-type information. Since Turbo Pascal also lets you declare a variable at a given address, you can (within your procedure) declare a data structure at that parameter's address and then manipulate it to your heart's content. (The routines AMin and AMax in INTEGERS.LIB used this technique.) Let's look at an example.

You saw the routine ISwap (in INTEGERS.LIB) that let you swap two integers. Now you can do the same with any two data structures: strings, arrays, records, sets, and so on. The procedure ASwap, shown in listing 1, remaps both of the structures passed into arrays of type Byte, then swaps them on a byte-by-byte basis. Since no data-type information is passed, you have to explicitly pass the size, like this:

```
var
  Str1,Str2 : string[255];
begin
  Str1 := 'Hello, world.';
  Str2 := 'This is a test.';
  ASwap(Str1,Str2,256);
  ...
```

This would do a complete swap of Str1 and Str2, including the length byte (Str1[0] and Str2[0]) and all the currently unused bytes in both strings.

The Boolean function Identical overcomes a serious deficiency in Turbo Pascal. Turbo Pascal does not let you compare two records for equality; given the definitions:

```
type
  QuickRec =
      record
        F1,F2 : Integer;
        Whatever : Real;
        Name : string[10]
        end;
var
  Rec1,Rec2 : QuickRec;
```

the expression "Rec1 = Rec2" is illegal. The function Identical, though, does a byte-by-byte comparison between the two records, so that you could write

```
if Identical(Rec1,Rec2,SizeOf(QuickRec))
  then WriteLn('records are identical')
  else WriteLn('records are different');
```

The same limitation (and solution) applies to arrays: You cannot do a direct comparison between two arrays, but

(continued)

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you can use Identical to check them.

A certain danger exists in comparing records, especially if one record has not been directly assigned to the other. Certain fields, such as strings, may have unused portions that currently hold "garbage" values. If you're going to use Identical, then you should always fill a record with some value (preferably 0) before initializing its fields. Likewise, if you're changing string fields, then you might want to zero out the entire string before setting it to its new value.

The last function, Any, is specific to sets. You pass it a set and a scalar variable (note that these do not have to be of the same data type, though you'll generally want it that way), as well as the size of the set. (Note: Since sets of the same type can be of different sizes, you should always take the size of the specific set you're passing.) If the set is currently empty, then Any returns False; otherwise, it returns True, assigns the lowest element of the set to the scalar variable, and removes that element from the set. In effect, this lets you set up a For loop with the following set of values:

```
var
  LoopSet : set of Byte;
  Indx: Byte;
begin
  LoopSet := [1,4,9,16,25,36,49,64,81,100];
  while Any(LoopSet,Indx,SizeOf(LoopSet)) do begin
     ...
  end
end.
```

The code within the while..do loop executes once for each value in LoopSet, with Indx set to each of those values, from the lowest to the highest.

LINKED LISTS

Pascal provides pointer and dynamic storage allocation, so you can create linked lists. The library LINKED.LIB is designed to make that as simple and painless as possible. Figure 5 shows the definitions for LINKED.LIB. It assumes that you have already defined two data types, Node and NodePtr:

```
const
  Front          = True;   { for use with Add and Take}
  Rear           = False;  { ditto }

procedure InsertNode(var NPtr,TPtr : NodePtr);
procedure RemoveNode(var NPtr,TPtr : NodePtr);
function GetNode(var NPtr : NodePtr) : Boolean;
procedure CreateList(var Header : NodePtr);
procedure RemoveList(var Header : NodePtr);
procedure Push(var NPtr,Header : NodePtr);
procedure Pop(var NPtr,Header : NodePtr);
procedure Add(var NPtr,Header : NodePtr;
  onFront : Boolean);
procedure Take(var NPtr,Header : NodePtr;
  offFront : Boolean);
```

Figure 5: *Constants and routines in* LINKED.LIB.


```
type
  NodePtr = ^Node;
  Node =
    record
      Next,Last : NodePtr;
      {other data fields}
  end;
```

These must be defined before the {$I LINKED.LIB} statement, since the library routines make reference to Node and NodePtr variables.

The routines in LINKED.LIB work on a circular, doubly linked list that uses a header node. "Circular" means that if you go through the list, you'll end up back where you began. "Doubly linked" means that each node points to both the previous and following nodes. A "header node" (usually) contains no information but just points to the start and the end of the linked list; if the list is empty, then it just points to itself.

InsertNode makes the node pointed to by NPtr follow the node pointed to by TPtr. In other words, after calling InsertNode(NPtr,TPtr), then TPtr^.Next = NPtr and NPtr^.Last = TPtr. By contrast, RemoveNode assigns TPtr to NPtr, then removes the node it's pointing to from the linked list. These are the two basic linked-list functions; all the other routines call one or the other of these.

GetNode is a bulletproof Boolean function for creating a new node (which you must do before you can insert it into the linked list). It makes sure that there is enough memory before creating the new node. If there isn't, it returns a value of False and sets NPtr equal to nil; otherwise, it creates a node, points NPtr at it, fills the data fields with all zeros, sets Next and Last to nil, and returns a True value.

CreateList sets up the header for you. If there isn't enough space, Header is returned with a value of nil. Otherwise, Header gets created, and its Next and Last nodes point to itself. This is the first routine you should call when using a linked list. By contrast, RemoveList is the last routine you should call. It removes all the nodes from the linked list, disposes of each of them (thus reclaiming the memory), and then disposes of Header.

The routines Pop and Push let you set up a stack or stacks. Since you pass the header node along with the node being pushed or popped, you can maintain several stacks simultaneously. Pop and Push make the appropriate calls to InsertNode and RemoveNode; if the stack is empty, then Pop sets NPtr to nil.

Likewise, with the routines Add and Take you can implement a queue or a deque (double-ended queue). Besides the node and header pointers, both routines expect a flag indicating whether to use the front (Header^.Next) or rear (Header^.Last) ends of the list. The constant values Front and Rear are defined for your use as that flag.

CONCLUSION

The idea of small, self-contained libraries as language extensions is a powerful one. It lets you expand the language as you need to. Indeed, Modula-2 can be thought of as a "bare bones" Pascal that is customized via libraries. Each of the libraries examined here is independent of the others, and there are no identifier conflicts between them (i.e., no data types, variables, or routines with the same names). Carefully crafted, well-thought-out libraries can greatly increase your effectiveness and productivity and can help you to customize Pascal to suit your own needs and tastes. ■

HENRY FORD
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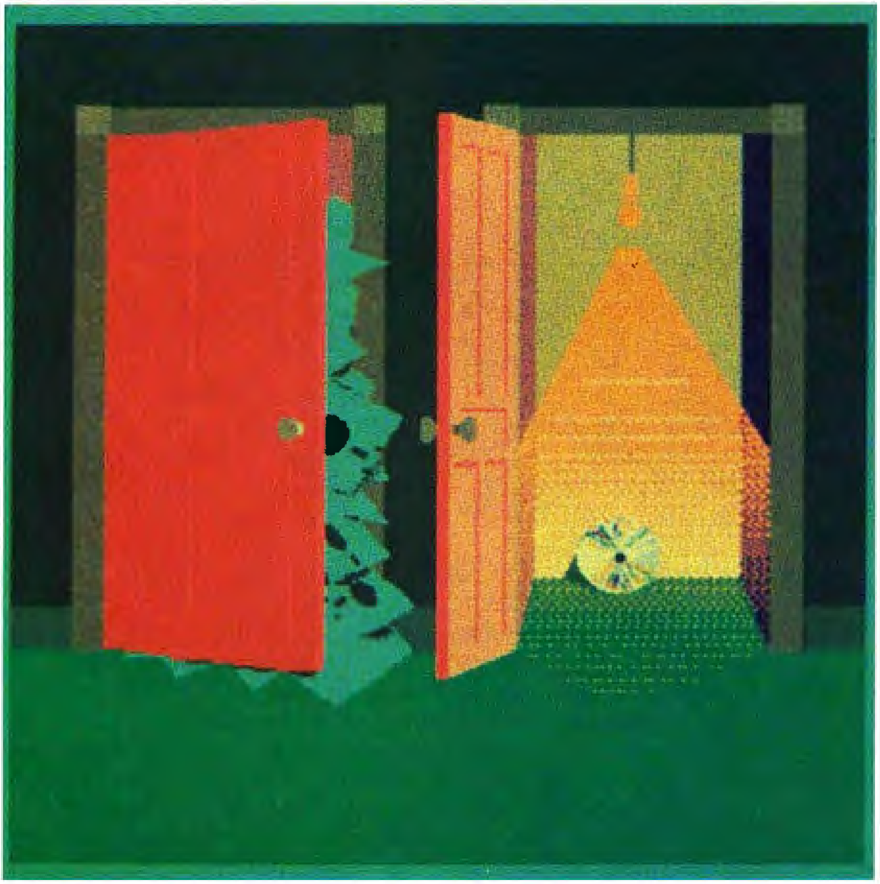
BY RICHARD S. SHUFORD

CD-ROMs AND THEIR KIN



Developments in optical data storage

The first users of personal computers preserved their data between work sessions (or system crashes) by punching holes in paper tape. It wasn't long before someone discovered how to harness an audio-cassette recorder for that same task. Since that time, users have demanded ever-increasing speed and capacity in microcomputer data storage and the simple tape gave way to the floppy disk and then to the hard disk. However, the device remained the same: A magnetic field was used to read and write the bits of data.

But traditional magnetic disks now have competition; optical data storage has emerged from the laboratory.

Such optical storage devices, featuring data capacities in the hundreds of megabytes, claim several other advantages over traditional storage: freedom from danger of head crashes, possibility of interchange of disks between drives, and good data permanence.

TYPES OF OPTICAL STORAGE

Just as there are different kinds of magnetic storage devices, there are a variety of optical disks and drives: drives that can only read prewritten data; drives that can be used to imprint data permanently (that is, nonerasably); and drives that can read, write, and erase data on disks.

The simplest optical storage peripherals are the read-only devices. These are used in much the same way as a phonograph record: You buy a program or a database on an optical disk that has been recorded by a professional vendor and "play it back" on the read-only drive. Read-only optical disks promise easier distribution of large software products than has been

(continued)

Richard S. Shuford, formerly a BYTE *special-projects editor, is currently a scientific programmer for Siecor Corporation* (489 *Siecor Park, Hickory,* NC 28603).

possible with floppy disks.

If you need to record your own data, the only products currently available off the shelf are optical drives that use a nonreversible process to write data onto their media. Once written, the data can be read back as many times as needed, so that these peripherals are sometimes known as write-once, read-mostly (or WORM) drives. Write-once devices are being used for archival service and for on-line storage in applications where large sets of data are kept that never, or rarely, change.

Data can be recorded on an optical disk by exploiting a wide variety of physical or chemical effects that change either the reflectivity or transmissivity of the media. In a read-only disk, bumps or holes representing bits are formed when the disk is manufactured. In a writable system, any of several phenomena may be exploited to modify a disk from its unwritten condition.

It's not too great a trick to make an optical disk on which you can write data once, indelibly. Several manufacturers, including Alcatel Thomson Gigadisc (ATG), Optimem, Information Storage Inc. (ISI), and Optotech, are beginning to deliver computer peripherals with this capability.

Write-once recording uses the concentrated energy of a strong laser beam to modify a tiny region in a thin sensitive layer in the disk to represent a 1 bit (an unmodified area represents a 0 bit). This modification varies from system to system, but the common effects are ablation, deformation, bubbling, and melting. Later, when a lower-power laser beam is passed over the disk, the written area reflects the beam in a manner different from its surroundings, or not at all. A photodetector can sense the change in reflectivity and generate an electrical signal corresponding to a 1 bit.

Figure 1 shows the structure of a write-once optical disk; in this case, it is that used by Optimem and ATG. The sensitive layer is a thin film of precious-metal alloy sitting on top of a polymer cushioning layer, all of which resides on top of a stiff glass substrate. Two layers of this structure can be placed face to face (with separators) for two-sided recording. In practice, the disk has concentric tracking grooves, not shown here, embossed into it during manufacture; the data bits are actually written into the grooves.

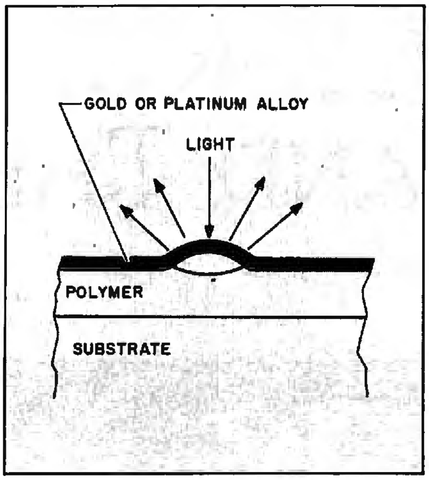


Figure 1: *In a write-once optical disk, the readable 1 bit is made by a strong laser beam melting, bubbling, or otherwise deforming the sensitive layer of the media.*

The permanence of the melted holes or deformed bubbles is desirable in archival applications, but devices incorporating them are inherently limited to write-once operation. While write-once technology has many potential uses, an optical storage system that can also be erased and rewritten is so obviously desirable that dozens of research teams around the world are feverishly working to develop a practical read/write system. Research is proceeding along two paths: one purely optical and the other a hybrid that borrows a few points from magnetic storage.

Changing Phases

The pure-optical technique of reading and writing (and rewriting) involves changing the physical phase of a thin metal-alloy film.

In the *phase-change* process, the disk contains a thin film of metal alloy (based on tellurium or selenium) that is initially in a polycrystalline state. To record a bit representing a binary 1, a relatively high-power beam of laser light is concentrated on a small area, inducing heat and causing the film at that spot to melt (changing its phase from a crystalline to an amorphous state). During read-out, when a low-power laser beam is shone on the spot, the amount of light reflected from the amorphous area is less than that reflected from its crystalline surroundings, and the spot appears dark. The data can be erased by applying laser energy and generating enough heat in the film to anneal the material back into the crystalline phase.

One reason phase-change data storage is taking so long to develop is the difficulty of choosing the materials for the disk's sensitive layer. The medium must be sensitive enough that the laser beam's heat can deform it in a few tens of nanoseconds, and it must have enough affinity for crystallization that it can be annealed under slightly less heat in microseconds; yet it must be stable enough in the amorphous condition to stay that way at room temperature for years (see figure 2).

Of Lasers and Magnets

The hybrid *magneto-optic* system for reading and writing (and rewriting) borrows much from conventional magnetic technology and is sometimes referred to as *thermomagnetic* or *optically assisted magnetic* storage. The first commercially distributed medium for magneto-optic data storage was announced by the 3M company. Various companies have demonstrated prototypes of the medium.

A magneto-optic disk drive uses both a laser apparatus and a magnetic read/write head. The sensitive layer of the disk is composed of an alloy film of rare-earth and transition metals, such as TbFeCo (terbium, iron, and cobalt) or GdTbFe (gadolinium, terbium, and iron). In the unwritten state, the magnetic domains in these materials are unaffected by the field of the read/write head. However, when intense light from the laser is focused on a point within the head's

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Conditional compilation	Yes	No
Full memory usage (to 1 megabyte)		
program code	Yes	No
data	Yes	Yes
Overlay support	Yes	Yes
Math library support		
8087/80287 emulation	Yes	No
8087/80287 coprocessor support	Yes	No*
Floating-point	Fast IEEE	non IEEE
BCD floating-point	Yes	No*
MS-DOS® 3.1 network support (incl. IBM LAN)	Yes	No
Link multiple routines	Yes	No
Link existing third-party libraries	Yes	No
Link with Microsoft FORTRAN, C and Macro Assembler	Yes	No
Relocatable object format	Yes	No
Transport source between MS-DOS and XENIX	Yes	No
Do source level debugging	Yes	No
LINKER included	Yes	No
Library Manager included	Yes	No
Utility to modify and examine header	Yes	No
Compress utility	Yes	No

Pascal Benchmarks—done on a COMPAQ Plus™ with 512K memory with no 8087

	—Execution Time—	
Gauss-Seidel	:05.15	:07.60
Sieve of eratosthenes	:13.15	:15.88
Trig	:13.11	:34.97

*Option available separately

field, the laser heats the alloy to a temperature above its Curie point, where it is easily magnetized by even a small field. As the laser beam passes and the spot cools, the medium retains the magnetization of the field and forms a tiny magnetic domain. Such magnetized regions may be much smaller than the gap spacing of any ordinary magnetic head.

The real cleverness comes in reading the data back. Certain alloys of rare-earth and transition metals have a peculiar effect on polarized beams of light, rotating the angle of polarization slightly in a direction that depends upon the direction of magnetization of the domains in the alloy. When this effect occurs through reflection, it is called the Kerr Rotation; if the light is transmitted through the layer, the effect is termed the Faraday Rotation. By aiming the laser back at the recorded bit area (at low power), magneto-optic systems can detect the different polarity angles that represent 1s or 0s of data.

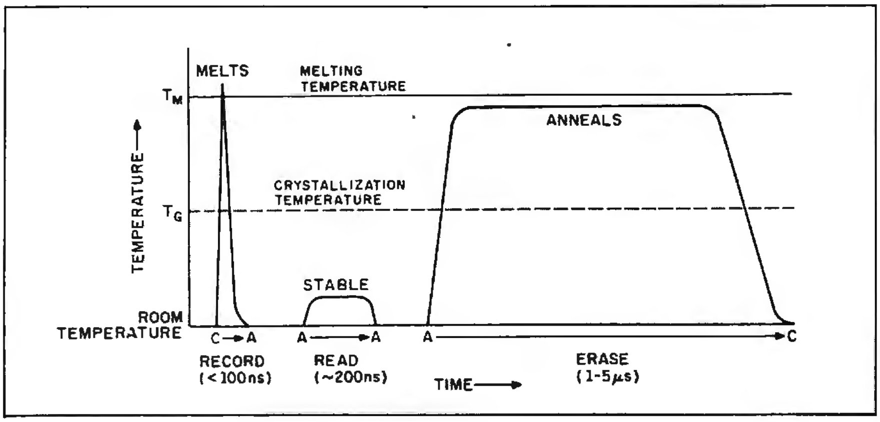

Figure 2: *Media for phase-change optical disks can be changed from crystalline to amorphous state by nanoseconds of high heat, and changed back by microseconds of slightly less heat, but they must be stable at room temperature.*

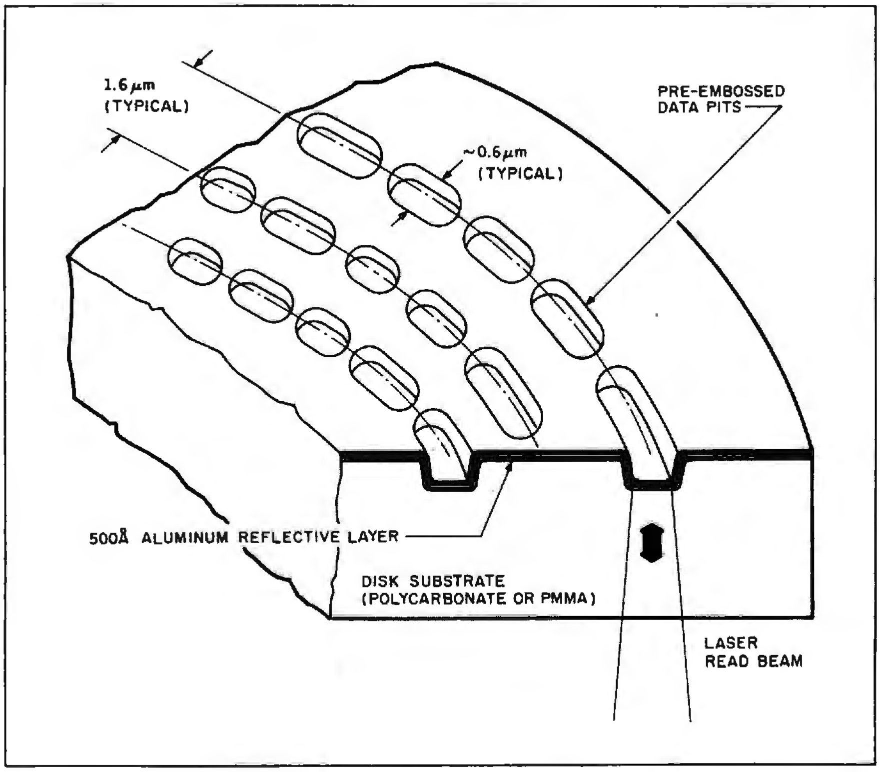

Figure 3: *The composition of a typical* CD-ROM. *The plastic substrate supports an aluminum reflective layer. The data-bearing pits are embossed during the disk's molding; aluminum is then sputtered onto the substrate.*

READ-ONLY TECHNOLOGY

Before magneto-optic or even write-once technology becomes widespread, you're likely to hear a lot about another type of data storage—a type that has its roots in a heretofore unrelated realm of electronic endeavor, high-fidelity audio. The same technology used in Compact Discs (CDs) can be easily and inexpensively adapted for use in personal computer systems.

Within the past year Sony, North American Philips, Hitachi, Denon America, and others have announced the development of computer peripherals that incorporate the basic mechanism used in audio CDs. These devices can read data that has been encoded onto a commercially prepared disk, and thus are called CD-ROMs, or compact-disk read-only memories.

The composition of a CD-ROM disk is shown in figure 3. A substrate of plastic (usually polycarbonate, although polymethyl methacrylate [PMMA] has been proposed) supports an aluminum reflective layer, over which another plastic layer has been laid for protection. The interface between the layers is characterized by pits spaced at more or less regular intervals in circular patterns—actually part of one long spiral. The 780-nanometer laser beam is focused on the aluminum layer, so it sees right through the protective layer and even through small amounts of debris on the outside of the disk (see figure 4).

Each CD-ROM disk is recorded in constant-linear-velocity mode. The

(continued)

claimed capacity of a CD-ROM disk differs between manufacturers but is agreed to be at least 540 megabytes. This generous storage region is divided into blocks; the user-addressable portion of each block is 2048 bytes, and there are around 270,000 blocks on a disk. Software houses are already studying the potential of this medium for distributing programs and databases too large to fit conveniently on a floppy disk.

DRIVE STRUCTURE

Figure 5 shows the physical structure of the pure optical and magneto-optic disk drives. In addition to the mechanical parts needed to spin the disk, the key elements are the laser and the data photodetector. A complex secondary optical structure links these together, providing the path through which the light beam travels. These secondary components include various prisms, beam splitters, mirrors, lenses, wavelength filters, and polarizing filters; most designs also have more than one photodetector for ease of tracking. The heavier components of the light path are mounted in a stationary position off to the side, while the remaining components are mounted in an optical head that moves on a carriage across the radius of the disk; this permits reading and writing any track on the disk.

Three types of movement occur in aiming the laser beam at the disk. A coarse-tracking mechanism moves the entire optical head back and forth along the radius of the disk. Fine adjustment of tracking is performed by the galvo-mirror, which deflects the light beam to modify its angle of incidence to the disk. And a lens mounted on a voice-coil-type actuator moves in and out to maintain focus on the data-bearing layer of the disk.

The disks in many systems contain embossed tracking grooves that absorb or scatter part of the light; the scattering varies according to how much light is falling on the walls and how much on the bottom, resulting in variations in reflected intensity that allow the tracking photodetector to tell whether the laser is aimed in the right place. When the reflected beam is directed onto the data photodetector, the variation in intensity can be measured so that the disk drive can tell if the beam has passed over a recorded area.

The data rate of optical disks varies. The Philips CD-ROMs run at 150,000 bits per second, whereas drives for larger systems often record at 3 megabits per second.

Some drives maintain the synchronous timing of the system through the presence of very shallow depressions, not as deep as a fully written data pit

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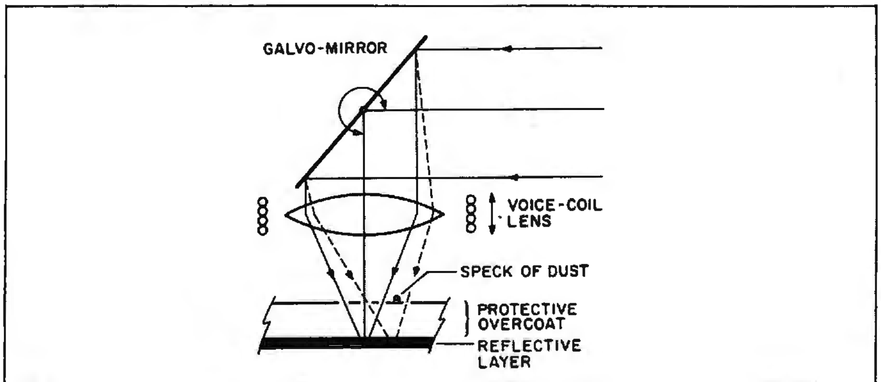


Figure 4: *The optical head contains two significant mechanisms. The galvanometer-mounted mirror (galvo-mirror) rotates slightly on an axis parallel to the disk to provide the fine-scale tracking adjustment essential to correct for minor wobble, disk asymmetry, etc., as well as high-speed track-to-track access for up to 25 tracks (spaced at 1.6 microns). The voice-coil-mounted lens keeps the laser beam in focus on the reflective layer. Both these tracking mechanisms are servo-controlled by corrective signals derived from photodiode arrays that sense the intensity of the reflected laser light.*

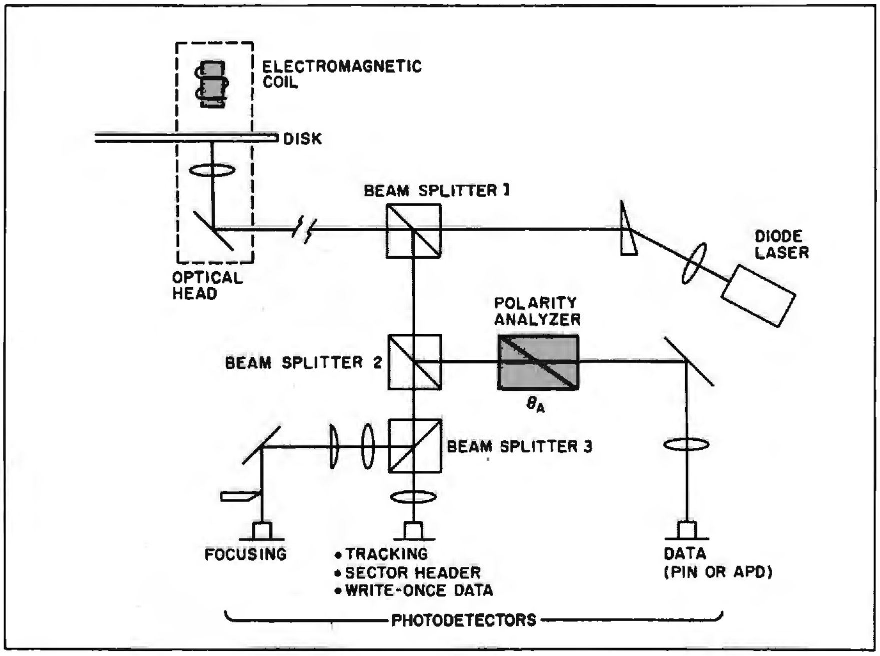
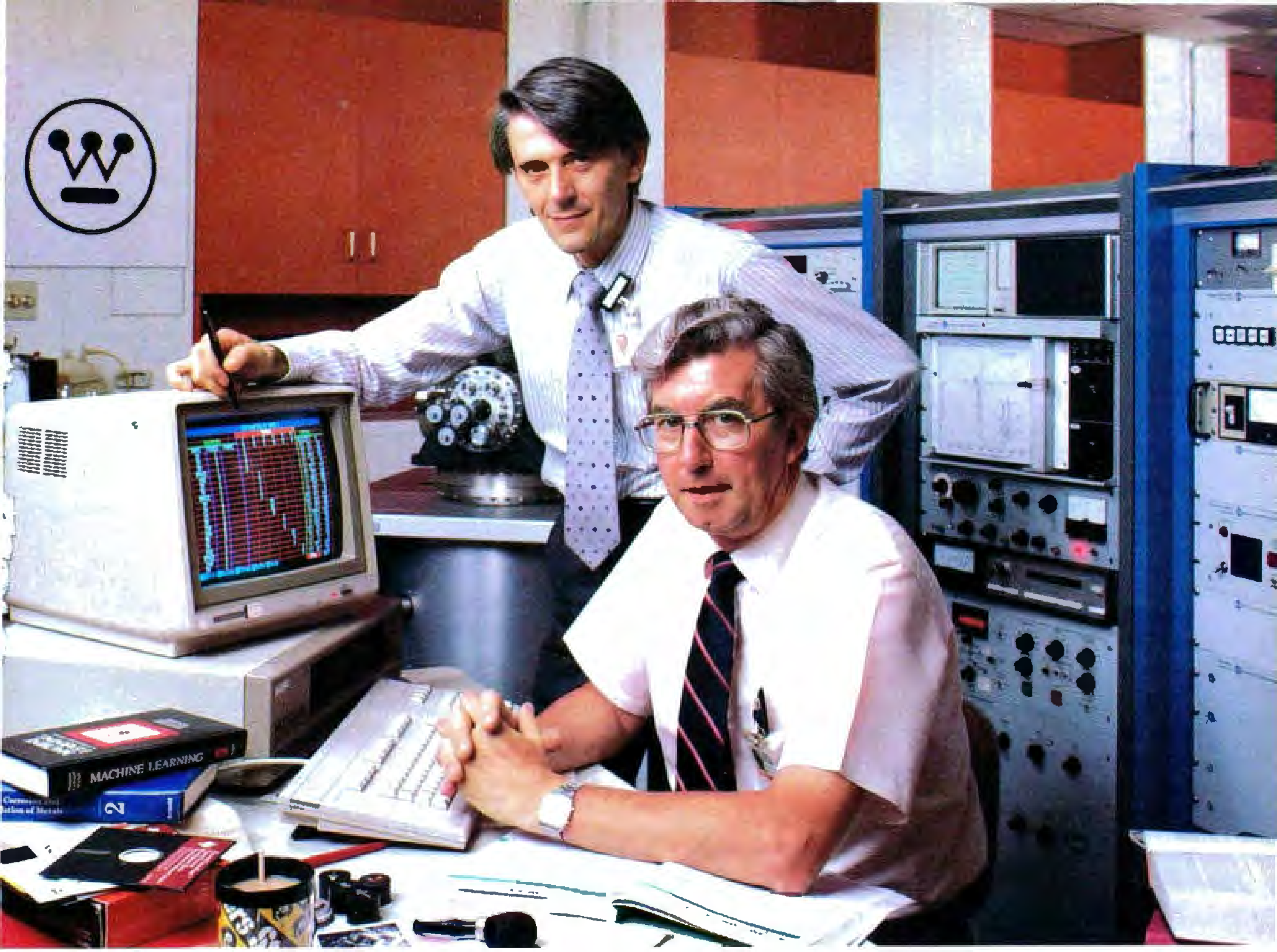


Figure 5: *The physical structure of a typical optical-disk drive. Shown here is a magneto-optic drive. Without the electromagnetic coil and the polarity analyzer (shown in red), the figure would represent a purely optical drive.*



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would be. These modulations within the grooves form a "subliminal" clock signal under the main data stream that increases the accuracy of readout. In addition to user data, encoded block-header and sector-identification data also appear on the disk. Different manufacturers vary in practice on whether the header information is embossed during molding or recorded in the usual way.

PROBLEMS

The most immediate problem with optical storage—faced by those who invest in the new write-once drives—is that very few software packages can work with a storage medium that cannot be erased. Even accounting packages, where permanent audit trails abound, were developed to run under operating systems assuming erasable magnetic media.

The first purchasers of CD-ROM drives will face a problem common to new technologies: There will not be much software available to use with their new machines. To take greatest advantage of the storage format and access characteristics of the CD-ROM, the data stored on the disks will have to be specially prepared before the disks can be pressed. Companies that plan to use CD-ROMs for distribution of large databases will have to learn how to do it most efficiently.

There is little progress so far toward standardization. For example, even as Atari and Activenture were announcing a CD-ROM product at this year's Consumer Electronics Show in Chicago, Sony Corporation disclosed at the annual conference on optical storage for small systems that it was abandoning support of 12-centimeter (4.7-inch) CD-ROMs in favor of new 13-cm (5¼-inch) DataROM disks—an action that sent manufacturers and software vendors scurrying to adjust their plans (see Microbytes, August BYTE, page 9). We can't expect much standardization in a field so new and rapidly changing, but many otherwise attractive optical storage devices and media being developed are not compatible with any other equipment.

The thin, sensitive active layers of writable optical media, while encapsulated in protective layers of glass or plastic, are still subject to some aging and corrosion. One reason for the use of polycarbonate in substrates rather than the optically nicer PMMA is that PMMA absorbs more water from the air. Thus, disks made from PMMA may be more prone to microcorrosion of the data-bearing layer.

Although extensive tests have been run by every company developing this technology, the ultimate longevity of data stored on these new media can be proven only by the test of time. Some drives automatically keep track of the raw error rate for each disk. When the error rate goes over a certain point, the overworked error-correcting circuitry recommends that the disk be retired.

The raw error rate of even a spanking-new optical disk is still much, much higher than that of inductive magnetic media. And the most common means of alleviating this problem, the use of error-correcting Reed-Solomon codes, introduces a couple of its own stumbling blocks: The electronic components that perform the error correction increase the cost and complexity of the devices, and the technique decreases the capacity of the optical disks to contain useful information.

The DRAW (direct read after write) error-correction technique, highly favored just a few years ago, has not been used in recent designs. The extra read operation takes too long to be practical when data is being recorded at high data rates, and it doesn't work at all in cases where errors are introduced during mass

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LASERS PERMIT HIGH DENSITY

The key component that allows an optical disk to store so much information in so little space is the laser. A beam of light can be focused precisely on an information-bearing medium in an area much smaller than the area covered by the magnetic head of a traditional disk drive.

In general, merely recording data at ever-increasing densities is not as hard as reading it back. Up to some theoretical limit, in both magnetic and optical processes you can cram bits increasingly close together on the recording surface. The problem comes when you have to detect and sort out the bits.

The traditional magnetic data-storage process depends on the inductance of the read head generating a tiny electrical current when the head passes over the magnetic domain that represents a bit. (You can think of the disk platter and head as an extremely inefficient electric generator.) If the domain is below a certain size (which varies between disk designs), its field is too weak, so the head amplifier cannot detect the current and the bit is not read.

The key advantage of optical storage in this regard is that the energy required for detecting the bits is supplied from outside the system. The coherent light beam of the laser is focused onto a tiny spot on a storage medium, and the effect of the medium on the light is measured.

With the high-precision optical gear available today, the beam can be made to converge on an area as small as 1 micron in diameter—and can read a data bit stored in an area of that scale. The linear density of bits in a track on a typical optical disk runs about 35,000 bits per inch, compared with 15,000 bits per inch in a high-performance traditional magnetic disk drive. With a track-to-track spacing somewhere around 1.6 microns, an optical drive can store around 560 million bits per square inch of surface—more than 20 times that of a very good magnetic disk.

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The attraction of optical data storage is its great capacity.

replication of the disks or by simple aging of the material.

System integrators have a few special problems to look out for. One of them is the variety of methods for interfacing the optical drives to computers. The SCSI (small computer system interface) is often mentioned as a good way to go about it, but the SASI (Shugart Associates Standard Interface) also has proponents. And one maker of CD-ROMs (Philips) uses a high-speed serial interface.

Aside from the intangible value of possessing the most advanced computer add-on available, the attraction of optical data storage is its great capacity. One certainty of computing is that applications always expand to fill available memory. With the main memory of microcomputers currently growing into the 1-megabyte range, the demand for more capacity in secondary storage will make optical storage technology increasingly attractive.

While magnetic storage is also getting better, proponents of optical storage claim that optical will always stay ahead in capacity. When optical disks match their theoretical advantages with practical attractiveness, you'll see a lot more of them. ■

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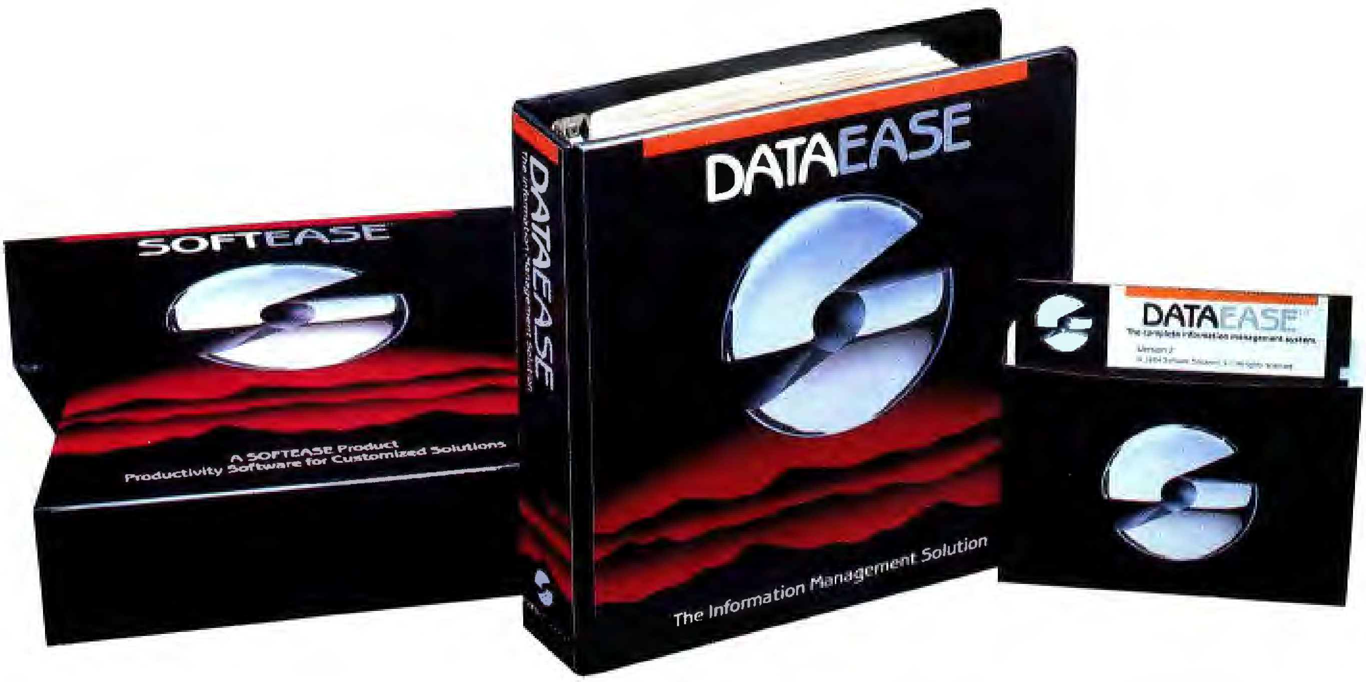

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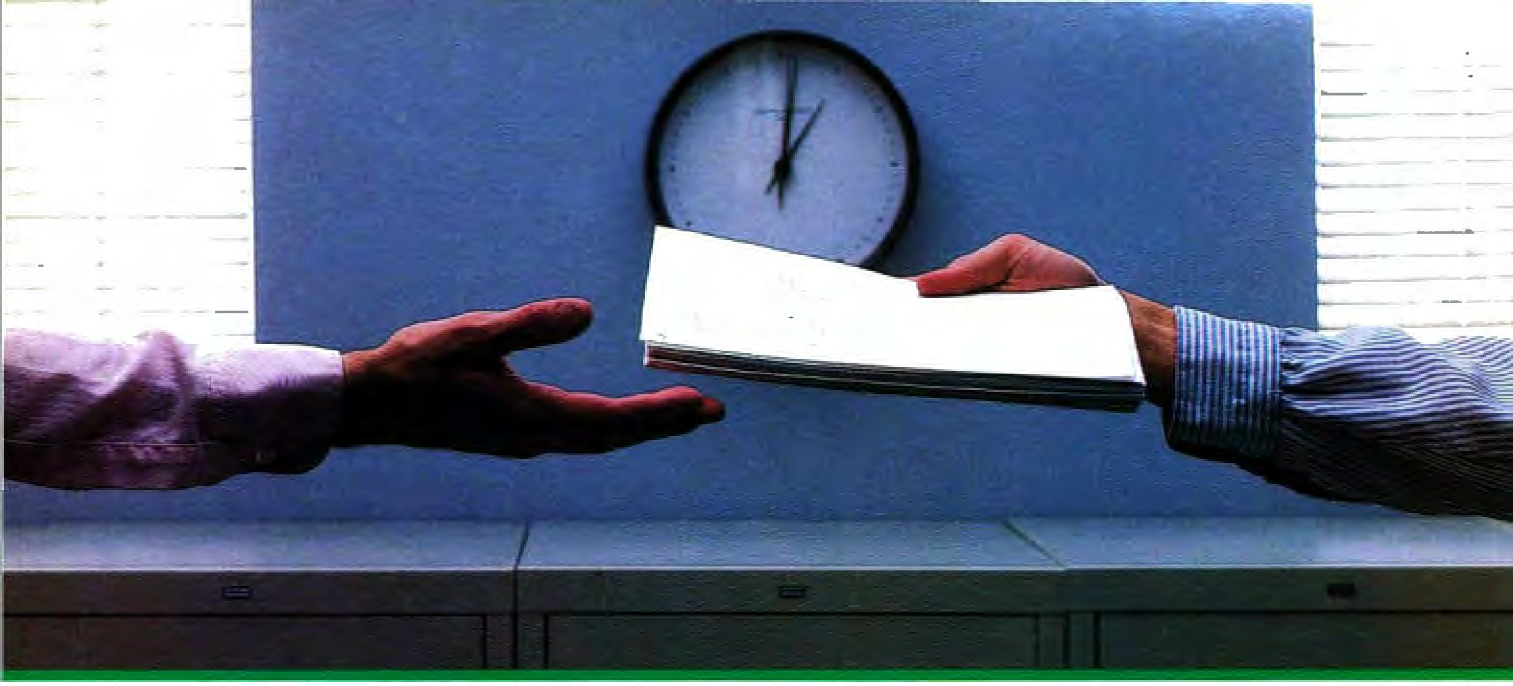

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BY MICHAEL KILIAN

HIGHS AND LOWS OF PARAMETER PASSING

You can access assembly-language routines from your Pascal or FORTRAN programs

There are times when you need to know how to interface assembly-language routines to higher-level-language programs, specifically those using the Microsoft IBM PC Pascal, FORTRAN, and COBOL compilers. By using my techniques, you can control devices, use the speed of assembly language for certain calculations, and perform other tasks requiring low-level support and high-level control.

In this article, I use the Microsoft IBM Pascal Compiler and Assembler for illustrative purposes. However, the techniques apply directly to other Microsoft languages—particularly FORTRAN and COBOL—and to non-Microsoft languages. (I have applied some of these designs to 6809 p-code Pascal with great success.)

REASONING

A great benefit of languages like Pascal and FORTRAN is the simplification of tasks that are complicated on the machine level. You do not want to write the amount of code required to calculate the function sin(*x*) in assembly language. A language like Pascal liberates you from these wearisome programming tasks and lets you simply use the result of sin(*x*).

However, high-level languages essentially allow only one way to do things. FORTRAN has only one function, which is sin(*x*). In standard Pascal, the only way to display on the output device is with a write or writeln command. While these are usually sufficient, you occasionally need more. For example, the Microsoft Pascal compiler for the IBM does not provide cursor addressing. The cursor, for all intents and purposes, sits in the lower-left corner of the screen. It would be nice if you could tell the cursor where it should move to and then do the write or writeln. It would be ideal if you could write code like this:

```
set_cursor(row,column);
writeln('This sentence begins
        at',row,',',column);
```

Writing the function set_cursor in assembly language and accessing it

(continued)

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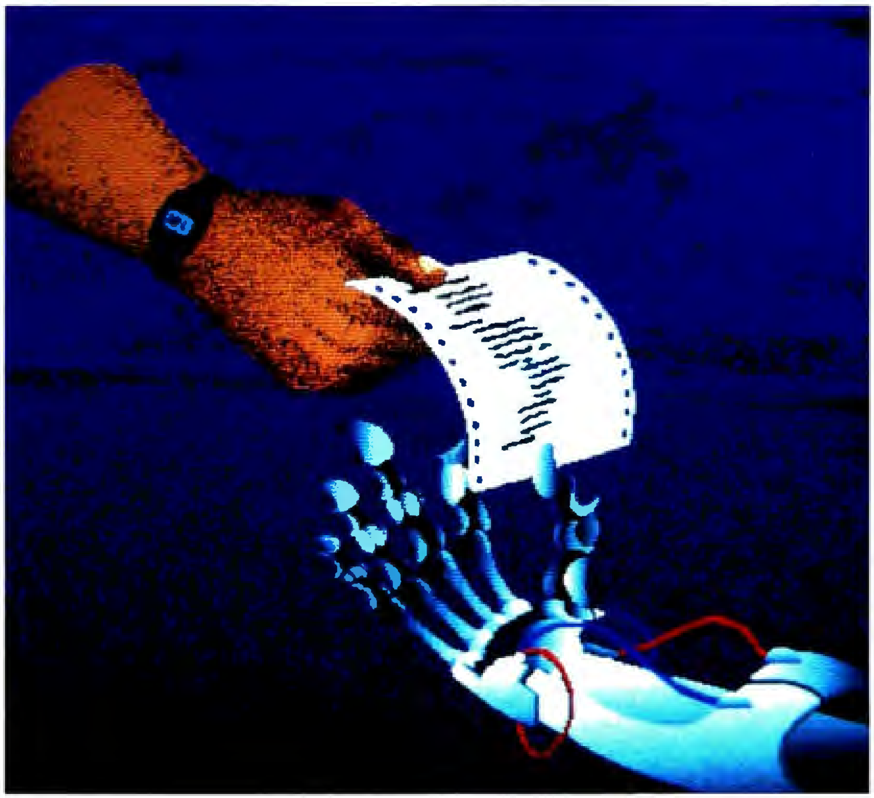

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from Pascal gives you the ability to calculate row and column using easy number crunching in Pascal, FORTRAN, or even COBOL. You can also use Pascal to do the I/O (input/output) that is almost always tedious in assembly language. In short, you can write a program using a low-level function without writing the whole program in the low-level language.

GETTING THERE AND BACK

Pascal calls an assembly-language routine, referred to as an *external* routine, exactly the same as if it were a standard Pascal procedure. This involves an activation record that contains bits of information, including return addresses, various pointers, local variables, and parameters for the procedure. For every procedure call Pascal makes, an activation record is placed on the program stack. For more information on activation records, see references 1 and 2.

Here is a simple example. Suppose you have the following declaration in a Pascal program:

```
procedure set_cursor(row,column:
                     integer); external;
. . .
set_cursor(5,10);
```

When the set_cursor call is reached, the following actions occur to build the activation record. First, the integers 5 and 10 are pushed onto the stack. Since the formal parameters *x* and *y* were not declared as type VAR or VARS, the actual values are placed on the stack. This is referred to as *call-by-value* and differs from *call-by-reference*, which occurs with VAR-type parameters.

Next, the return address is pushed onto the stack. This is where the external routine should return. In this example, the return address occupies 4 bytes: 2 for a segment register and 2 for a byte offset into that segment. (In 8088 assembly language, this would be a FAR call.)

Control then transfers to the external routine responsible for maintaining a proper stack frame. See figure 1 for a diagram of the activation record at this time. Note that the stack grows from high memory to low. The base pointer of this stack frame is somewhere above (i.e., at a larger memory address than) the activation record. The stack pointer points to the last byte pushed on the stack. You can consider everything below the stack pointer free space for the external routine, which must now set up its own stack frame. The first step is to save the old frame pointer—the BP register—and set up a new one. You can do this with two instructions:

```
BP — >
           .        High memory
           .
           n        The parameter 5. (MSB)
           n-1                       (LSB)

           n-2      The parameter 10. (MSB)
           n-3                        (LSB)

           n-4      The return address (4 bytes).
           n-5
           n-6
SP — >     n-7
           n-8      Effectively free stack space.
           n-9
           .
           .        Low memory
```

Figure 1: *A diagram of the activation record when control is transferred to the external routine. Note that the stack grows from high memory to low.*

```
OLD BP — >
           .
           .
           n        The parameter 5 (2 bytes).
           n-1

           n-2      The parameter 10 (2 bytes).
           n-3

           n-4      Return address and
           n-5      saved base pointer (6 bytes).
           n-6
           n-7
           n-8

BP — > SP — > n-9
           .
           .
```

Figure 2: *A diagram of the stack after the external routine has been activated. It now has its own stack and can proceed.*

```
PUSH      BP
;  Save old frame pointer.
MOV       BP,SP
;  And initialize a new one.
```

The stack now looks like figure 2. The external routine has its own stack frame and can proceed. It is also responsible for cleaning up after itself—removing the saved registers and parameters from the stack. This is as simple as establishing the stack frame and requires only two instructions:

```
POP       BP
;  Recover old stack frame.
RET       4
;  Recover return address
;  and remove parameters.
```

(continued)

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The RET 4 recovers the return address as well as removing the 4 bytes that the parameter values occupied. The following is a rough outline of the external routine:

```
ROUTINE_NAME PROC FAR
   PUSH      BP
   MOV       BP,SP

; Routine's actions.
   .
   POP       BP
   RET       n
ROUTINE_NAME ENDP
```

In general, other registers should be pushed onto a stack to avoid losing them; this is a good habit to get into when programming in assembly language. To prevent inconsistencies among a set of external routines, you could define a pair of macros as follows:

```
PASCAL_ENTRY MACRO
   PUSH      BP
   MOV       BP,SP
   PUSH      reg1
   PUSH      reg2
; etc.
PASCAL_ENTRY ENDM

PASCAL_EXIT MACRO
     NUM_OF_BYTES
; NUM_OF_BYTES = the total
; number of bytes of parameters.
   POP       regn
; etc.
   POP       reg2
   POP       reg1
   POP       BP
   RET       NUM_OF_BYTES
PASCAL_EXIT ENDM
```

This is exactly how to begin and end each of the external routines you wish to link with Pascal.

GETTING AT PARAMETERS

Although you can have *parameterless* procedures such as moving the cursor up, down, left, and right, you are more likely to have parameters as in the set_cursor(row,column) example. You need a way to access these parameters so you can use them. This is where the BP pointer that was

(continued)

saved and repositioned to the bottom of the activation record in figure 2 comes in. By using an indexed + offset addressing mode, you can easily obtain a parameter.

When an external routine is entered and a new stack frame initialized, BP always points to just below the return address at the saved BP value. In the set_cursor example, the first parameter (5) is always 8 bytes above the BP register—remember that the stack grows from high memory to low memory. If you use the indexed + offset addressing, retrieving the first parameter requires only a single instruction: MOV AX,word ptr [BP + 8]. You can retrieve the second parameter similarly: MOV BX,word ptr [BP + 6]. In this example, the row must be between 1 and 25 (one screen length) and the column between 1 and 160 (two screen widths). Due to the reversed-byte storage of words in 8088 architecture and since each of these values can fit into a single byte, a single 16-bit register can hold the coordinates:

```
MOV   AH,byte ptr [BP+8]
MOV   AL,byte ptr [BP+6]
```

This parameter retrieval can be simpler if you use the 8088 assembly-language feature for defining structures. This option lets you define patterns that serve as addressing templates. They are analogous to Pascal's record types. (See reference 3 for details on structure definition.) The pattern you want to describe is one of two parameters plus 6 bytes consisting of the return address and the saved BP register. The structure for this is

```
P_2    STRUC
       DB       6 DUP (?)
P2_2   DW       ?
P1_2   DW       ?
P_2    ENDS
```

This structure is identical to the activation record if you scan it from low memory to high, or backward. The fields are named P2_2 and P1_2, representing parameter 2 of a two-parameter set and parameter 1 of a two-parameter set, respectively. The first parameter of a routine with three parameters is offset differently than the first parameter of a two-parameter routine. The three-parameter routine STRUC includes P3_3, meaning the offset to P1_3 is 2 bytes greater than the offset to P1_2.

You can address the first of two parameters MOV AX,[BP].P1_2. The assembler calculates the offset of P1_2—in this case it is an 8—and automatically translates this to MOV AX,[BP + 8].

When you use a STRUC routine, the painstaking job of counting bytes and figuring out reversed bytes disappears. Also, each operand is essentially *typed* by the assembler—the parameters in the STRUC example would be typed WORDs. This lets the assembler do more error checking for you and helps you avoid type mismatches.

In most cases the parameters sent to an external routine are integers. Implementing STRUCs as parameter templates is an equally effective method for dealing with other types of parameters. For example, suppose the row and column of set_cursor were 6-byte (three-word) real integers. You would only have to change the entries in the STRUC to DW 3 DUP (?), and the addressing offsets in the program would automatically change. Using STRUCs makes your program easier to read, more self-documenting, and easier to maintain.

RETURNING PARAMETERS

You would commonly use the structure and base-pointer-indexed addressing scheme to access the assembly-language parameters. However, at times the external routine must return values to the calling routine, such as the cursor location. You must pass it a pointer telling it where to put the returned values. This is referred to as *call-by-reference* parameter passing, and Pascal implements it with VAR parameters in procedures. Microsoft's version of IBM Pascal has two varieties of VAR: VAR and VARS. For the purposes of this article, I will assume that all call-by-reference parameters are declared as VARS.

An example of a typical heading in a Pascal program follows:

(continued)

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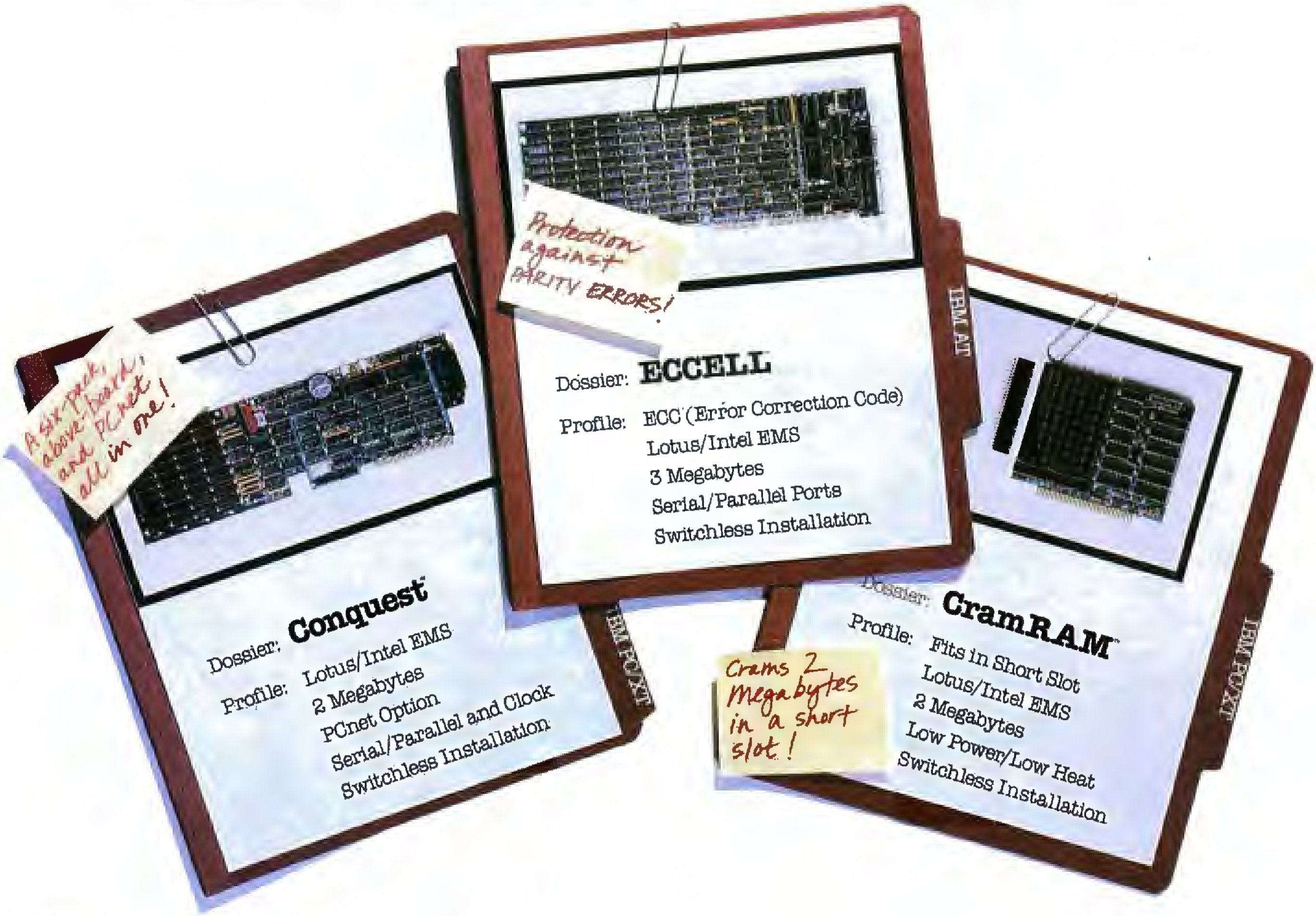

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```
procedure read__cursor(VARS
      row,column: integer);
      external;
. . .
read__cursor(i,j);
```

The VARS tells the compiler to put *pointers* to the variables making up the parameters into the activation record, *not* the values of those parameters. (It is illegal in Microsoft's IBM Pascal to use anything but variables as VARS-type parameters.) In this illustration, a pointer to the variable i and a pointer to the variable j are placed in the activation record. Because of the VARS, the pointers are in segment/offset form so they can reside anywhere in the 8088's 1-megabyte address space. If you used a VAR statement, only the offset into the current data segment would be passed. The STRUC for read__cursor's activation record would be formatted as follows:

```
VP__2    STRUC
         DB       6 DUP (?)
VP2__2   DD       ?
; double word.
VP1__2   DD       ?
VP__2    ENDS
```

The only difference between VP__2 and P__2 is that in VP__2 the parameters are allotted double words, one word for the segment register and one for the offset. Accessing the parameters, however, is very different. It becomes a two-step process to retrieve or store a parameter. One method for transferring AX to parameter 1 might be:

```
LDS     SI[BP],VP1__2
MOV     word ptr (SI),AX
```

The DS and SI registers have been loaded with the pointer off the stack and the value put in AX where the pointer indicated. When the routine completes, the value of the variable passed as a parameter is changed.

Other Parameter Passing

Another area of interest is the use of functions instead of procedures. While parameter passing is the same as call-by-value—the way in which the function returns its value is different: The value is not returned on the activation stack. Instead, it is placed in a register: AX for 16-bit quantities, AX-DX for 32-bit quantities. While not all compilers return values in this convenient manner, it is fairly common.

In FORTRAN, all parameters are passed as call-by-reference.

In FORTRAN, all parameters, even constants, are passed as call-by-reference. Therefore, every parameter entry in a STRUC should be a double word, DD. You should expect only the addresses of values to be on the stack, not the actual values; therefore, you must be careful in accessing the parameters so you don't inadvertently change a variable that was supposed to remain fixed.

Linking

Once you have written your high-level-language and external support routines, you must set up communication between them. The IBM PC has a nice mechanism for accomplishing this. The object modules (i.e., the compiled high-level-language code and the assembled support code) are linked together. In Pascal, external routines are given a special header:

```
procedure set__cursor(row,column:
                   integer); external;
```

The keyword external notifies the compiler that this routine exists outside the source code and that it will not be available until link time. However, the header is stored so that the type and number of parameters passed to the procedure can be checked by compile time.

FORTRAN does not require such an external declaration; any unresolved subroutine calls are assumed to be external. While this may seem convenient at first, it can lead to disastrous results if the subroutine named is spelled incorrectly or the number or type of parameters does not match what the external routine expects. Pascal has the advantages of detecting these errors at a much earlier stage than FORTRAN and of giving more useful error diagnostics.

That defines the external routine to the high-level-language program, but how about on the level of the external routine? It too has the responsibility of telling the linker—and in effect the higher-level language—what routines it offers. In 8088 assembly language, this is done with the EXTRN directive, which contains a list of symbol names and types, e.g., NEAR and FAR (see reference 3). The symbols referenced then become accessible to the higher-level routine.

The high-level-language routine knows what it wants, and the low-level-language routine knows what it has. All that's left is the linker. The purpose of a link is to put two or more object programs together to make a single one. The linker can move object programs around, but it patches their code so they still function correctly. It resolves external symbols, fills in CALL operands, and makes the appropriate linkages between the high-level and the low-level languages. The resulting object code looks as though the various pieces had never been separate, and they function together as one.

Conclusion

The ability to link from high-level to low-level external routines is useful. While activation records and call-by-whatever might seem confusing at first, once you set up the appropriate macros and structures, the whole process becomes almost transparent. Loading parameters requires only a move and you are almost unaware of the activation record. This allows greater flexibility and expands the use of high-level languages beyond their original design. ■

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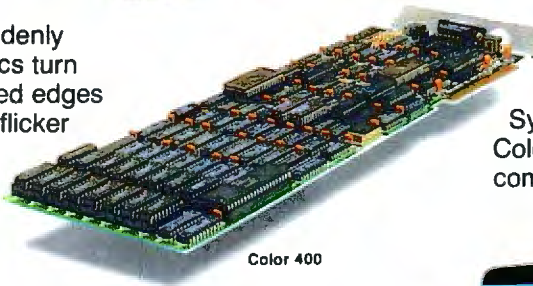

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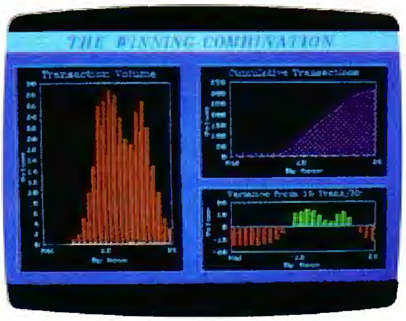

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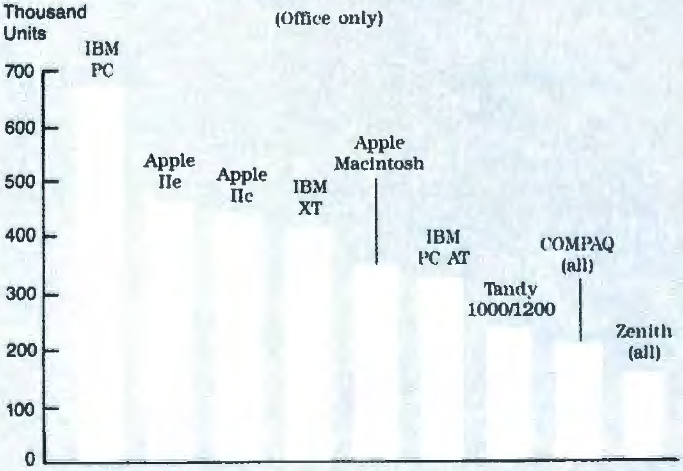

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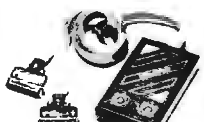

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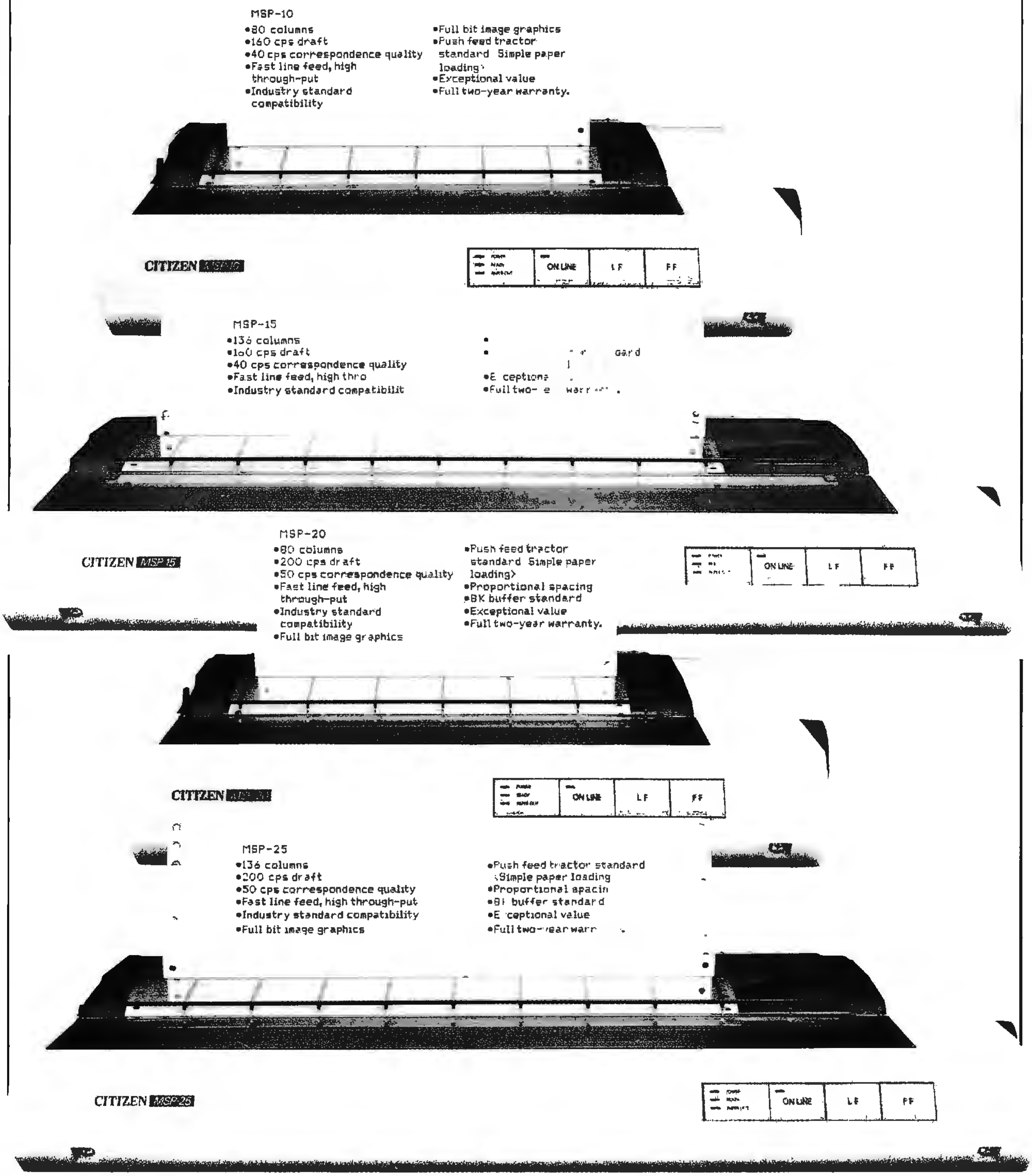

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Inquiry 501

GAME-PADDLE CONTROL LINEARITY TEST

BY MARVIN L. DE JONG

Measuring resistance with the Apple II

IT IS POSSIBLE to use the game-paddle inputs on the Apple II to measure physical properties like resistance, capacitance, temperature, and light intensity. There are two important considerations in such measurements. The first is whether the output of the game-paddle instruction, y= PDL(x), varies linearly with the physical property. Equally important is the scale factor—the ratio of y to the value of the physical property corresponding to y.

The program in listing 1 tests the linearity of the game-paddle input and obtains the scale factor. The program contains two simple loops. The inside loop reads the game-paddle port, prints the output on the screen of the video monitor, and tests the keyboard of the Apple II for a keystroke. When a keystroke occurs, the program requests the input of a physical quantity.

I measured a resistance connected between +5 V (volts) and the GC1 input, pins 1 and 10, respectively, on the Apple II game I/O (input/output) connector. The resistance was a resistance substitution box of the type found in a high school or college physics laboratory. The box uses resistors with a precision of 0.5 percent. I could also have used a 10-turn potentiometer.

After adjusting the resistance to a desired output, I pressed a key on the Apple keyboard and, following the prompt, entered the value. The program then plotted y and the value of the resistance on the high-resolution screen, and the printer, interfaced through card slot #1, plotted the same two values. For this example, I applied a scale factor of 159/120 in order to use most of the high-resolution screen.

Figure 1 shows r, resistance, as a function of y after plotting approximately 100 points. I used a ruler to draw a straight line through the points. Clearly, the output, y, is a linear function of r, between +5 V and the game-control input.

You can obtain the scale factor from the printed output. For example, with the GC0 input, I got a y of 224 when r was 100K Ω (ohms), resulting in a scale factor of 2.24/K Ω. With GC1, we got a scale of 2.19/K Ω. Fitting a least-squares line to the points would probably be overkill.

The game-control circuitry in the Apple II consists of a QUAD 558 timer. This integrated circuit holds a 0.022-μF (microfarad) capacitor in a discharged state until a pulse is applied to a trigger input on the 558. This pulse is produced by referencing location 49264 (C070 hexadecimal). After a pulse is applied, the 558 allows the capacitor to charge until it reaches two-thirds of the supply voltage. At this time, the q output of the 558 switches to logic zero. The time between the trigger pulse and the q output switching to logic zero is approximately

$$t=1.1*r*c$$

where r is the resistance of the game-

(continued)

Marvin L. De Jong teaches in the Department of Mathematics-Physics at The School of the Ozarks. He has a Ph.D. in Astronomy from Rensselaer Polytechnic Institute and is the author of several books and articles on microcomputing. He can be reached at the Department of Mathematics-Physics, The School of the Ozarks, Point Lookout, MO 65726.

paddle potentiometer in ohms and c is 0.022 μF.

The Apple II uses a simple machine-language timing loop to measure this time interval. Although the Apple II reference manual indicates that this cycle is 12 clock cycles long, it is actually only 11 clock cycles long. Thus the time, t, is related to the value of y returned by the y=PDL(x) instruction by the formula $t=11*y*tc$, where tc is the period of the microcomputer clock. For the Apple II, tc = 0.9778 μs (microseconds). The maximum value of y, 255, produces a t of 2.743 ms (milliseconds), which corresponds to an r of 113.3K Ω. With the GC0 input, I obtained a y of 255 when r was between 113K and 114K Ω. With the GC1 input, I obtained a y of 255 when e was between 116 and 117K Ω. Thus, given the precision of the components, the game paddles behave exactly as expected.

Listing 1: A *program to graph the output of* y=PDL(x) *as an input parameter is changed.*

```
10 INPUT X
20 KYBD = 49152
30 HGR : HCOLOR = 3
40 HPLOT 0,0 TO 255,0
50 HPLOT 0,0 TO 0,159
60 Y = PDL(X)
70 FOR J = 1 TO 50
80 NEXT J
90 PRINT Y
100 Z = PEEK(KYBD)
110 IF Z<128 THEN 50
120 INPUT R
130 Z = INT(R*160/120+.5)
140 HPLOT Y,Z
150 PR# 1 : PRINT R,Y
160 PR# 0 : GOTO 50
```

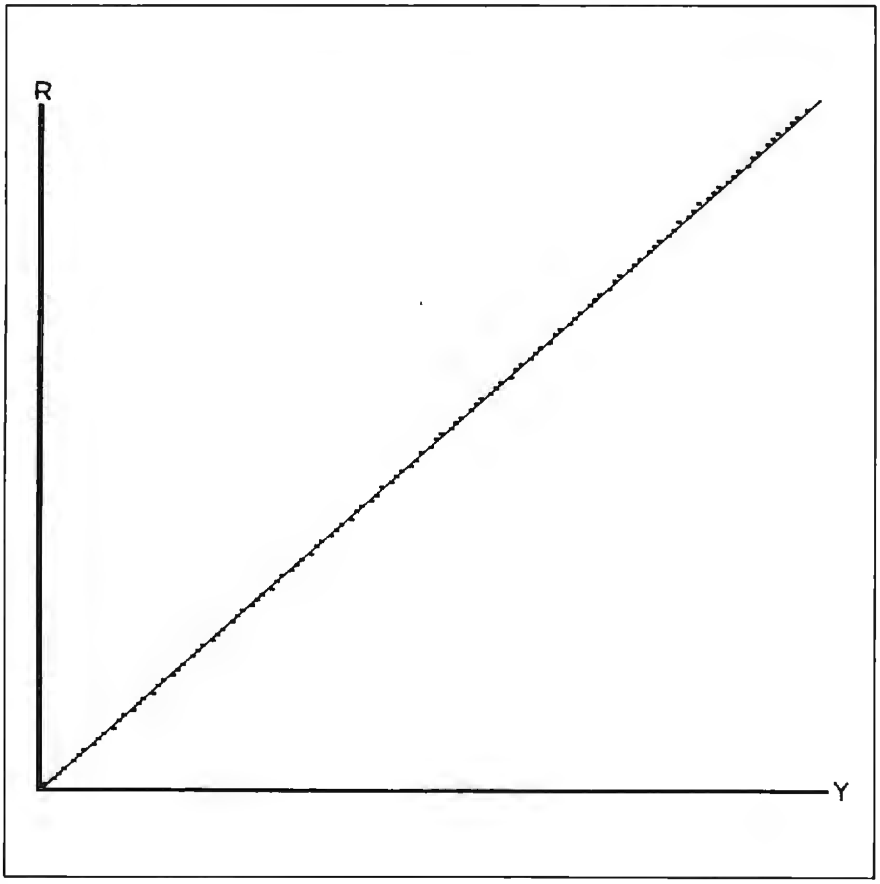

Figure 1: *The resistance, r, as a function of the quantity* y=PDL(x) *as it is graphed on the high-resolution screen by the program in listing 1. The relationship between y and r is clearly linear.*

My results show that the game-paddle outputs vary linearly with resistance. They also show that each game-control input must be individually calibrated for best results. This program provides a simple check of the linearity of the game-control inputs.

The fact that the game-control output varies linearly with resistance implies that it varies inversely with current. Devices such as thermistors will show a highly nonlinear behavior if the program in listing 1 is used to find y as a function of temperature. In that case, the program can be used to plot a calibration curve. The game-control outputs will vary linearly with the capacitance placed in parallel with the 0.022-μF capacitance internal to the Apple II.

This information should be helpful for computer users who want to use the game-control inputs to measure physical quantities. These inputs exhibit a high degree of linearity, and sample experiments allow the inputs to be calibrated. Inherent in the timing-loop approach is a timing error. My analysis shows that the largest error is 10 clock cycles, while the smallest error is -1 clock cycle. This error is independent of y; the most precise measurements are therefore obtained when y is as large as possible.

You also might want to try to expand the range of resistances that can be measured using the game-control inputs, either by placing another capacitor in parallel with the one inside the Apple II or by using a 16-bit timing loop. ■

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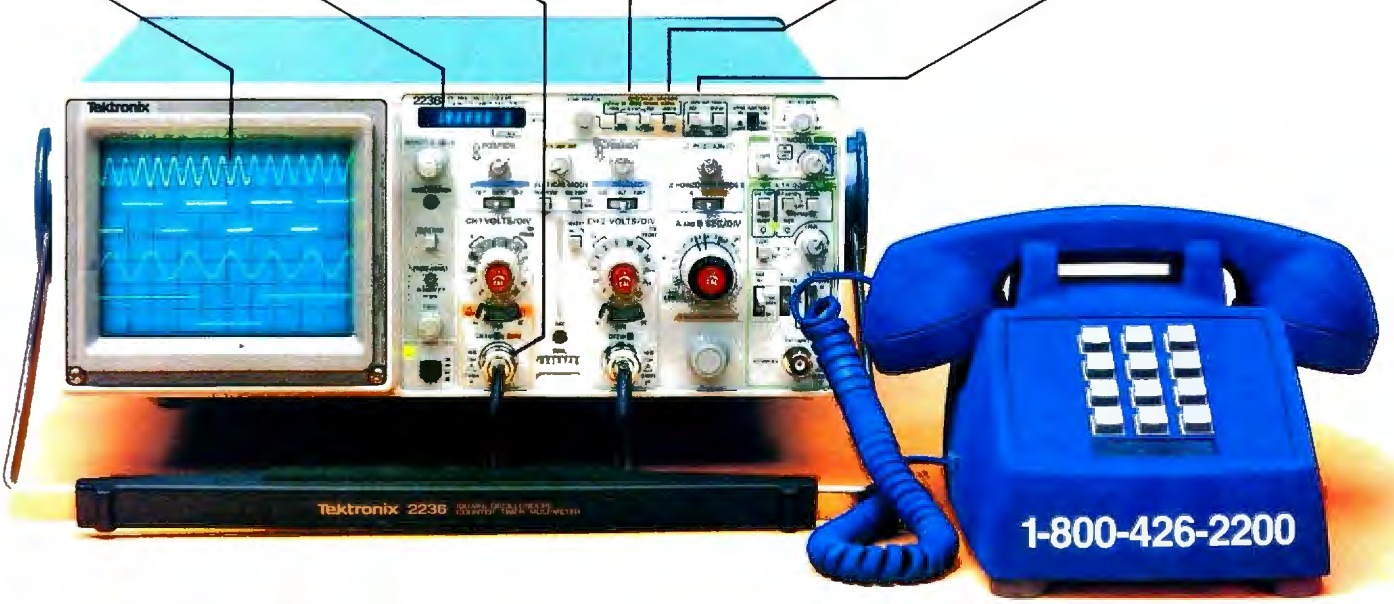

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Graphics Hardware

THE AMIGA'S CUSTOM GRAPHICS CHIPS
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THE μPD7281 PROCESSOR
by Tom Jeffery **237**

ONE CLEAR FACT about microcomputing is this: The field has grown tremendously large and wide. Organizing this Graphics Hardware theme demonstrated that fact immediately and forcibly. Our initial goal was to recruit at least one article from each area of possible interest. But that would have produced a haphazard array of articles that wouldn't slake any particular thirst. So we focused attention on the silicon behind many of these devices.

When memory chip prices took a nosedive in 1984, many companies had to look for other, more profitable ways to turn sand into logic. The popular appeal of interfaces such as the Macintosh's and the unending hunger for more powerful CAD and CAM workstation displays led many designers to graphics. The lack of a clear standard chip, after the first-generation NEC 7220, was also a factor. Many companies hoped to set the next standard and capitalize on it in a big way.

Even after we decided to focus on chips, it was soon obvious that there were far too many developments to cover. Intel, AMD, Texas Instruments, Hitachi, Silicon Compilers, and an avalanche of other firms were announcing new, more powerful graphics controllers. Instead of repeating much of the same coverage available elsewhere, we chose to look at some of the basic design philosophies behind graphics silicon.

Custom graphics chips are at the heart of the new Amiga microcomputer from Commodore that we previewed in the August BYTE. For this issue, we went back for a talk with Jay Miner, the designer of the Amiga's custom chip set.

The new generation of computer displays based on bit maps simplifies the graphics-control scheme and allows multiple fonts, sizes, and modifications of characters. To handle the manipulations of such a screen, a new type of hardware has been developed that performs RasterOp (raster operations) or BitBlt (for bit-mapped block transfer; a name coined at Xerox PARC). John Bennett, the president of Pacific Mountain Research (a Seattle firm that has designed the 96016 Blt chip) describes the theoretical underpinnings and reasons for BitBlt operations.

One surprising facet of graphics silicon is the rush to new memory architectures. Stefan Demetrescu, a vice president of Lasergraphics, describes the bottlenecks in displaying data and then explains the possible silicon solutions, including his own novel RAM architecture.

Nippon Electric created the first graphics-controller standard with its 7220 chip. Now, NEC is trying a new tack with the μPD7281 processor that is not based on the standard von Neumann computer architecture. Instead it uses pipelining and data-flow architecture to bring parallelism to image processing. Tom Jeffery of NEC describes the inner workings of this new kid on the block.

After summarizing that slew of silicon specialties, we end on relief note: the software that will convince a dot-matrix printer to print up to 240 dots per inch horizontally and 216 dots per inch vertically. Mark Bridger and Mark Goresky give the details.

What conclusion can be tied together from these various strands? The sure answer is that there is room for a lot more coverage of graphics hardware.

—Phillip Robinson, Senior Technical Editor

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THE AMIGA'S CUSTOM GRAPHICS CHIPS

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A conversation with Jay Miner, the chips' designer

COMMODORE'S NEW AMIGA *microcomputer contains a custom* NMOS *(negative-channel metal-oxide semiconductor) chip set that provides many powerful graphics functions. The Amiga preview in the August issue of* BYTE *("The Amiga Personal Computer" by Gregg Williams, Jon Edwards, and Phillip Robinson, page* 83*) briefly described those chips. Later, we went back for more details and talked to Bill Kolb, Amiga's director of hardware engineering, and Jay Miner, the vice president of product development and the designer of the chips. Miner also designed the graphics hardware for the Atari VCS (2600), 400, and 800 personal computers.*

Although the Amiga team set out to build a general-purpose microcomputer, Kolb states firmly, "We not only wanted graphics, we wanted enough power to do real animated graphics—where you're not just moving one sprite around on the screen. We wanted to take the next major step, and VLSI *[very-large-scale integration] was the only way to be that aggressive and keep the cost within reason."*

The Amiga was originally Miner's idea for the world's most powerful game machine. But as other people joined the team, that conception changed, and features, capabilities, and more ROM *(read-only memory) were added to the system.*

Block diagrams of the three chips and of the Amiga's overall architecture accompany this interview (see figures 1, 2, 3, and 4).

ORIGINS

BYTE: *What are the names of the three chips?*

Kolb: Agnus, Denise, and Paula. All DMA (direct memory access) channels reside in Agnus. Agnus is sort of a shortening of address generator. Denise handles most of the video output. Paula's two main functions are sound and the various I/O [input/output] functions. Logically, it's one big chip. For instance, both Denise and Paula are dependent on Agnus for their addresses, but they just weren't feasible as one chip. So they were split up functionally, but it looks like a giant control block to an assembly-language programmer.

BYTE: *When did this design start?*

Miner: It really started with the beginning of the company. In the early days there was more emphasis on the video game than there was on the personal computer. The cost targets were for a much lower-priced machine. We were thinking in terms of $300 or less at the beginning.

At that time we planned to use the 68000 chip, and we didn't expect to have much memory or a built-in disk. The low-cost game machine might not even have a keyboard, but it would have high resolution, a 68000 chip, and superior graphics. Then as time went on, it grew and grew. The individual chips grew, too. The software people talked us into putting in things like hardware line-draw and hardware area-fill.

BYTE: *So even at the beginning you were picturing custom chips for the graphics?*

Miner: Oh, yes. I did the chip set that was in the Atari 400 and 800 and in the original Atari VCS machine. I had a good appreciation for the power of custom graphics chips. We didn't have nearly the extent of the circuitry that's on the chips now. We had visions of a fairly crude form of blitter, nothing

(continued)

Phillip Robinson is a senior technical editor for BYTE. *He can be contacted at McGraw-Hill, 1000 Elwell Court, Palo Alto, CA 94303.*

as sophisticated as the three-input, generalized blitter we have now.

The Bimmer

BYTE: *Tell us about the blitter.*

Miner: I like to call it a *bimmer* because that stands for bit-mapped image manipulator. The term *blitter* is left over from literature referring to block transfer. This machine does block transfer, but it does much more because it has three inputs, and those three inputs can be combined in many different ways.

The logic operations that can be performed are complete. If you think of three variables, you can perform 256 logic operations on them. The bimmer is intended to be a non-real-time machine that transforms images from one location to another or back. Its main distinguishing features are the logic functions on all four inputs and the capability of barrel shifting, so you can move an image on any pixel boundaries. Only two of the sources have barrel-shift capability. Also, the bimmer can do "modulos," which means that if you're looking at a large image in bit-mapped memory, the bimmer can operate on a small portion of that image. When it gets to the end of that small portion, you add a modulo to the address to jump it to the next line. That's true of the entire display circuitry; all of the bit planes have the same feature, so you can display a small image out of a larger image.

BYTE: *We're pretty familiar with the Atari 800 and the chips there. To do horizontal and vertical scrolling you had to reset the pointer to a new byte.*

Miner: You could only move one byte before you had to reinitialize things in memory. Here you can do the same thing, but you can also be displaying a portion of an actually larger memory. You've got both ways you can go here. The engine that puts the bit planes up on the screen also has modulo capability, so the address at the end of one line doesn't necessarily have to be one less than the address of the beginning of the next line. It can be many less. Simply by changing the beginning pointer of the entire screen, you can move the image through memory. You give it a starting address, which is the address of the point at the top left of the screen. You give it a length and a modulo value.

BYTE: *That would be the whole width?*

Miner: Right. Well, it would be the difference between what you're showing

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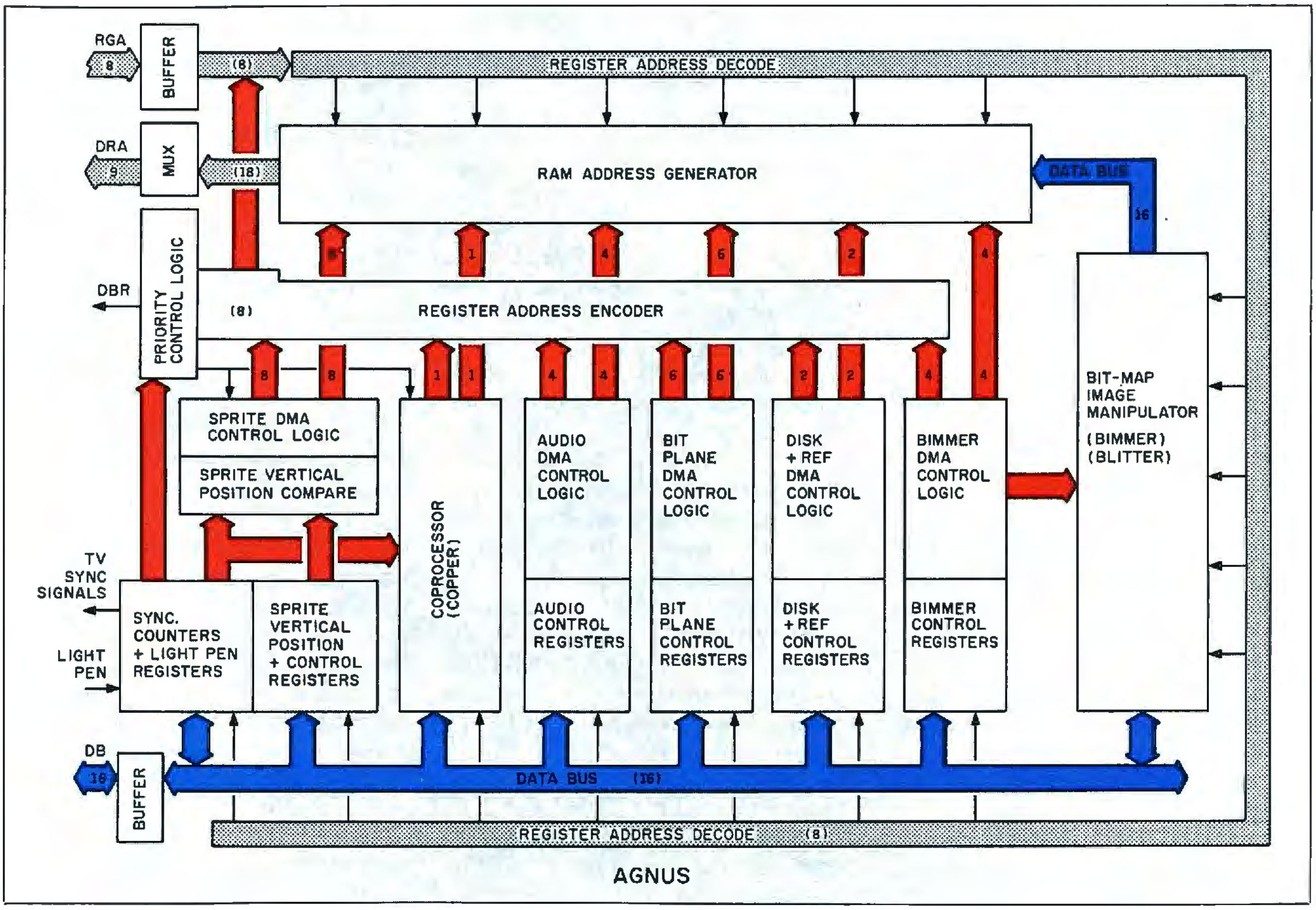

Figure 1: *A block diagram of the Agnus chip.*

and the whole width. There's the capability of six bit planes in this thing. The bit planes can be grouped into two playfields, and each playfield has its own modulo and its own horizontal-scroll register, the same type of horizontal scrolling as in the Atari 800. We thought several times about giving each bit plane its own modulo, but I couldn't think of any display that would really make good use of that, and the extra hardware didn't seem worth it. All the pointers, modulos, backups, and the 18-bit adder that makes them work—by doing both the incrementing and the modulo jumps—are on Agnus, as is all the control logic that sets the priority for which one of those DMA channels gets on the bus at which time.

Agnus Priority-Control Logic—DMA

Miner: The line coming from Agnus's priority-control-logic block should really be labeled DBR, which stands for data-bus request. But it's really not a request, it's a demand, because Agnus always has control.

BYTE: *How do you determine who has priority?*

Miner: The whole priority structure is really interesting. There are a lot of things that have individual time slots that occur, for example, during horizontal blanking. All of the sprite data transfer takes place during horizontal blanking, and it's assigned definite time slots. Each sprite has its own time slot, so it can't interfere with the transfer of the other sprites.

BYTE: *So after each horizontal sync, there are set chunks of time?*

Miner: There are set chunks of time for these data transfers, which include the sprites; the audio, which has some time slots there [four audio channels]; the disk, the refresh—all of these things are assigned. And the display itself, of course, is out here in the display time, so in a sense it also has fixed time slots; it can never compete with these other things. This is all highest, top-level priority. They don't compete with each other because they're always independent. You could have them all at the same priority level without worrying about it. And the stuff at the top priority is the display stuff and data transfer that goes in fixed time slots during horizontal blanking.

The three other things that we have to worry about are the coprocessor, the bimmer, and the main CPU [central processing unit]. That's the way it goes, in that order. The coprocessor is the next most important. It's a real-time coprocessor that's used frequently as a real-time engine to synchronize with the beam for various things like display and audio. It gets any cycles that are empty that it can use, but in order to not make it a hog, it's an every-other-cycle machine at the most. It's looking for empty cycles. If it finds one, it will use it, but it won't use two in a row.

BYTE: *In the top priority, there are no empty spaces?*

Miner: Oh, there are some empty spaces, especially in low resolution. At low resolution, the display portion has empty spaces, another key feature

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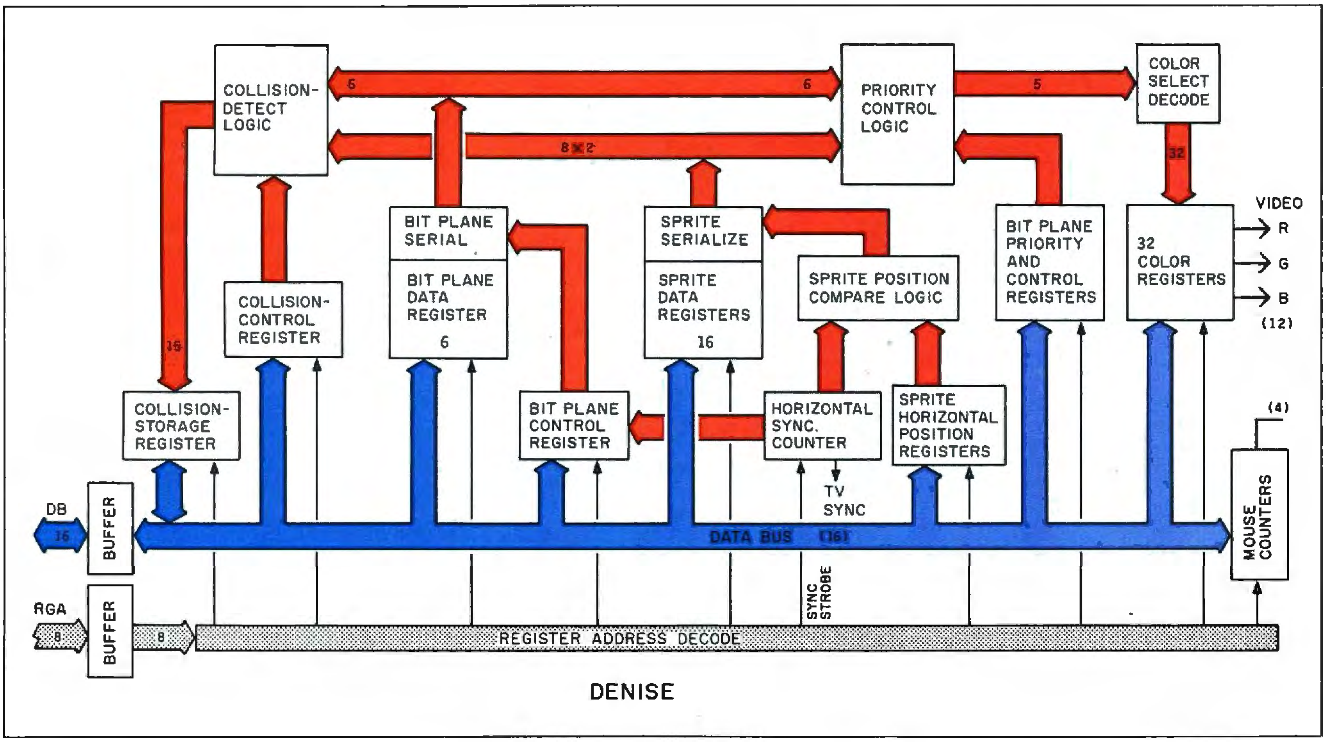

Figure 2: *A block diagram of the Denise chip.*


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of the machine. Our normal resolution, what we consider normal low resolution—320 dots across the screen—leaves 50 percent empty slots during the display.

BYTE: *It puts out a dot and then it has a little time?*

Miner: No, putting out dots is continuous. I'm talking about memory fetches to support those dots, which have every other cycle empty.

BYTE: *And there's enough time to switch over and let somebody else use that memory cycle and then switch back?*

Miner: Oh, yes. An empty cycle is up for grabs, always. And during horizontal blanking, to maintain that concept, we have every other time slot assigned to a sprite or an audio refresh. That means that during horizontal blanking, 50 percent of the memory cycles are empty. So looking at the whole time, approximately 50 percent of the cycles are empty. The reason we did this is because the 68000 CPU can use the bus efficiently only 50 percent of the time.

BYTE: *Why is that?*

Miner: Because of the way it's made internally. It has to fetch an instruction, which is a memory cycle, decode that instruction, and do some operation like storing data. The way it's set up, the length of time—the number of clock ticks it takes to decode the instruction—is almost equal to the length of time it spends on the bus. So at the lowest resolution—320 dots across the screen—we match the processor, and the processor thinks it's got an empty bus because it interleaves right in between those display cycles. This is something that is unique to this machine. And the processor is as happy as a clam; it thinks it's got full bus access.

If we go from 320 dots up to 640 dots, then that fills in the display time. But what I just said is still true during horizontal blanking. The microprocessor has the bus all the time that Agnus lets it. The coprocessor is an every-other-cycle machine. It goes along using time slots as it can, based on those rules.

The bimmer, however, is a real hog. If a time slot is available, the bimmer will use it, especially when it's in what's called the nasty mode. Now *there* is a mode where you can tell the bimmer, "Hey, don't be so nasty, don't take so many cycles, leave some for the main microprocessor in case there's an interrupt." Because if the bimmer gets to operating heavily, it's operating on a large area of screen in a non-real-time way; churning memory up, it can hog a lot of bus cycles. Of course, it's the right arm of the main microprocessor, so it's doing things that the main micro would have to do otherwise, in terms of graphics manipulation. Still, if you want to be at all responsive to interrupts—and in a multitasking machine like this, you have to be responsive to interrupts—you've got to have a mode where the

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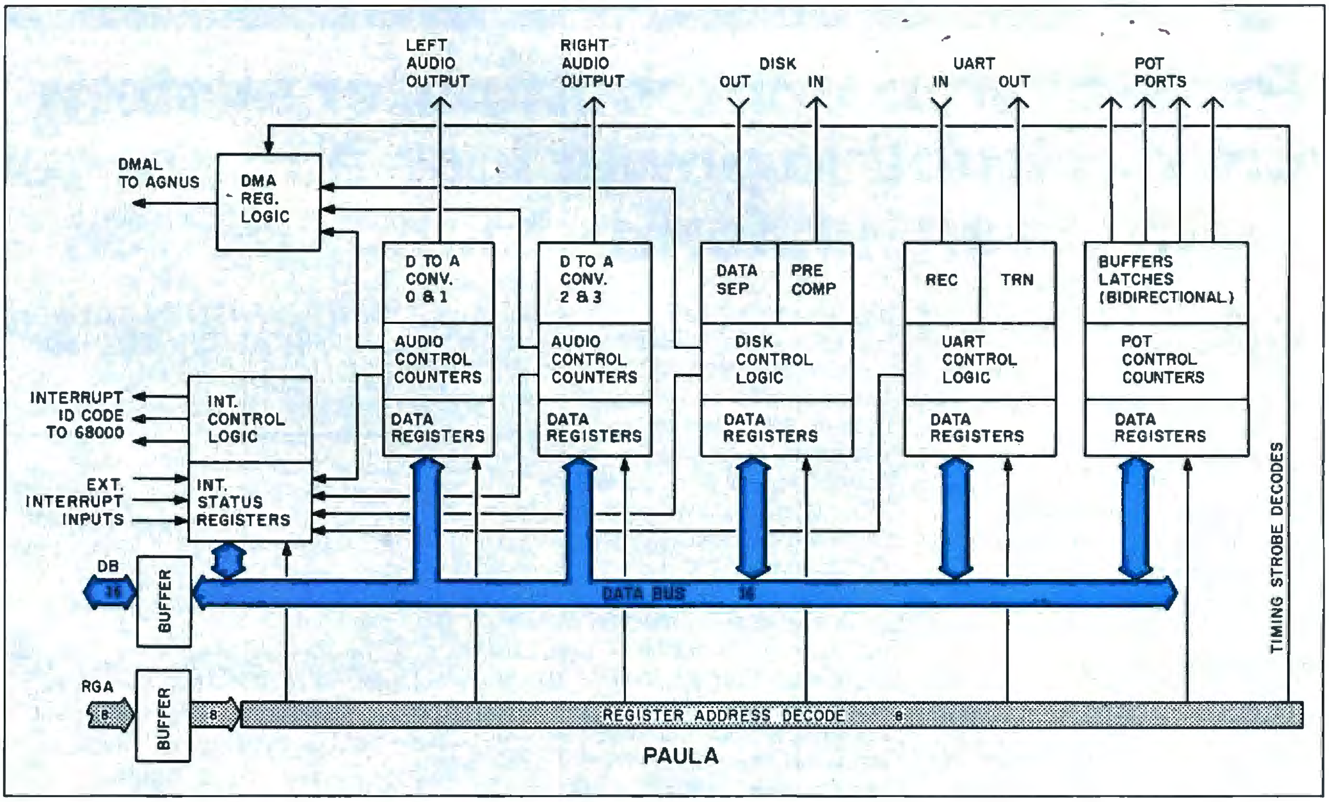

Figure 3: *A block diagram of the Paula chip.*

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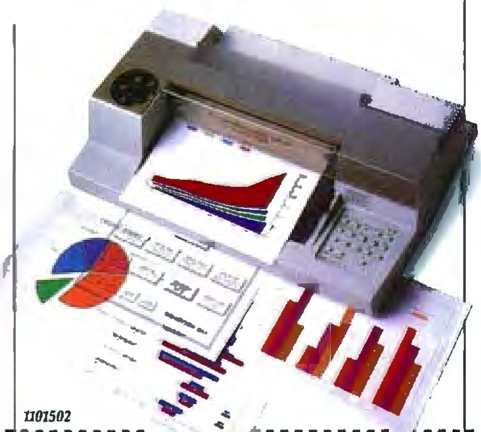

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bimmer once in a while takes a pause and says, "Okay, microprocessor, here, I'll give you a couple of time slots."

SPRITES

BYTE: *We're curious about the sprite hardware.*

Miner: Unlike the Atari 400 and 800, we do not have "players"—sprites with a vertical bit map. The idea was to save vertical registers and vertical comparisons in hardware and put them into the software by requiring the programmer to reposition the image in the vertical bit map.

BYTE: *That was a direct outgrowth of the way you did the players in the Atari 2600, where they were only one line long and one bit wide. You had to redefine them on the fly for each video line. A logical extension would be to make that two-dimensional.*

Miner: It wasn't that so much. You see, the 2600 had no bit map at all except in ROM, where there were some bit maps of sprite images. All of the stuff was created on the fly. I was really tight on register space—the design rules were *big*—we were trying to save as much hardware as we could and put functions into software. So we came up with the idea that if we didn't have any vertical comparators at all, and no vertical position registers, then what we would end up with is a sprite that is not a real sprite in both directions, but only in the horizontal direction. In the vertical direction it's a bit map. That was the concept that we patented in the Atari machine. We don't have that here at all. We've got a general-purpose sprite both horizontally and vertically—a classical sprite concept with a vertical start position and a vertical stop position.

BYTE: *The sprite is 16 bits wide, but it can have any height?*

Miner: It can be any height because it can have any start and stop position, but its height is not related to the bit-map image like it is in the Atari 400 and 800. Its height is related to the line count given by a start-control register and a stop-control register. There are eight sprite engines. Each one is 2 bits deep (which allows for four colors per sprite) and 16 bits wide at low resolution (at the 320-dot horizontal rate).

BYTE: *What choices do you have for the four colors? Is there a separate color table for each sprite?*

Miner: There's a separate color table, but not for each sprite. There's some sharing that has to go on. We've got only 32 color registers, and those have to be shared between the playfields and the sprites. Sometimes the playfield uses 16 of the colors and the sprites have the other 16. Sometimes some of them are shared, depending on how many colors you're trying to show on the playfield. Those eight sprites can be combined to make four sprites that are 4 bits deep with 16 colors each. The total sprite bit resolution, however, does not go down to as fine as the high-resolution playfield.

BYTE: *How do you get more than eight sprites?*

Miner: You can reuse the sprite engines any time you want.

BYTE: *You mean you just have to reset them between frames?*

Miner: You reset them horizontally or vertically. Once you finish using one

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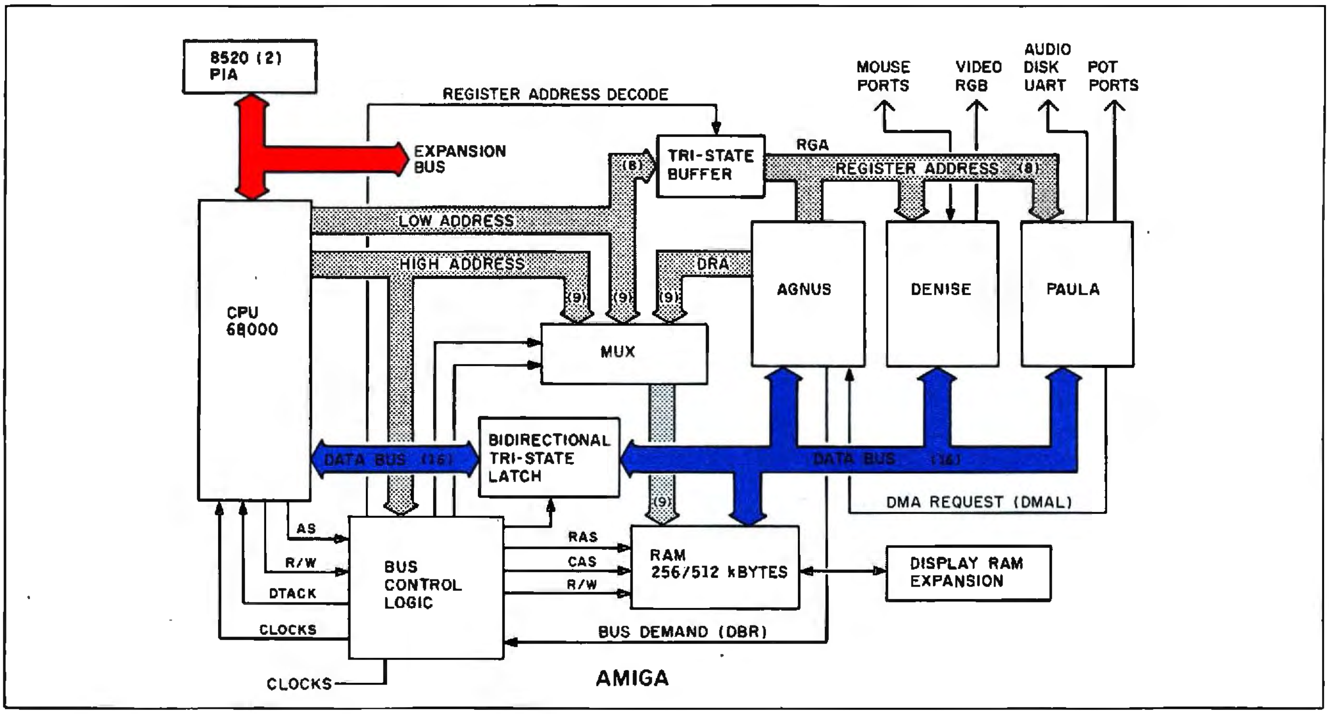

Figure 4: *A block diagram of the Amiga's overall architecture.*

vertically, you have to wait one line time before you can use the same engine again vertically. You can use the same engine over and over again on a horizontal line if you can get enough microprocessor or coprocessor time to go in there and rewrite the registers.

Digital RGB, Analog RGB, and NTSC

BYTE: *When you put out* RGB *[red-green-blue] data, how does it come out?*
Miner: It comes out as 4 bits, 4 bits, and 4 bits.

BYTE: *And that's how* RGB *monitors normally take their information?*
Miner: Off chip it goes into a ladder. There are three groups of 4 bits coming right out of the 32 color registers, and then there's a four-resistor ladder on each one of those that converts it into three analog values. That's what goes to the monitors.

BYTE: *Then the values of that analog data—which you've changed from the digital data—determine how strong each of the* RGB *guns is when it's firing at a particular point?*
Miner: Yes, on the so-called analog RGB. There are two kinds of RGB: digital and analog. This is important to stress because IBM talks about 16 colors, but what IBM really means is two shades of eight colors, and those two shades are always the same color. There's no way to change them. That's what's called digital RGB, or RGBi. It's got red on and off, it's got green on and off, it's got blue on and off, and it's got an intensity level that determines brightness or darkness for each one of those. It's a four-wire control, but it's completely digital. We put that out too, in order to be compatible, but we also put out the analog RGB, which has 4 bits, 4 bits, and 4 bits, into ladders, so you get 16 values of red, 16 values of green, and 16 values of blue. It's equivalent to 2^{12} total colors and luminances.

BYTE: *So on the analog output, you could have any number of bits that you wanted? You could put out 10 bits on each line?*
Miner: Yes, if you had big enough registers. In fact, that's probably one of the things we'll be expanding in the future chip set.

BYTE: *Why did you choose 4 bits in the first place?*
Miner: Originally, this wasn't going to be RGB; it was going to follow the NTSC [National Television System Committee] standard. NTSC works on intensity, hue, and saturation. Color and luminance. YIQ is what they call it. The *Y* is the intensity, and the *I* and the *Q* define a vector that determines the saturation. Having 4 bits of each was about the best we could tackle in terms of having on-chip ladders that would take the 4 bits for each one of these and convert them into an actual phase angle.

BYTE: *So that ladder is on Denise?*
Miner: No, it was when we had the YIQ; when we were emphasizing NTSC, we had a ladder on board. Then we deemphasized it. We found a Motorola chip that did a good job of converting RGB into NTSC. We needed the extra room on the Denise chip for extra resolution on the color registers, so we dropped the YIQ NTSC completely. But we've still stuck with the 4, 4, 4 bits. Also, you've got a real pin limitation on a chip like this. We tried to keep the chip simple and low-cost to manufacture, and on-chip ladders take up a lot of area. They're notoriously inaccurate, and you can buy 1 percent resistors external for a penny apiece.

BYTE: *Is there still* NTSC *output from the Amiga?*
Miner: In the box there is, yes. But not in the chips.

Bit Planes

BYTE: *Explain the bit planes to me a little better. You've got ones and zeros in memory and you overlay them; you look at a group of them simultaneously to determine what the color is of something that's actually on the screen. Do you have an address for the beginning of each bit-plane area?*
Miner: Yes. The concept of bit planes is very deeply ingrained in this architecture. There are really two conflicting display concepts here. One is pixel addressing; the other is bit-plane addressing. We've chosen bit-plane. One reason for our decision is that we wanted to do a very efficient area-fill.

BYTE: *You mean filling in a particular zone on the screen?*
Miner: Yes, and that's done quite well and efficiently with bit-plane addressing on a single bit-plane basis. We wanted to have a lot of variety in the number of bit planes that you can specify. We wanted to have our two separate playfields—each one with a controllable number of bit planes in it. We didn't want to waste a lot of data transfers if we had fewer bit planes than others did. So we decided not to transfer data on a pixel basis, which wastes a lot of transfer time if you don't use all of your pixels or all the bits within a pixel. Even if you don't use them all, you still have to address them, and it still takes a memory cycle. When you're bit-plane-oriented, if you've got only two bit planes instead of eight, since you're moving data out of a single bit plane only, it doesn't matter because you're using all the bits that come across. That was really why it came about: to increase the efficiency of data transfers and the sprite transfers for different numbers of bit planes and different organizations.

BYTE: *When the bimmer is operating on its three sources and sending to its destination, is it operating on pieces of bit planes?*
Miner: It's always operating on only one bit plane at a time. If you want to do a picture with multiple bit planes, you just do the same routine and point it to where that other bit plane is located.

BYTE: *But it can't take a chunk and move it from bit plane number 1 over to bit plane number 2?*
Miner: It could, sure. But that isn't normally the way it's done. Usually you define the bit planes, and you operate on them as though they were images one behind the other.

(continued)

BYTE: *This screen that you have that's looking at a section of the large image is actually looking at the bit planes stacked on top of each other?*
Miner: No, the bit planes are never really stacked.

BYTE: *Well, in memory then, because memory is just stretched out.*
Miner: Memory is contiguous, right. So the bit planes are really located separately in memory, but since they're fetched by the bit-plane DMA channel, a word at a time from each bit plane, they're placed into these holding registers in Denise. Then when bit plane number 1 comes along, they know they've all been filled, so you simultaneously convert them all from parallel to serial and start squirting them out. While they're squirting out, the parallel's being reloaded to get ready for the next squirt-out. As they come out, you're looking at them as though they were a pixel, at a single instant in time.

BYTE: *How does barrel shifting fit in?*
Miner: The bimmer's barrel-shift capability lets you move images on pixel boundaries. If it weren't for the barrel shifter, the bit-plane concept wouldn't work at all. When you're doing pixel addressing, since each pixel has its own address, to move stuff by one pixel all you have to do is increment the address by 1. There's no problem in moving stuff—using pixel addressing—on arbitrary pixel boundaries. But when you're using bit-plane techniques like we are, where each word represents a whole bunch of pixels from one bit plane, then to move that image within a word, within a single pixel boundary, you've got to shift it by an arbitrary number from 0 to 15.

BYTE: *Even across words?*
Miner: Yes. The barrel shifter allows you to do that here. As the data is transferred from source to destination, you can move it by an arbitrary number of pixels.

SCROLLING

BYTE: *Could you explain the scrolling process?*
Miner: The bit planes need the horizontal-sync-counter output bits because they have to fetch over and over again across the line. Also, they need to do scrolling. The bit planes have a delay capability called horizontal scrolling built into them. This hardware scrolling actually delays the fetching of data so that it shows later on the screen. To do that, it's got to have a counter that causes 0 to 15 bits of delay.

What shows on the screen is the size of the screen display. The picture in memory can be quite a bit larger than that, and it can have multiple bit planes. There are two ways to change

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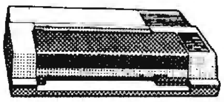

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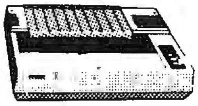

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Collision Detection

BYTE: *What about the information feeding over to the bit-plane controls and the whole interaction of bit planes and sprites? Collision detection has nothing to do with what shows; it just tells you when something has happened, right?*

Miner: Exactly. Collision detection is looking in real time at the simultaneous occurrence of objects. Sprites are on the 16 lines out of the sprite-serialize block, and bit planes are on the six lines out of the bit-plane-serialize block. Any simultaneous, real-time occurrence of more than one object at the collision-detection logic will be detected and stored in a latch in the collision-storage register. The program or the programmer can read this back out any time.

BYTE: *How do you know when there's an object here if there's always some sort of data on the line? If this line is low, then do you assume that it's not data?*

Miner: Right. Zero is always nothing. Zero is transparency.

BYTE: *But collision is more complicated than just "There are two things here."*

Miner: Collision control is quite complex. We've got an ability in this machine that I've never seen in any other machine before. Take a four-bit-plane playfield. Here's a sprite coming along. It can collide with that playfield by virtue of hitting any of those planes. This whole architecture is bit-plane-oriented rather than pixel-oriented. I can collide with any bit plane or mask any bit plane from the collision. Or I can actually invert the polarity of the bit plane with which I'll collide. The collision-control register decides which bit planes get looked at by the collision monitor and with what polarity. You can be very picky about what kinds of playfield the sprites collide with. By using all bit planes and getting the right polarity, you could have a collision with any individual color.

BYTE: *With 128 virtual sprites as a possibility and the various bit planes, it seems like you'd have an enormous number of things for the collision-control register to keep track of.*

Miner: Well, the collision-control register doesn't keep track of those virtual sprites. It only keeps track of real sprite-engine collisions. For real sprites, you use the collision-control register every vertical-blank time, and if a sprite collided during the previous frame, then you know that a collision occurred. ■

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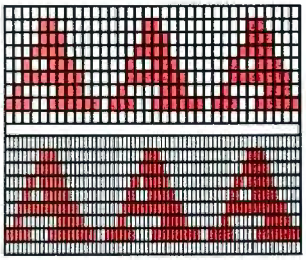

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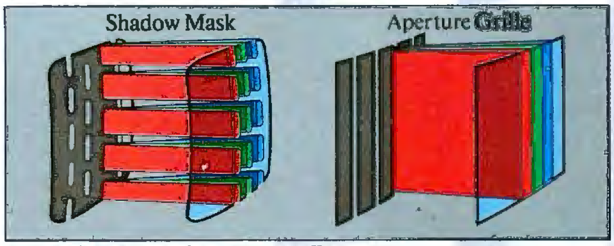

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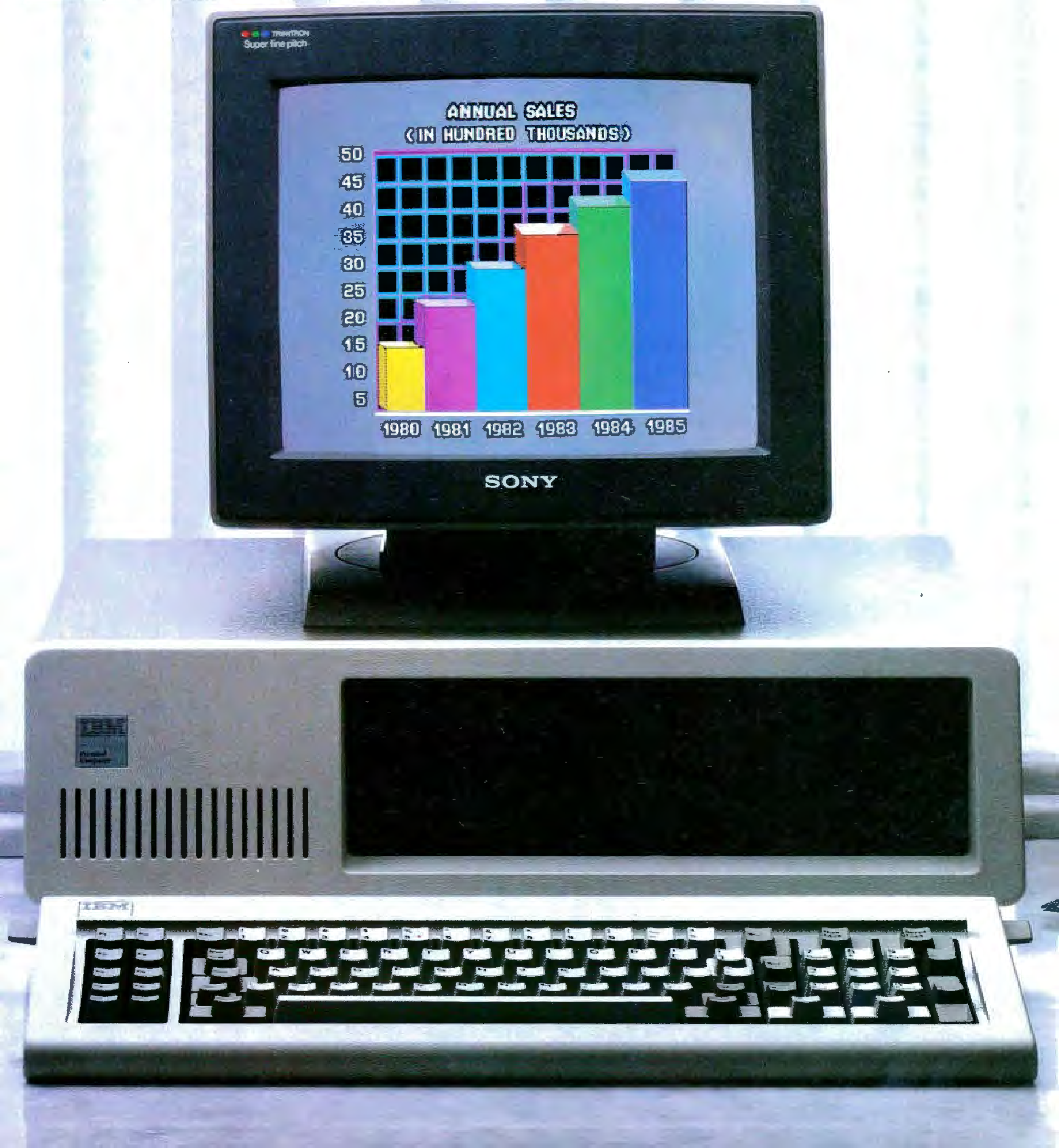

RASTER OPERATIONS

BY JOHN BENNETT

Integrating text and graphics in high-performance systems

IN RECENT YEARS memory prices have fallen to the point that it is economical to represent text and graphics using a bit map. A bit map represents a two-dimensional image by dividing it into a rectangular matrix of pixels, each represented by a fixed number of bits. The pixels are normally displayed by a raster technique; information is fed to the screen as a series of horizontal lines (as in television images).

All bit maps must have at least one bit per pixel assigned to convey color information. Additional bits may be used for more color information or to convey intensity, depth, priority, and a broad range of other application-dependent information.

Because of their flexibility and decreasing cost, raster displays have gained broad popularity. Systems that use more than one bit per pixel are somewhat more complex but are not substantially different in principle than those that use a single bit.

Decreasing memory prices and increasing user demand for display quality have also caused an increase in the resolution of raster displays. This increased resolution has placed significant demands on display hardware. We will examine the origin of these demands and a few cost-effective techniques for meeting them.

RASTER DISPLAY HARDWARE

A basic raster display system is shown in figure 1. The heart of this system is the *frame buffer*, a block of memory with storage assigned to each pixel of the displayed image. This memory is accessed by the *sweeper* and the *graphics processor*. The sweeper accesses the frame buffer periodically to obtain the data necessary to update the display device. The most common raster display device is the cathode-ray tube (CRT). Other examples include bit-mapped impact printers and laser printers.

Since the horizontal and vertical timing of a raster display system is usually fixed, the sweeper must provide new data at precise intervals. For this reason, the sweeper is given priority access to the frame buffer. On a high-resolution system, this decision can have a significant impact on performance. Consider a 1024-pixel by 1024-pixel display that is refreshed by the sweeper at 60 frames per second. The sweeper must obtain 62.9 million pixels per second from the frame buffer!

The graphics processor also accesses the frame buffer, either to read its current contents or to write new information. The graphics processor must synchronize its requests for access to the frame buffer with the sweeper's requests so that it does not interfere with sweeper access.

Failure to perform this synchronization results in corruption of the displayed image during graphics-processor access to the frame buffer. Since the sweeper must always access the frame buffer, that portion of the frame buffer's bandwidth not used by the sweeper is the time allotted to the graphics processor to manipulate graphic data to be displayed. With conventional memory components, this percentage approaches zero as display resolution increases much beyond 1024 by 1024 pixels. Later we will look at a new memory compo-

(continued)

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nent called a video RAM (random-access read/write memory) that allows the practical construction of much higher-resolution displays without severely affecting the percentage of time available for graphics-processor update of the frame buffer.

Raster displays are not a panacea for all graphics applications. Line-drawing and point-plotting display systems also serve in several application areas. What is perhaps unique about raster display systems is their ability to effectively emulate other technologies. This ability, coupled with the relative simplicity of raster-based systems, makes them an attractive choice for many graphics applications.

USING RASTER DISPLAYS

Raster displays are used to display and manipulate graphic images and text. Although text is conceptually just another form of graphic data, in practice it is often convenient (and more efficient) to treat text as a distinct entity.

Nontext graphic images are composed of one or more primitive elements. The most common primitive element is the point. A point is a pixel that is displayed with some color and/or intensity. Points are used to compose lines and curves. Lines are used to compose polylines and polygons (open or closed sequences of lines). Curves may be simple (e.g., a circle) or complex (e.g., a parametric cubic surface).

Lines and curves need not be only a single pixel in width; they may be of arbitrary width. Lines and curves may also be textured. A textured line or curve is created by replacing each pixel with a bit map. Bit maps are themselves primitive graphic elements. Figure 2 shows textured lines created using a bit map composed of a circle.

Bit maps may be much more complex—for example, a LANDSAT (earth reconnaissance satellite) image. Closed regions created with other primitive elements may be filled with a solid color or with a pattern. The pattern is simply another bit map. By combining these primitive elements, virtually any image can be created.

Because text occurs so frequently, it is usually treated as a special graphic element. A character of text may in reality be just a rectangular bit map of some size. Characters may also be created from lines (called *stroke characters*). Examples of stroke characters are character strings displayed on pen plotters or vector displays.

Raster displays customarily use bit-mapped character strings. Characters are stored in a *font*. A font is a set of bit maps of the letters of the alphabet and any other special characters that may be displayed. These bit maps are usually densely packed in a safe area of the address space, such as in ROM (read-only memory).

The characters that make up a font are generated within a rectangular bit map sometimes called a cell. Within a particular font, cell sizes may be fixed or variable. If all cells have the same width, the font is said to be *monospace*. If cell widths vary according to the character being displayed, the font is said to be *proportionally spaced*. Strings built from proportionally spaced fonts have characters starting at "arbitrary" pixel boundaries along a line of text.

Monospace fonts usually have characters aligned at "specific" pixel intervals along the line. If the character cells are word-aligned within the raster (for example, they might correspond to byte boundaries within the frame buffer), we have the simplest (and least flexible) mechanism for text display.

INTEGRATING TEXT AND GRAPHICS

Many applications require text and graphics to be displayed simultaneously. Bit maps are a natural choice for this environment. Even the lowest-priced personal computers now provide bit-mapped displays and some level of support for interactive graphic editing. High-quality document-preparation systems often have high-resolution displays emulating phototypesetters and laser printers for "what you see is what you get" document preparation.

With the exception of single-pixel-width lines, nearly all graphics primitives involve the display, manipulation, and combination of bit maps. One of the most popular and complete tools for manipulating bit maps is the BitBlt operation (pronounced

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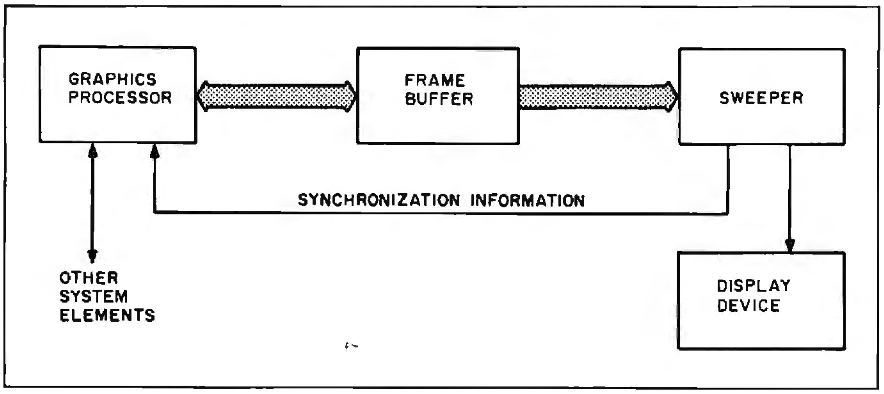

Figure 1: *Basic raster display system.*

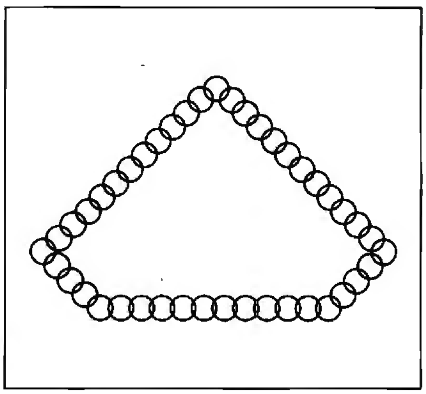

Figure 2: *Some textured lines.*

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bit-blit), also known as RasterOp. BitBlt is a general-purpose abstract procedure for copying, moving, and combining portions of bit maps. BitBlt got its name from an instruction called Bit-Boundary Block Transfer on the Alto personal computer developed by the Xerox Palo Alto Research Center in the early 1970s. William Newman and Robert F. Sproull first coined the term "Raster-OP" in *Principles of Interactive Computer Graphics* (McGraw-Hill, 1979). BitBlt is an integral part of the user interface of the Smalltalk-80 system, also developed at Xerox PARC.

BitBlt is general enough to perform a wide variety of graphics operations, including text display using arbitrary fonts, scrolling, window management, and highlighting. Successive applications of BitBlt can perform operations such as scaling, area fill, rotation by multiples of 90 degrees, and textured line drawing.

Bit maps are usually stored in physical memory in what is called *raster order*. Assuming that the unit of storage is a 16-bit word and that there is one bit of information per pixel, the leftmost 16 bits of the top row of the bit map would be stored in the first word, followed by zero or more words containing the remainder of that row, followed by zero or more additional words containing subsequent rows from top to bottom. The order of pixels within words is dependent on the systems' particular hardware and software implementation.

The left and right edges of bit maps may fall on arbitrary pixel boundaries. Arbitrary pixel boundaries imply arbitrary bit positions within the underlying physical memory. One of the most useful properties of BitBlt is its ability to mask the details of source-to-destination bit-map alignment from the user. All direct handling of bit maps and the word boundaries inherent in them is encapsulated by the BitBlt operation. The user specifies desired operations with dimensions given in pixels.

BitBlt Functions

BitBlt performs the following operation: An arbitrarily aligned rectangular region of a destination bit map is replaced on a pixel-by-pixel basis with one of the 256 Boolean functions of three variables—the previous contents of the destination bit map, the corresponding pixel from an arbitrarily aligned rectangular region of a source bit map, and the corresponding bit from a halftone bit map. The halftone bit map is typically a 16- by 16-pixel array interpreted as one tile of a pattern covering the entire destination bit map. Examples of typical functions are shown below.

- Clear all pixels to 0
- Set all pixels to 1

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PERFORMANCE

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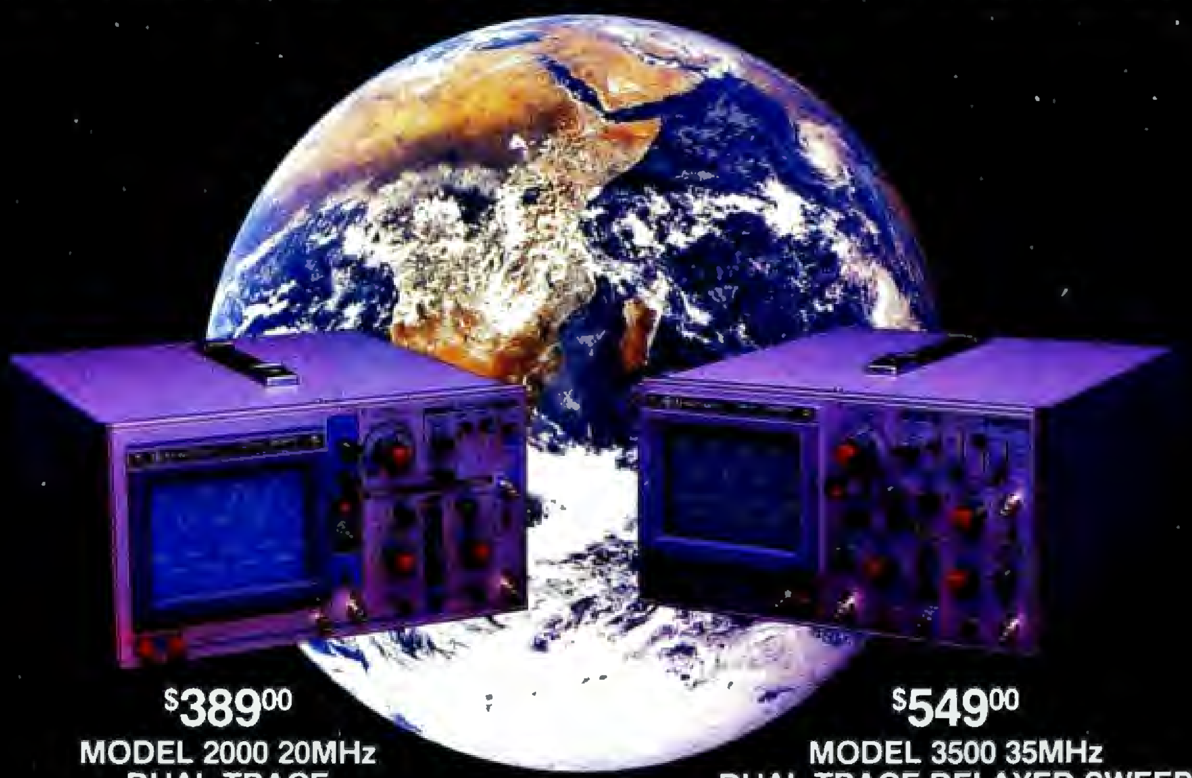

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- Paint (source OR destination)

With the exception of single-pixel-width vectors and arcs, BitBlt provides a natural and powerful tool for manipulating text and graphics. Although BitBlt can be performed one pixel at a time, such an implementation would be quite slow. It is therefore highly desirable to devise a means of performing the BitBlt operation on multiple pixels simultaneously. We will examine this and other techniques for improving the performance of BitBlt in the next section.

IMPROVING PERFORMANCE

Increases in resolution and capability in a raster display system place the sweeper and graphics processor in conflict for frame-buffer access. Since sweeper bandwidth requirements are usually inflexible, two alternatives exist for reducing this conflict: Allow the sweeper to obtain more pixels per frame-buffer cycle, or provide a means to dual-port the frame buffer, enabling concurrent sweeper and graphics-processor access.

The first alternative requires increasing the width of the data path between the frame buffer and the sweeper. This approach is usually practical only for widths up to 64 bits, where component cost and layout considerations tend to make further increases infeasible. Because of this limitation, increasing data-path width can provide only a four- to eightfold improvement in bandwidth.

Further improvements require dual-porting the frame buffer. Since standard memory devices are single-ported, special hardware is required.

VIDEO RAMS

Recently, Texas Instruments, NEC, and AMD have announced products that can dual-port the frame buffer. These so-called video RAMs consist of a conventional memory element and a large shift register. The shift register is loaded with a number of bits (on the order of 256) with a single memory cycle. These bits can then be shifted out independently of other access to the memory element. Video RAMs have other capabilities that may also be useful in graphics applications—for example, shifting in data to the shift register and copying the register to the memory element with one memory cycle.

In a frame buffer constructed from video RAMs, the graphics processor accesses the frame buffer in the usual manner. The sweeper, however, needs to access the memory only from time to time when the shift register requires new data. When video RAMs are employed in a system with a wide data path to the sweeper, extremely high data rates are possible.

Put in simple terms, a 2K by 2K 60-Hz noninterlaced display is nearly impossible to attain with conventional memory devices. With the use of video RAMs, it is a comparatively easy task.

A VLSI SOLUTION

When we reduce sweeper demand on frame-buffer bandwidth, the graphics processor is potentially able to access the frame buffer at a higher rate. This will not be the case, however, if the graphics processor is compute-bound, which is to say it is overwhelmed attempting to perform the computation necessary to generate the graphic elements of interest. In this case the raw performance of the graphics processor must be improved before the benefits of higher bandwidth can be exploited.

As an example, consider BitBlt. Because BitBlt is a powerful abstraction, it is difficult to implement efficiently. Microcoded implementations have proved successful. Other combinations of hardware and software have met with varying success.

Since BitBlt is a repetitive process, an obvious mechanism for improving

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the performance of BitBlt is to optimize the inner loop. Within the inner loop, the following actions occur:

1. Data from a region in the source bit map is shifted and aligned to produce words of source pixels aligned with destination words. This is necessary since, in general, word boundaries of the source bit map will not line up with word boundaries in the destination bit map. Two words of the source bit map may be required.
2. Source, destination, and halftone values are combined according to the specified function. Recall that the function can be any of the 256 possible functions of three Boolean variables.
3. Destination modifications are clipped so that only pixels within the designated destination region are affected. The left and right boundaries of this region will not usually fall on word boundaries.

After studying several techniques for improving performance of BitBlt, we decided that a hardware accelerator for the inner loop was the most cost-effective solution. We first built an MSI (medium-scale integration) TTL (transistor-transistor logic) version of the accelerator to demonstrate the validity of our ideas. Encouraged by excellent results, we developed a full custom CMOS (complementary metal-oxide semiconductor) VLSI (very-large-scale integration) device that embodied what we learned from the TTL version. Some key design criteria of the device were:

- The device should function as a general-purpose data path so as not to constrain the user to a particular microprocessor family or memory technology. Control should be kept external to ensure this flexibility.
- The device should support all of the 256 possible Boolean functions of source, destination, and halftone.
- The performance of the device should not place limits on system-design criteria. The device should support current and projected memory speeds.
- The device should have a low-power-consumption design to allow its inclusion in battery-operated equipment.
- The device should have TTL inputs and outputs and require only a single 5-volt power supply.
- The device should be as small as possible to facilitate multiple device configurations.

The result of these design decisions was the PMR 96016 (called the "Blt chip"). A block diagram of the 96016 is shown in figure 3.

PMR 96016 Circuit Description

The PMR 96016 contains a data path and a number of configuration registers. The data path performs (in

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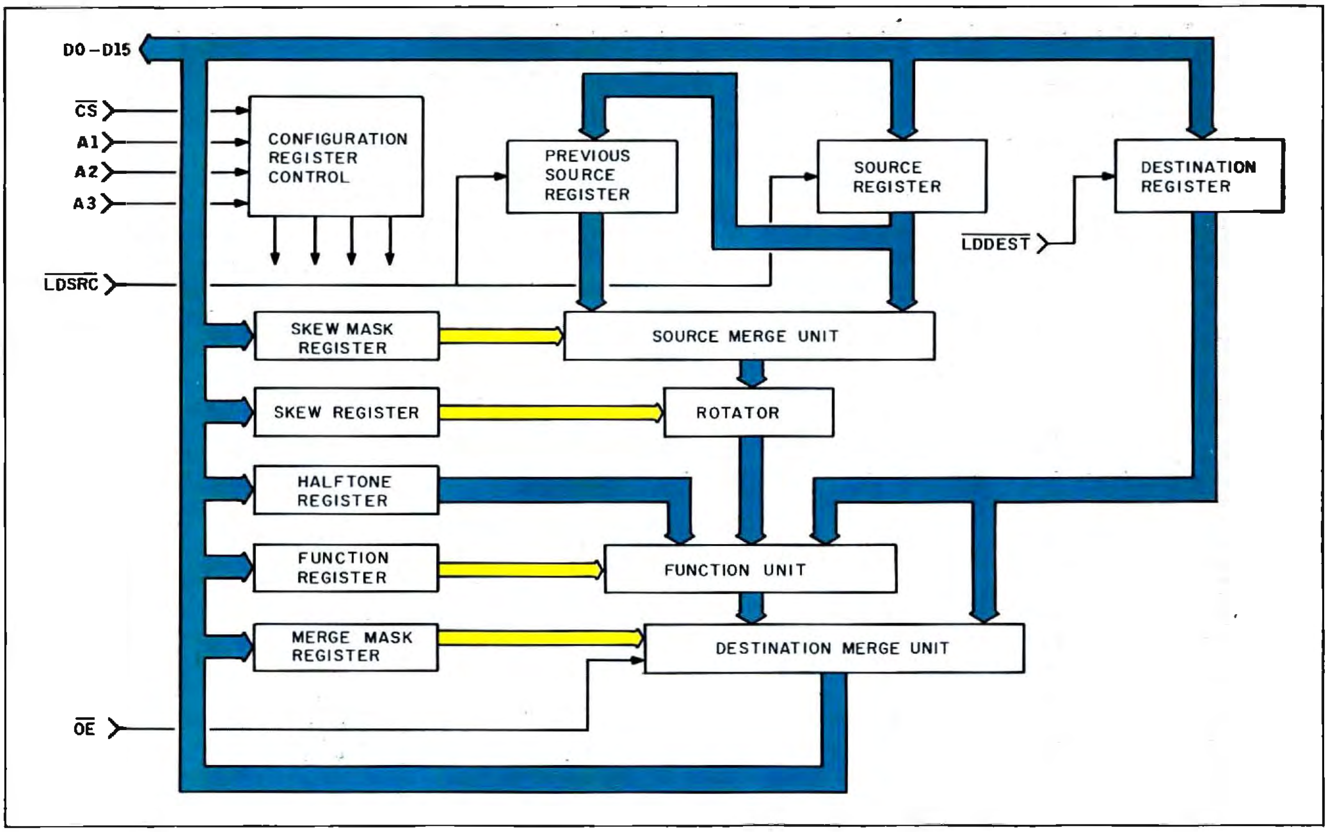

Figure 3: PMR 96016 *functional block diagram.*

Inquiry 422

hardware) the functions that consume the most time in a software-only implementation of BitBlt—namely, shifting, masking, and Boolean combination.

As shown in figure 3, the Blt chip consists of two Source registers, a Destination register, a data path, and five configuration registers that control the data path. All data-path elements are 16 bits wide. The three data-path registers are the most frequently used and therefore are controlled by dedicated interface pins. These registers are described below.

The Source register holds a word of source pixels. It is loaded from the data bus using the LDSRC- pin.

The Previous Source register holds the former contents of the Source register so that two adjacent words of source pixels are available in the device at one time. This register is loaded from the Source register whenever the Source register is loaded.

The Destination register holds a word of destination pixels as they appear prior to modification. This register is loaded from the data bus using the LDDEST- pin.

The configuration registers control the operation of the data path. The CS- interface pin causes the configuration register addressed by A1–A3 to be loaded from the data bus. Except where otherwise specified, all configuration registers are 16 bits wide.

The Skew Mask register controls the source merge unit, which forms one word from portions of two source words. For each of the 16-bit positions, a "1" selects the corresponding bit of the Previous Source register, while a "0" selects the corresponding bit of the Source register.

The Skew byte, bits 3–0, specifies a left-rotate amount for the rotator. For example, Skew = 2 moves bit positions 0-2, 1-3, . . ., 15-1.

The Halftone register contains the row of halftone region appropriate to the current row of destination. If used, the Halftone register is rewritten at the beginning of each row.

The Function byte, bits 7–0, specifies the Boolean function for combining the rotated source word, Halftone register, and Destination register. Each of these eight bits specifies the desired result (0 or 1) for one of the eight possible combinations of source, halftone, and destination. There are 256 possible functions.

The bits of the Merge Mask register specify the portion of the destination word to be modified. For each of the 16-bit positions, a "0" selects the corresponding bit of the function unit output, while a "1" selects the corresponding bit of the Destination register (i.e., leaves that bit unmodified).

The pin-out of the PMR 96016 is shown in figure 4.

The PMR 96016 in a Microprocessor-Based System

During BitBlt operations, the PMR 96016 acts as an accelerator for a controlling microprocessor. The BitBlt algorithm for which the Blt chip design is optimized operates in scan-line order. It can be viewed as two nested loops, with the outer loop moving from one scan line to the next and the inner loop moving from one word to the next along a scan line. Setup of the Blt chip configuration registers is done outside of the inner loop. In fact, most of the configuration registers need be written only once for the entire BitBlt.

Four different types of cycles are used to access different portions of the Blt chip circuitry. All cycle types use the same 16-bit data bus. The cycle type is specified by asserting one of four control pins. The CS- pin is used to access configuration registers, while the other three control pins access portions of the data path. All four cycle types are summarized below.

The CS- pin controls loading or writing one of the configuration registers (specified by A1–A3) with the data on the bus.

The LDSRC- pin controls loading the Source register with the data on the bus and simultaneously transfers its previous contents to the Previous Source register.

The LDDEST- pin controls loading

(continued)

PIN DESCRIPTIONS

D0–D15	DATA INPUT/OUTPUT
A1–A3	ADDRESS INPUTS TO SPECIFY CONFIGURATION REGISTER TO BE ACCESSED FOR A GIVEN OPERATION AS FOLLOWS:

A3	A2	A1	
0	0	0	– SKEW MASK REGISTER
0	0	1	– SKEW REGISTER
0	1	0	– HALFTONE REGISTER
0	1	1	– FUNCTION REGISTER
1	0	0	– MERGE MASK REGISTER
1	0	1	– RESERVED
1	1	0	– RESERVED
1	1	1	– RESERVED

CS-	CHIP SELECT INPUT. LOW TO WRITE CONFIGURATION REGISTERS.
TEST	USED FOR TESTING. SHOULD BE GROUNDED FOR NORMAL OPERATION.
LDDEST-	LOAD DESTINATION DATA. DATA IS CLOCKED INTO THE DESTINATION REGISTER ON THE RISING EDGE.
LDSRC-	LOAD SOURCE DATA. ON THE RISING EDGE OF LDSRC-, DATA IS CLOCKED INTO THE SOURCE REGISTER AND THE OLD VALUE OF SOURCE IS TRANSFERRED TO THE PREVIOUS SOURCE REGISTER.
OE-	OUTPUT ENABLE. LOW TO ENABLE THE 96016 DATA OUTPUT BUFFERS. THE OUTPUT DATA IS THE DATA PATH RESULT.

PIN CONFIGURATION

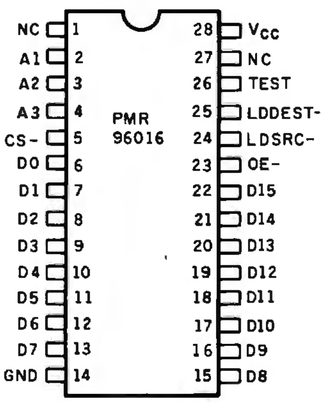

Figure 4: PMR 96016 *pin-out.*

the Destination register from the data bus.

The OE- pin controls reading the data-path result to the data bus.

The sequence of actions that constitute the body of the inner loop, and that therefore must be performed the most frequently, is as follows:

1. Read a word from the source region in memory and load it into the Source register using LDSRC-.
2. Read a word from the destination region in memory and load it into the Destination register using LDDEST-.
3. Use OE- to obtain the new destination word and write it to the same memory address that was read in step 2.
4. Increment both the source and destination memory addresses so that they point to the next word along the scan line.

It is possible to design the Blt chip into a system in such a way that all of the actions in steps 1 through 4 above can be performed with a single microprocessor instruction. If the microprocessor has a special instruction for moving a string of words, the entire inner loop becomes one string move.

The system components relevant to BitBlt operation include a microprocessor, a PMR 96016 Blt chip, dynamic RAM, and a RAM controller. Whether or not the RAM has a second port for generating video to refresh a raster display device has little effect on the portion of the design described here. All data buses are 16 bits wide, although the microprocessor might have 32-bit-wide data paths internally. Figure 5 is a block diagram of a typical application showing the relationship of these components and the primary buses and control lines interconnecting them.

The microprocessor serves as the BitBlt controller in addition to its task as CPU (central processing unit) for the system. It accesses the Blt chip configuration registers directly as individual words in its I/O (input/output) address space (that might be memory-mapped). The three types of Blt chip data-path access cycles, however, are implemented as side effects of accessing memory within certain address ranges. We will call this type of memory cycle, further described below, Blt-Special.

Blt-Special Read and Write Cycles

In a typical application, the 96016 performs its task by intercepting data transferred from memory on Read cycles (Blt-Special Read) and substituting its own data on Write cycles (Blt-Special Write). The memory controller participates in this task by causing BitBlt memory Write cycles to be converted into Read-Modify-Write (RMW) cycles.

The Read portion of the RMW cycle reads the previous destination contents. During the Write portion of the

(continued)

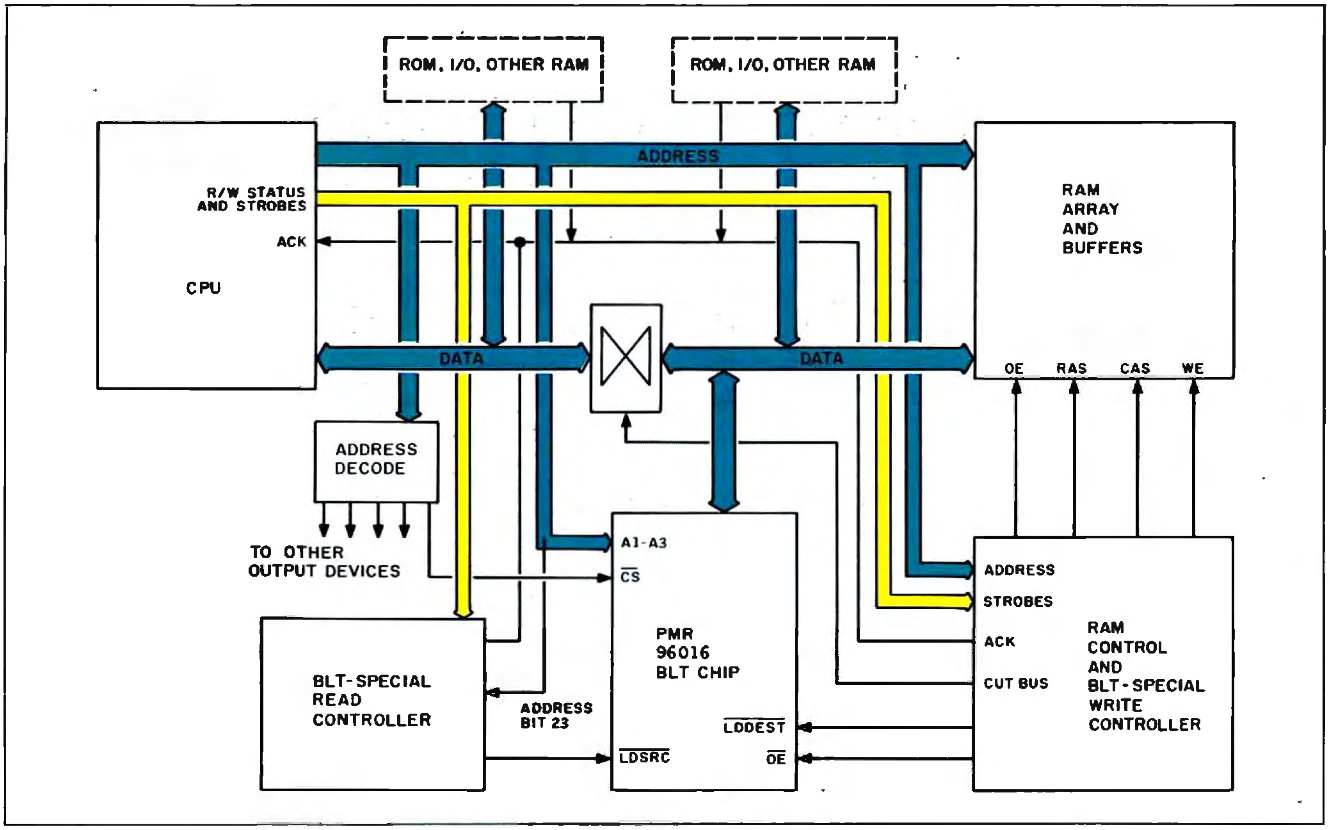

Figure 5: *Block diagram of a typical* PMR 96016 *application.*

Blt-Special cycles are cycle-by-cycle context-switching.

cycle, the 96016 outputs the new destination contents. The host processor is used as an address generator and for initial setup. The result is that a horizontal row of pixels can be read from the Source, combined with the Destination and Halftone, and written back to the Destination, all requiring only two bus cycles per 16 pixels, plus a small amount of setup time.

Previously, we outlined the sequence of memory and Blt chip cycles that occurs most frequently during a BitBlt operation and therefore should execute as fast as possible. The sequence involves two memory addresses, one for a source word and one for a destination word, and these addresses must be incremented before the next loop iteration. Most microprocessors can generate this type of alternating sequence of addresses rather quickly, using either a single string-move instruction or a sequence of move instructions where both source and destination addressing modes are register auto-increment (address registers are automatically incremented at the end of each iteration).

Outside the microprocessor, at the bus level, this type of instruction manifests itself as a Read cycle followed by a Write cycle, with both cycles addressed in appropriate ranges to cause the cycles to be Blt-Special.

By using these Blt-Special cycles, we are able to transfer data between memory and the Blt chip in a single bus cycle. By encoding this special type of cycle in the address, we get a sort of cycle-by-cycle context switch between Blt-Special and normal bus cycles.

In this example we will assume a microprocessor that generates a 24-bit address (for example, an MC68000) and we will use the highest-order address bit, A23, as a Blt-Special indicator. This divides the 16-megabyte address space into two 8-megabyte spaces. The lower half is allocated among memory-mapped I/O, ROM, and RAM, including RAM used for program and data storage and any dual-ported RAM used as video frame buffers. The upper half is then used to access the same resources, but with Blt-Special action. Blt-Special action is not appropriate for all system resources, but it is not necessarily limited to frame-buffer memory.

A Blt-Special Read cycle is identical to a normal Read cycle except for the side effect of asserting LDSRC- so that the Read data from memory will be loaded into the Blt chip Source register. The resource addressed (regardless of A23) might be RAM or might be ROM containing fixed images. The circuitry to generate LDSRC-, known as the "Blt-Special Read Controller" (BSRC), need only look at the CPU's Status or Strobe, address bit 23, and the Acknowledge or Ready line to the CPU. The timing of LDSRC- should be such that its rising edge occurs at the time when the CPU captures the Read data. This is shown in figure 6.

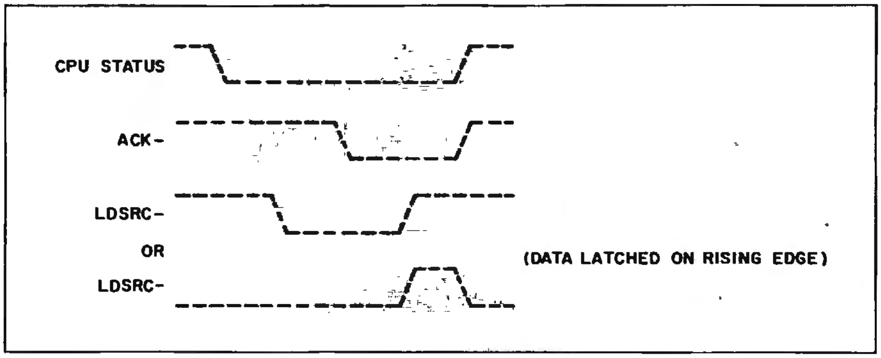

Figure 6: *Timing diagram of a Blt-Special Read cycle.*

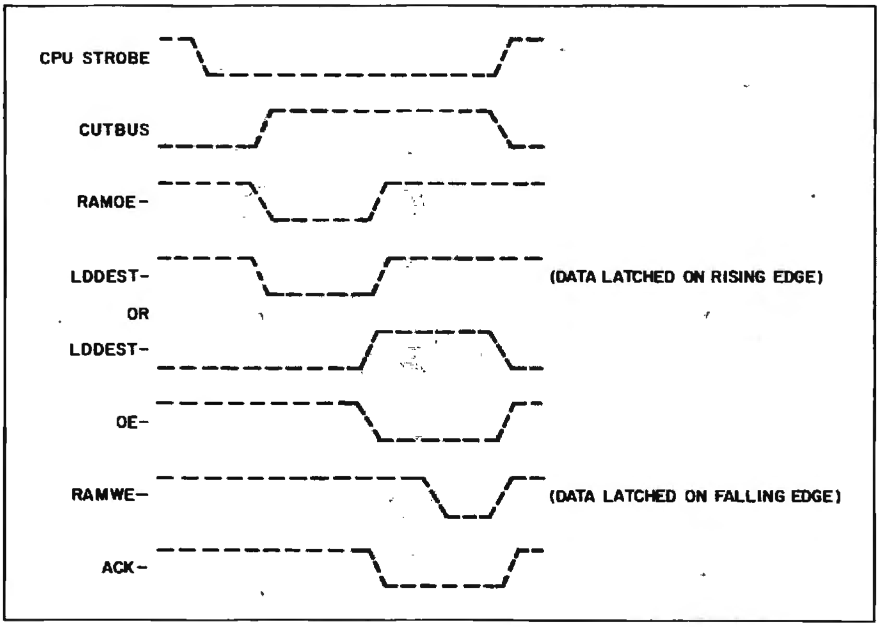

Figure 7: *Timing diagram of a Blt-Special Write cycle (Read-Modify-Write).*

A Blt-Special Write cycle is quite different from an ordinary Write cycle. It is orchestrated by a Blt-Special Write

(continued)

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```
#define             BLT__BASE              0x100000  /* Implementation Dependent !!!*/
/* Address Definitions */
/**** Blt Chip Registers: ****/
#define             SKEW                          *(short*)      (BLT__BASE)      /* W Only */
#define             SKEWMASK                      *(short*)  (BLT__BASE+0x2)  /* W Only */
#define             HALFTONE                      *(short*)  (BLT__BASE+0x4)  /* W Only */
#define             BLTFUNC                       *(short*)  (BLT__BASE+0x6)  /* W Only */
#define             MERGEMASK                     *(short*)  (BLT__BASE+0x8)  /* W Only */
typedef struct form {
    short *bits;
    short width;          /* in pixels */
    short height;         /* in pixels */
    } FORM;
short rightmasks[17] = {0x0000, 0x0001, 0x0003, 0x0007, 0x000f,
                        0x001f, 0x003f, 0x007f, 0x00ff,
                        0x01ff, 0x03ff, 0x07ff, 0x0fff,
                        0x1fff, 0x3fff, 0x7fff, 0xffff};
#define BLTSPECIAL          0x400000          /* byte address bit A23 */
bitblt(sourceform, destform, htonebits, sourcex, sourcey, destx, desty,
       width, height, combrule)
FORM *sourceform, *destform;
short *htonebits;
short sourcex, sourcey, destx, desty, width, height;
short combrule;
{
    register wordcount, junk;
    register short *srcptr, *dstptr;
    short *srcbits, *dstbits;
    short srcraster, dstraster, skew, mask1, mask2;
    short preload, nwords, srcdelta, dstdelta;
    short startbits;
/* Compute skew and first/last word masks.                              */
                                      /* Dest/Src first word address    */
                                      /* and width (in words)           */
    dstbits = destform->bits;
    dstraster = ((destform->width+ 15) / 16);
    srcbits = sourceform->bits;
    srcraster = ((sourceform->width + 15) / 16);
    skew = (sourcex - destx) & 15;    /* skew = # bits to rotate from      */
    SKEW = skew;                      /*            src word to dest word */
                                      /* skew mask = select bits to rotate */
```

Figure 8: *C-language code for implementing a complete* BitBlt *operation.*

Controller (BSWC) that may be combined with the dynamic memory controller in some systems. Upon detecting that the microprocessor has initiated a Write cycle with a Blt-Special address, the BSWC in fact performs a Read-Modify-Write cycle. First, the CPU data buffer is turned off in order to keep the CPU's Write data from being driven onto the bus on which the Blt chip resides, and the memory is accessed for reading. When the Read data becomes available, LDDEST- is asserted to load it into the Blt chip Destination register. Finally, the Blt chip OE- pin is asserted and the datapath result is written to memory at the current address. The microprocessor Ready (or Acknowledge) line is used to stretch the bus cycle until the Read-Modify-Write process is complete.

The Write data provided by the microprocessor in a Blt-Special Write cycle is not used. The only reason that the cycle is a Write is because that is a convenient way to indicate that the address is a destination address rather than a source address and therefore requires a different type of interaction between the memory and the Blt chip. Figure 7 shows the actions of the BSWC during a Blt-Special Write (Read-Modify-Write).

Clearly Blt-Special Write cycles are available only within RAM that has this special kind of controller. If possible, it is desirable to have this type of control for more RAM than just the frame buffer. This allows images to be built in nondisplayed memory and then transferred to display memory later.

Figure 8 shows simplified but functionally correct code for implementing the complete BitBlt operation. For clarity of presentation, this version does no clipping and operates from top to bottom and left to right. The full version of the code clips to account for different-sized rectangles and rectangles that go outside of their

```
    SKEWMASK = (skew == 0) ? 0 : rightmasks[16 - skew];
    startbits = 16 - (destx & 15);      /* # of bits in first dest word        */
    mask1 = rightmasks[startbits];
    mask2 = rightmasks[15 - ((destx + width - 1) & 15)];
         nwords = ((width - startbits + 15) / 16) + 1;
/* Calculate starting addresses, word increment between lines.                 */
                                        /*     Check if need 2 words of src    */
                                        /*       to store the first dest word  */
    preload = (skew != 0  &&  skew <= (sourcex & 15));
                                        /* Calc starting addresses             */
    srcptr = srcbits + BLTSPECIAL + sourcey * srcraster + (sourcex / 16);
    dstptr = dstbits + BLTSPECIAL + desty   * dstraster + (destx/ 16);
                                        /* Calc scanline offsets               */
    srcdelta = srcraster - nwords;
    dstdelta = dstraster - nwords;
    if (preload) srcdelta -= 1;
/* Copy one row at a time                                                      */
    BLTFUNC = combrule;
    while (height-- > 0) {              /* copy one row                        */
       if (htonebits) {                 /* setup halftone row                  */
          HALFTONE = htonebits[desty & 15];
          desty += 1;
          }
       if (preload)
          junk = *srcptr++;             /*           preload previous word     */
       wordcount = nwords;
       MERGEMASK = mask1;               /*           copy first word           */
       *dstptr++ = *srcptr++;           /*BLTSPECIAL read, BLTSPECIAL rmw*/
       if (--wordcount > 0) {
          MERGEMASK = 0x0000;           /*           copy full words           */
          while (--wordcount > 0)
             *dstptr++ = *srcptr++;/*BLTSPECIAL read, BLTSPECIAL rmw*/
          MERGEMASK = mask2;        /*       copy last word          */
          *dstptr++ = *srcptr++;        /*BLTSPECIAL read, BLTSPECIAL rmw*/
          }
       srcptr += srcdelta;              /* calc address of next row            */
       dstptr += dstdelta;
       }
}
```

bit maps. It also correctly handles overlapping source and destination rectangles for operations such as scrolling down and/or to the right.

Reads with the Blt-Special bit (address bit 23) set cause the Blt chip to load the data (from the memory location addressed by the other address bits) into its Source register. The previous source word is transferred to the Previous Source register. A Write operation with the Blt-Special bit set results in a Read-Modify-Write operation to the memory location addressed by the other address bits. The previous contents of the memory word are loaded into the Blt chip's Destination register; the new destination word is computed combinatorially by the Blt chip and is written to the same memory location.

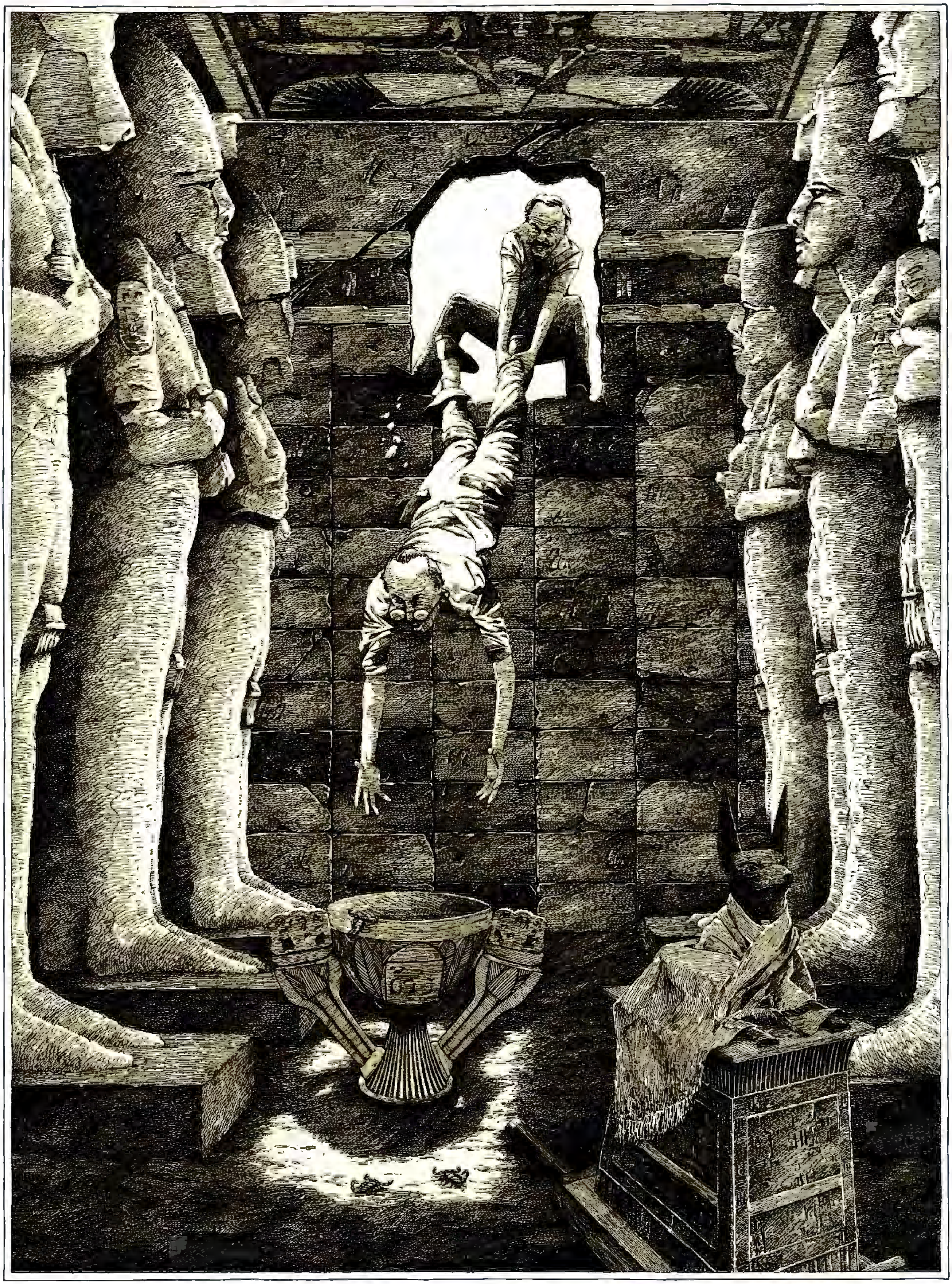
The Halftone register is written once per scan line with a word from a 16- by 16-pixel bit map.

Further optimization is possible—for example, unrolling loops or creating dedicated code for special cases including the design of small rectangles, such as characters.

WHAT LIES AHEAD

Encouraged by our success with the Blt chip, we are turning our attention to an application area in which the BitBlt operation provides little help: fast display of vectors. By employing some of the same techniques used in the development of the Blt chip, such as operating on as many pixels as possible concurrently and optimizing inner loops with cost-effective hardware support, we anticipate low-cost vector emulation on raster displays that competes effectively with the highest performance display technology available.

Much work remains to be done, and it will require a great deal of effort. But the problems involved and the potential rewards are both significant. ■



Inquiry 5

MOVING PICTURES

BY STEFAN DEMETRESCU

Designing systems for real-time graphics performance

WHY IS IT difficult and expensive to generate moving images on a computer screen in real time (that is, 30 times per second)? After all, drawing lines and filling polygons is a very simple operation. The problem, of course, is that these simple drawing operations must be repeated thousands to millions of times per second, since even simple images consist of many hundreds of lines and polygons that must be redrawn 30 times per second.

If we analyze the overall architecture of high-performance graphics systems, we see that a major performance problem is the organization and access methods used for the image memory. This is the memory that stores the image picture elements (pixels) as the image is being drawn and displayed. Because of limitations in their image-memory architectures, currently available inexpensive systems can't achieve real-time performance (that is, they can't redraw the image 30 times per second).

To solve this performance problem, I have developed a new kind of VLSI (very-large-scale integration) graphics chip that provides a significant speed improvement over conventional graphics systems and promises to make real-time inexpensive display systems a reality.

REAL-TIME GRAPHICS SYSTEM ORGANIZATION

For our purposes, a real-time graphics system is one that can draw moderately complex images very fast. If these images are being displayed on a screen, they appear as though they are changing continuously. For example, the system might display an image of a building and rotate it smoothly to show it from different perspectives. If the image is to appear to be moving continuously, the system must be able to recalculate and redraw the image 30 to 60 times per second (a standard TV-monitor refresh rate).

Figure 1 shows a block diagram of a typical graphics system. Initially, the application program must create the image description (known as a "display list"). This is a list of graphical primitives (e.g., lines, polygons, and cubes) described in the three-dimensional coordinates (or "world coordinates") of the object being drawn. This description is usually created once and modified very slowly. For example, if an architect is designing a building on a CAD (computer-aided design) system, he may make minor modifications to it (such as moving a wall). Since the majority of objects in the display do not move, this type of change is not difficult. Changing the vantage point, however, requires redrawing all the objects in different places, 30 times per second—a much more difficult task.

To do this, the rest of the graphics system must take the relatively static description of the image in the display list and display it on the screen. Because the vantage point is changing 30 times per second (to give the illusion of smooth motion), the rest of the pipeline must meet very stringent performance requirements. In the geometric transformation stage, the vertices of the graphical primitives are converted from the three-dimensional

(continued)

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With double buffering, the system displays one image while it is erasing and redrawing the other.

model in the display list (x,y,z) to their proper position on the screen (X_{SCREEN}, Y_{SCREEN}). The transformation formulas are:

$$X_{SCREEN} = (AX+BY+CZ+D)/W$$
$$Y_{SCREEN} = (EX+FY+GZ+H)/W$$
$$W = IX+JY+KZ+L$$

This transformation, which performs scaling, translation, rotation, and perspective, involves 20 floating-point operations (9 additions, 9 multiplications, and 2 divisions) for each 3-D vertex.

After the graphical primitives have been converted to two dimensions, they are "clipped" against the edges of the screen: that is, objects or parts of objects that are beyond the edges of the screen are not displayed.

At this stage, the original 3-D image has been converted to a set of 2-D commands in the coordinate system of the screen (e.g., a line from pixel 200,450 to 300,210). The image is still far from complete. The polygons and the lines must be converted into colored dots (pixels) in the image-raster memory. This step, called rasterization, is perhaps the simplest step in the procedure to understand.

The process of coloring all of the pixels inside a polygon from a list of vertices is shown in figure 2. First, the vertices are sorted from top to bottom. Then the polygon is filled one horizontal line (scan line) at a time. The system calculates the intersection of the polygon's edges with the scan line to give the first and last pixels on the scan line that are inside the polygon (X_{LEFT} and X_{RIGHT}). It then modifies the pixels that lie between these extremes to a new color.

Figure 3 shows a block diagram of this rasterization scheme. The scan-line processor accepts 2-D polygons described by their vertices. It then processes these polygons into a sequence of horizontal line-fill commands that specify, for each scan line intersected by the polygon, which pixels are to be modified. These commands are sent to the horizontal-fill processor, which modifies all the selected pixels.

After all the graphical primitives have been converted into a raster, the image is represented as an array of colored pixels. This image can then be displayed on a TV monitor or printed on a printer. In low-cost systems such as personal computers, which cannot update the image quickly, the image memory is displayed repeatedly, and you can see the graphical primitives being redrawn. If you want to draw a new image 30 times a second, you normally use two image memories. In this scheme, called double buffering, the system displays one image while it is erasing and redrawing the other. This way, only complete images are displayed and the viewer perceives a smoothly changing image.

In the following sections, we will look at each of the major subsystems in the typical graphical-display system and describe alternative ways to implement them. We also estimate the

Table 1: *Performance times for various methods of transforming an image with 2000 vertices.*

Method Used	Floating-Point Multiplication Time	Floating-Point Addition Time	Floating-Point Division Time	Time to Transform 1 Vertex	Time to Transform 2000 Vertices	Achievable Images per Second
Software Only (8086)	1600 µs	1600 µs	3200 µs	35,200 µs	70,400 ms	0.015
Floating-Point Coprocessor (8087)	19 µs	17 µs	39 µs	402 µs	804 ms	1.25
Floating-Point Multiplier Chip	0.2 µs	0.2 µs	0.8 µs	5.2 µs	10.4 ms	96

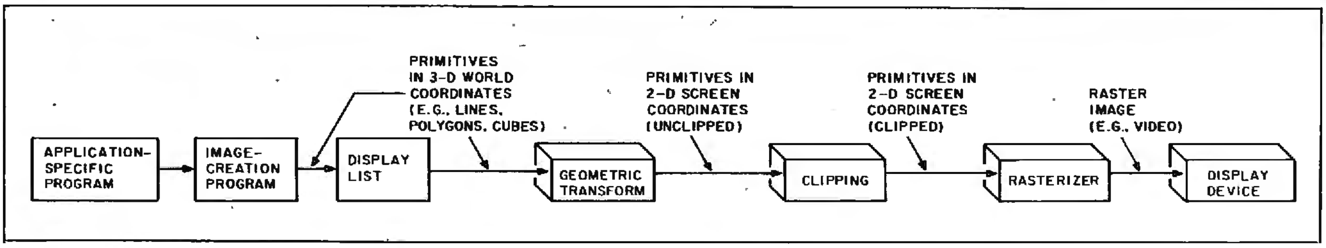

Figure 1: *A typical graphical-display system, including the major steps of geometric transformation and rasterization.*

performance of the alternatives using a "typical" image with approximately 1000 polygons, with an average size of 100 by 100 pixels. We'll assume the number of vertices to be 2000 since many vertices are shared among polygons.

TRANSFORMATIONS AND CLIPPING

A graphical-display system must invoke the transformation formulas mentioned earlier for each vertex of the image. There are three principal ways to calculate these formulas: software in the main processor (e.g., the Intel 8086), software with the floating-point coprocessor (e.g., the Intel 8087), special-purpose floating-point hardware-multiplier chips (e.g., the AMD Am29325 and the Weitek WTL 1032).

Table 1 summarizes the performance of these methods. Note that to transform 2000 vertices 30 times per second (with 20 floating-point operations per transformation) requires 1,200,000 floating-point operations per second (flops) or 0.8 microsecond (μs) per operation. Unfortunately, the inexpensive methods, using microprocessor software, are 2000 times too slow, and even with the floating-point coprocessor the performance is 20 times too slow.

Over the last few years, however, a number of semiconductor companies have begun to offer very fast floating-point calculation chips (see the last entry in table 1), with performance levels in the 5,000,000 flops range. These chips are ideal for performing such geometric transformations and are reasonably priced (in the $100 range).

Clipping calculations are more complex, and I will not discuss them here. Suffice it to say that most of the graphical primitives are either completely inside the screen or completely outside, so they require no processing. Consequently, the time spent for clipping is usually a small fraction of that used for transformation.

Geometric transformations and clipping are computationally demanding but well within the grasp of today's technology. This is because even a complex image consists of only a few thousand vertices and hence only a few thousand transformations.

RASTERIZATION

Rasterization is computationally much more difficult than transformation or clipping. Even the simplest image consists of hundreds of thousands of pixels, each of which must be accessed at least once during the rasterization process. For example, assume that the display image consists of 1000 polygons, with an average size of 100 by 100 pixels. This translates into 10 million pixels per image, which must be redrawn 30 times per second, resulting in 300 million pixels per second to be drawn (i.e., accessed and modified). This means a rasterization system must spend less than 3.3 nanoseconds (ns) per pixel (1/300,000,000) on the average to perform in real time. Unfortunately, the average microprocessor execution time is 2000 ns (2 μs) per instruction.

The simplest rasterization system is

(continued)

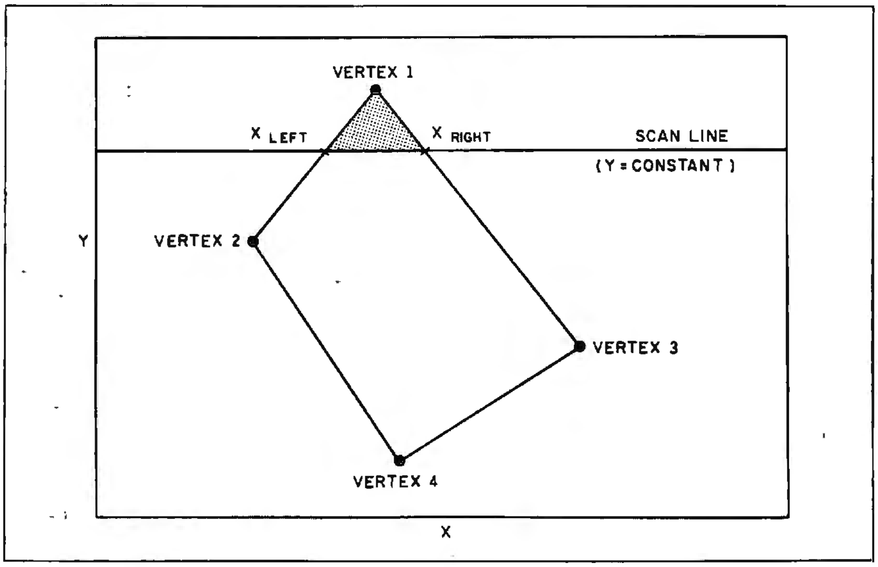

Figure 2: *Rasterizing a four-sided polygon involves repeatedly determining where the polygon's edges intersect a moving scan line and modifying the pixels between those points to a specified color.*

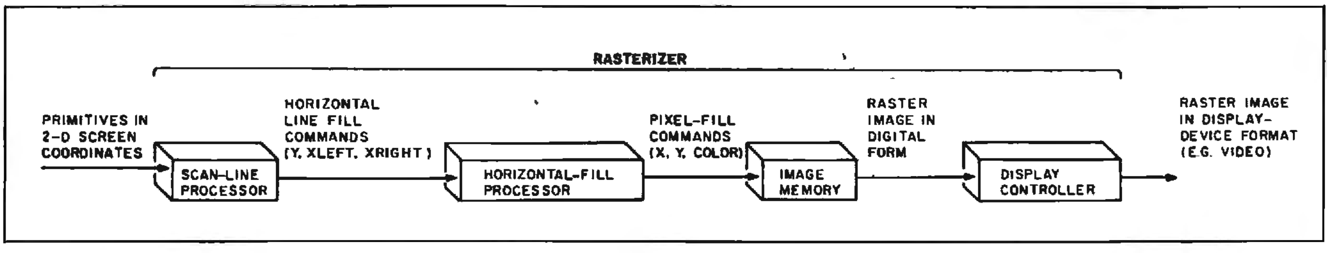

Figure 3: *The process of rasterization depicted in figure 2. The scan-line processor converts the vertices of the 2-D polygons into horizontal line-fill commands. The horizontal-fill processor modifies the pixels between X_{LEFT} and X_{RIGHT} to the appropriate color.*

Table 2: *Performance times for various methods of rasterizing an image with 1000 polygons of 100 pixels by 100 pixels (10 million pixels total). Note: For real-time performance a system must be able to rasterize 30 images, or 300 million pixels, per second. These are estimated optimum times for systems where memory is the limiting factor. The number of achievable images per second assumes that these are double-buffered systems; that is, the memory is not being displayed at the same time as it is being rasterized.*

	Pixels per Memory Cycle	Average Time to Access 1 Pixel	Average Time to Rasterize 10 Million Pixels	Average Time to Rasterize 300 Million Pixels	Achievable Images per Second
Software Only (1 pixel/byte)	1	2000 ns	20 sec	600 sec	0.05
Graphics Processor (1 pixel/byte)	1	800 ns	8 sec	240 sec	0.125
Software Only, Bit Map (16 pixels/ 16-bit word)	16	125 ns	1.25 sec	37.5 sec	0.8
Graphics Processor (16 pixels/word)	16	20 ns	0.20 sec	6 sec	5
Graphics Processor and SLAM Chip	1 to 1024 (typically, 100)	0.2 ns to 200 ns (typically, 2 ns)	0.02 sec	0.6 sec	50

shown in figure 4. In this system, each pixel of the image is represented by a byte in the computer's memory. The content of each byte indicates the pixel's color. Most of the color-graphics boards available for the IBM PC and others operate on this principle. The display controller reads the pixels and displays them through a second port of the memory.

Assuming that we make the optimistic estimate that the software in the microprocessor can modify one pixel every instruction, it takes 20 seconds (10 million pixels times 2 μs per pixel) to rasterize all the polygons (table 2). This is 600 times too slow.

To speed up the accesses to memory, some semiconductor vendors have introduced special graphics processors. Perhaps the best known one is the NEC 7220 chip. A system using such a chip is shown in figure 5. The central processing unit sends the geometrically transformed graphical primitives to the graphics processor, which then accesses the individual pixels. The graphics processor itself still accesses pixels one at a time, but at a somewhat faster rate of 800 ns per access. Rasterizing the 100 polygons would take 8 seconds (800 ns times 10 million pixels), still 240 times too slow for real-time performance (see table 2). Again, the problem is that pixels are only being modified one at a time. Furthermore, many of these processor chips place severe constraints on the kind of graphical primitives that they can draw. For example, the NEC 7220 only fills polygons if they are rectangles aligned with the *x*-axis.

When the display is black and white, the system needs only one bit per pixel. As a result, it can store 16 pixels in one 16-bit word and access all of them simultaneously with one instruction (figure 6). This method is usually known as a bit map and is used by the Apple Macintosh. When filling large polygons, this allows for a performance improvement of 16 times over the 8-bits-per-pixel frame buffer, at the expense of color.

Nevertheless, as table 2 indicates, such a system is still 37 times too slow for real-time performance. This estimate is actually too optimistic since bit-map systems must spend a lot of time at the edges of polygons to determine which of the 16 bits are in and which are out. For small polygons, this "edge tweaking" dominates the rasterization time.

AMD has recently announced a graphics processor that offers the advantage of accessing 16 pixels simultaneously while still allowing for a color display (i.e., multiple bits per pixel). AMD calls this chip (promised to be available by the middle of next year) the Am95C60 Quad Pixel Dataflow Manager, or QPDM. This processor can access the display memory up to 16 pixels of 4 bits each at a time in 300 ns (figure 7). Even this large improvement does not allow for real-time imaging and is in fact 6 times too slow to draw 1000 polygons in real time (30 images times 0.02 second per image) as shown in table 2. It also suffers from overhead due to edge tweaking and can only fill triangles, so other polygons must be broken up into triangles by the host processor. Lastly, the wide data path

(64 bits) is expensive in terms of packaging (the QPDM has more than 100 pins) and interface electronics.

As you can see, getting the required pixel bandwidth to memory (that is, getting pixels in and out of memory) is very difficult. Systems that can rasterize fast enough for real-time drawing do exist, but they are extensions of the architectures described above. These systems use very fast graphics processors that access many pixels at a time (for example, 64). These processors are also very expensive, and the systems end up costing many hundreds of thousands of dollars, so they are not practical for the average user.

SCAN-LINE ACCESS MEMORIES

The rasterization problem can be summarized as follows: Graphics systems need to access many pixels simultaneously to rasterize polygons and fill areas quickly, but wide bandwidth to the memories is very expensive.

The best place to access many pixels at once is as close as possible to the memory that stores the pixels. Consider for a moment the internal structure of a conventional 64K-bit

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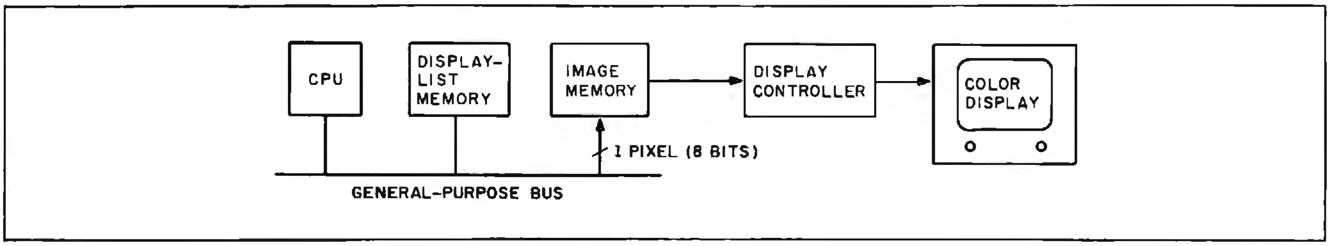

Figure 4: A *typical software-driven frame-buffer system for rasterization.*

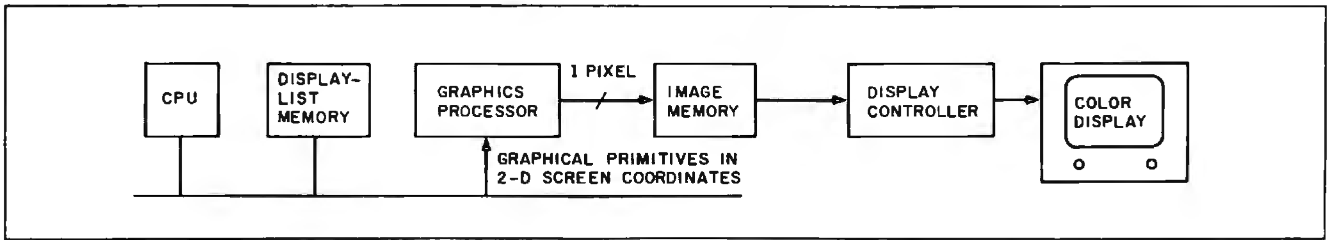

Figure 5: A *typical graphics-processor-driven frame-buffer system for rasterization, such as used by the* NEC 7220 *chip.*

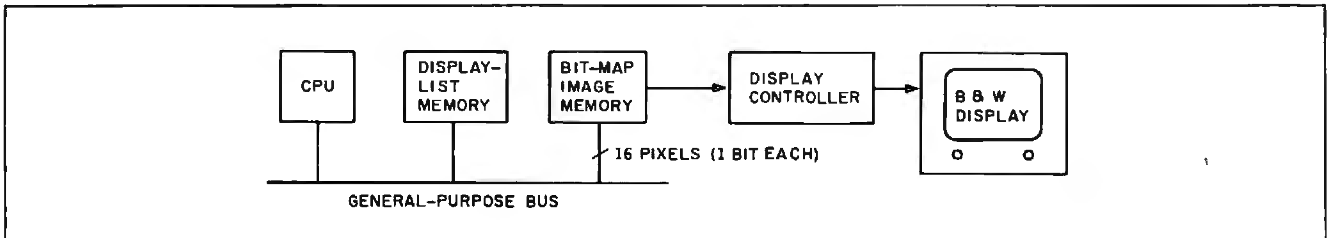

Figure 6: A *typical software-driven bit-map system for rasterization, such as used by the* Apple Macintosh.

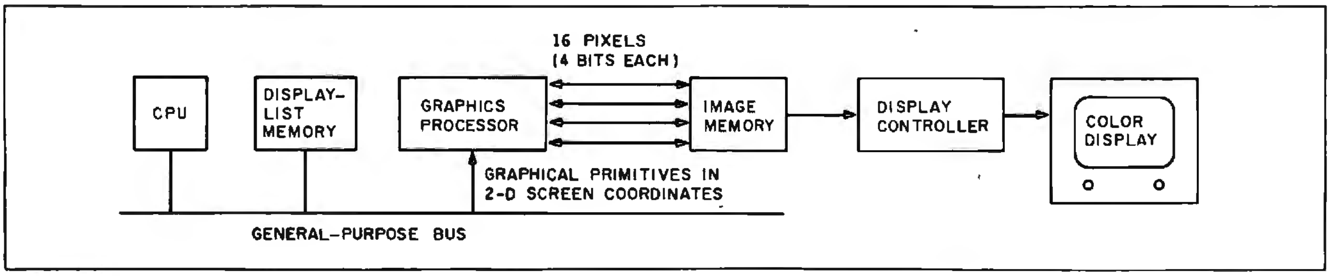

Figure 7: A *typical graphics processor with multiple-pixel access to the image memory. Such a system is being developed by* AMD *for its* QPDM *chip.*

dynamic RAM (random-access read/write memory) chip. This kind of chip is used as the basis of virtually all image memories. Externally, the memory appears as 64K locations of 1 bit each. Each memory access refers to only 1 bit. As figure 8 indicates, the memory is a closely packed array of memory cells in a square grid of 256 rows and 256 columns. The first 8 bits of the address select a row of the memory location to be accessed. Then all 256 bits of the selected row make their way up to the top of the array, where one of the 256 bits is read or written and all 256 bits are then written back into the selected row.

When used as an image memory, each row of the RAM can be made to represent a horizontal scan line and each bit of each row to represent a pixel on that line. Thus, each RAM represents a portion of an image buffer that is 256 lines tall and 256 pixels wide. Many such chips can be used to represent a larger image with many bits per pixel.

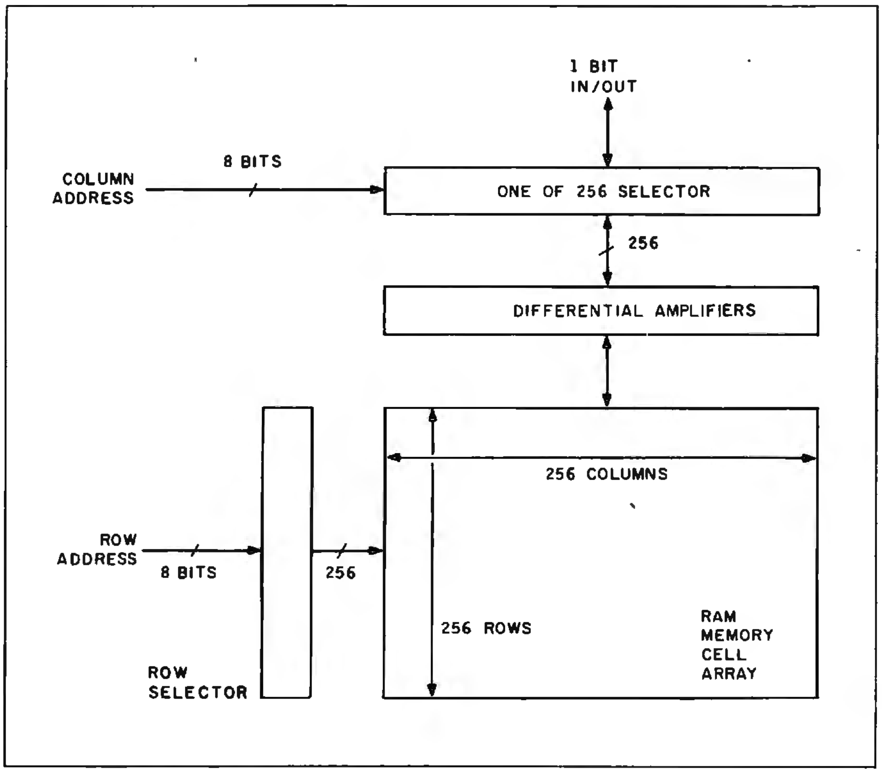

Figure 8: *Internal structure of a conventional 64K-bit dynamic* RAM.

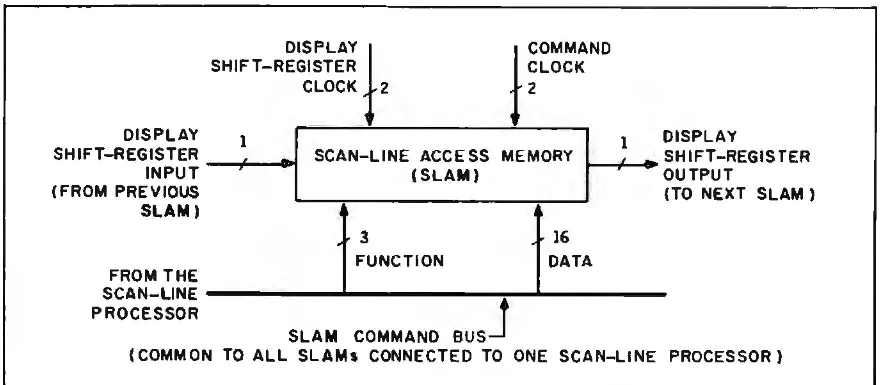

Figure 9: *External view of the* SLAM *chip.*

In a conventional image buffer, each time a pixel is modified the whole scan line is recalled, but only one of the 256 pixels makes it off the chip. It would be impractical to allow all 256 bits of the memory to be accessed simultaneously off the chip, since each chip would end up with more than 256 pins! However, the scan line is available *inside* the memory chip. You can add a special-purpose processor (right above the memory array), which can modify large parts of the scan line without ever having to move the pixels off the chip.

This concept is the basis of my research of fast rasterization architectures done at Stanford University. I have called this "smart memory" chip a SLAM, for "scan-line access memory." Figure 9 shows the external view of a SLAM chip. The SLAM chip executes commands that it receives over the 19-bit bus shown. SLAMs are capable of directly executing the horizontal line-fill commands that form the basis of the polygon-fill function.

The fill operation is accomplished through the use of four SLAM commands. Figure 10 shows the effect of this operation on the image buffer. The first command specifies the scan line that is to be filled (LOAD Y). The second command specifies a 16-bit pattern that will be used to fill all pixels that will be modified. The third command specifies the X_{RIGHT} coordinate and directs the SLAM to read the selected scan line from the memory array. Finally, the fourth command specifies the X_{LEFT} coordinate and directs the SLAM to modify all pixels in the range $[X_{LEFT}, X_{RIGHT}]$ and to write the scan line back into the memory array.

A system of SLAM chips can modify from one to many thousands of pixels simultaneously since the whole scan line is accessed at once and any part of it may be modified in one memory cycle. Nevertheless, the commands

(continued)

are very short and can be sent over a narrow bus (19 bits). Thus, the SLAM chip converts low-bandwidth commands into a high-bandwidth result inside the VLSI memory chip where the bandwidth is inexpensive.

Figure 11 shows a block diagram of a 16K-bit prototype version of the SLAM chip, while photo 1 is a microphotograph of the prototype chip that I have built at Stanford. Note that the "smart" part of the smart memory (everything but the conventional RAM array) is only a small fraction of the total chip area. Thus, the expected cost of such a chip will be close to that of conventional memory.

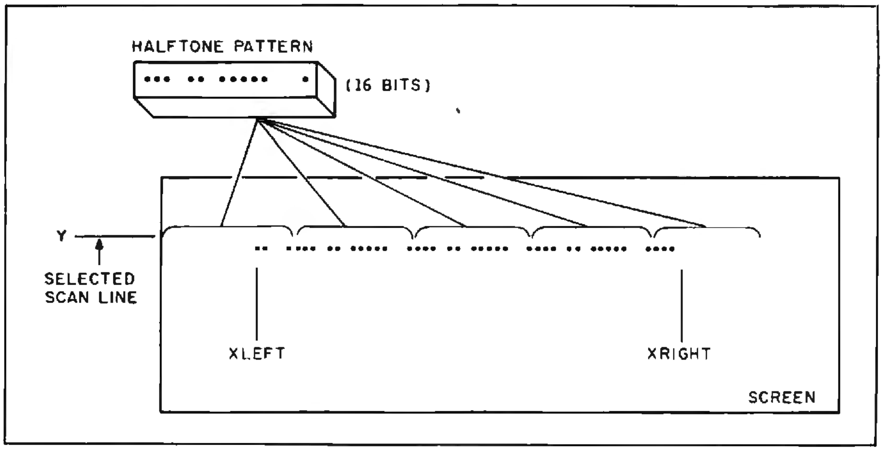

Figure 10: *The SLAM chip performs the horizontal line-fill operation by simultaneously filling a specified scan line, between the X_{LEFT} and X_{RIGHT} coordinates of the line, with a specified 16-bit pattern.*

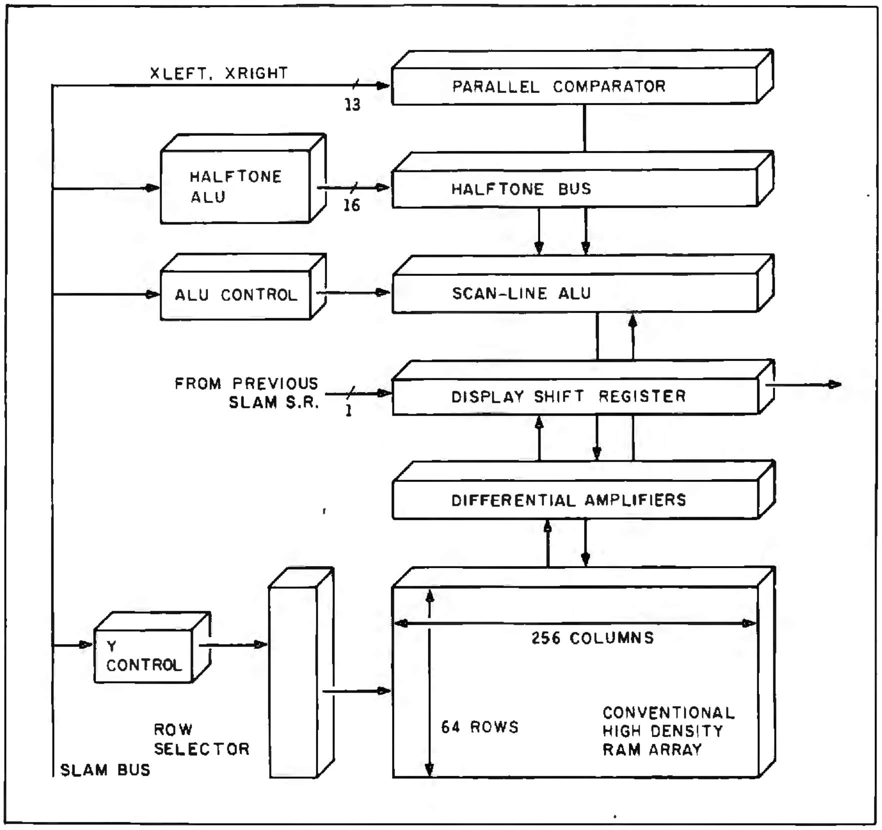

Figure 11: *Internal structure of the SLAM chip.*

The SLAM chip consists of six main sections:

- The memory array is a conventional dynamic RAM array.
- The halftone ALU (arithmetic and logic unit) performs Boolean operations on the incoming halftone pattern before it is used (its use will not be discussed here).
- The parallel comparator accepts the X_{LEFT} and X_{RIGHT} values and generates a 1 bit for each of the 256 horizontal bit positions that lie in the range $[X_{LEFT}, X_{RIGHT}]$ and a 0 bit for all the others.
- The scan-line ALU determines what values are to be stored back into the memory array as determined by the the parallel comparator and the halftone bus.
- The Y control and row selector enable the proper row of the memory when given the Y scan-line number.
- The display shift register latches a selected scan line so it can be displayed independently of the rest of the SLAM chip.

A very simple SLAM system is shown in figure 12. This system is as simple as the simplest of the conventional (graphics-processor-driven) systems (figure 5), except the conventional DRAMs are replaced by the SLAM memory chips. Because the SLAM chip can modify any part of one scan line in one memory cycle (currently 200 ns), it can rasterize a 100- by 100-pixel polygon in 100 memory cycles (one for each scan line), a total of 20 μs (200 ns times 100 cycles). As a result, the SLAM system can rasterize the 1000 polygons in 20 milliseconds and can rasterize 50 screen images per second, well over the number required for real-time performance (table 2).

The SLAM chips are capable of rasterizing lines and characters as well as polygons, but space limitations do not allow me to describe these features in detail. It is possible to build

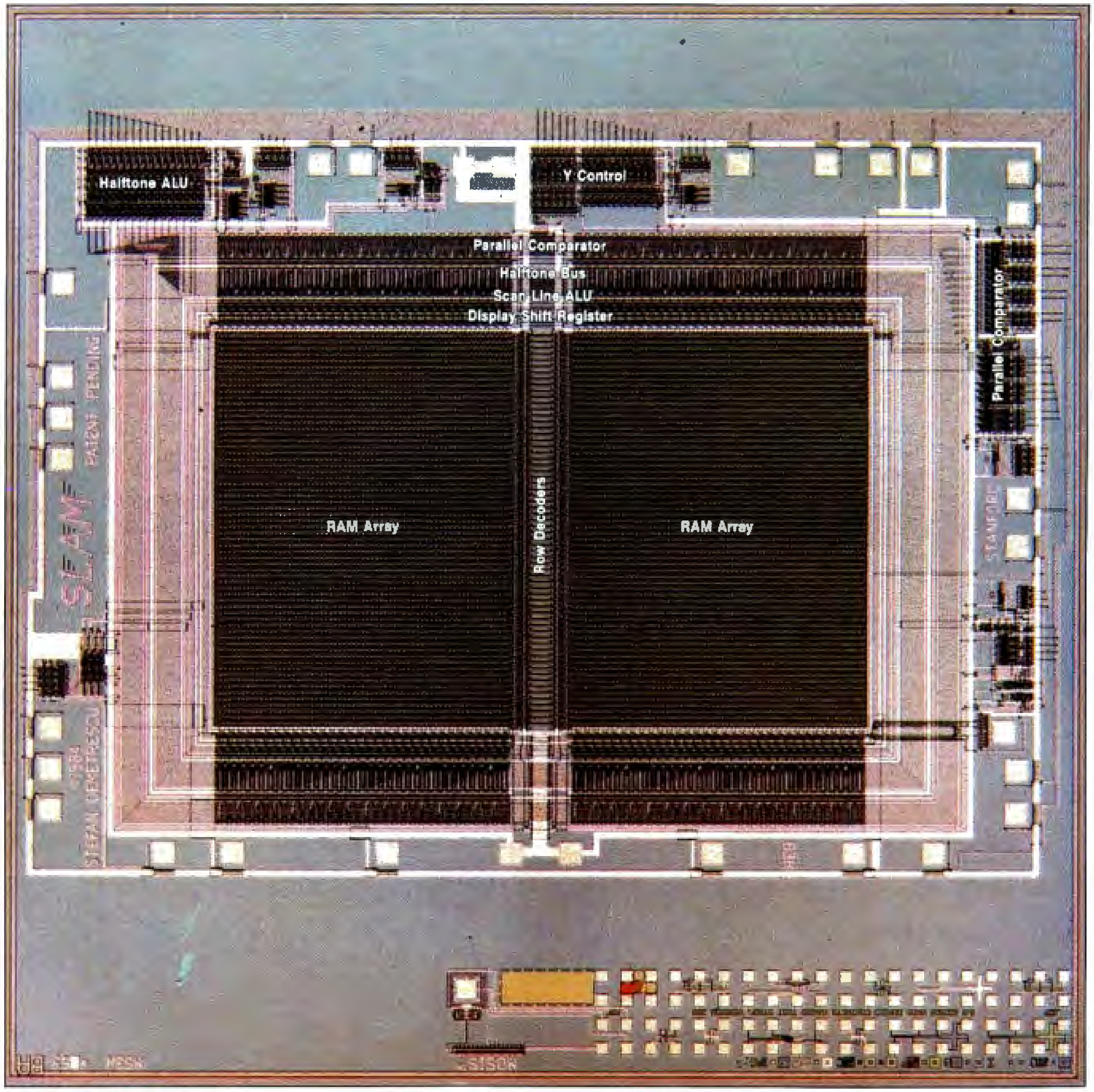

Photo 1: *The* SLAM *chip. (Reprinted from the* 1985 Chapel Hill Conference on Very Large Scale Integration, H. *Fuchs, editor, with permission of the publisher, Computer Science Press Inc.,* 1803 *Research Boulevard, Rockville,* MD 20850.)

even higher performance SLAM systems by using many SLAM chips in parallel.

At present, the SLAM chip is only a research tool and is not available commercially, but there are strong indications that a SLAM chip will be developed soon by a major semiconductor vendor, under a patent license from Stanford University.

THE DISPLAY SYSTEM

So far, we have assumed that the image memory can be used exclusively for rasterizing the image primitives. This is accurate if the image memory is double buffered, that is, one image memory is being displayed while the other image memory is being updated. As stated, double buffering is essential if the image is to appear to be changing smoothly. Otherwise, the observer would see glimpses of half-

(continued)

completed images as one is erased and the next is drawn. The problem with double buffering is that it requires twice the memory. This can be significant for a display of 1000 by 1000 pixels at 8 bits each (1 megabyte for each of the two buffers).

In lower-performance systems, where images are not changing quickly, one image memory is displayed and modified simultaneously. This introduces another major performance problem: Both the display and the rasterizer must contend for the same memory bandwidth. This results in a severe degradation of rasterization performance.

For example, the Macintosh display memory (refer to figure 6) is busy with updating the screen 50 percent of the time. Only 50 percent of the time is available for all other accesses to RAM (even nongraphics accesses). This reduces the performance by a factor of 2.

As another example, the NEC 7220 display processor (refer to figure 5) only allows changes to the image buffer during horizontal and vertical retrace times of the TV display (50 percent of the total time).

In general, we can safely assume that at least 50 percent of the image-buffer bandwidth is required by the display if the system does not use double buffering.

Recently, a number of memory makers have begun to offer special memory chips designed to alleviate this problem. These chips are often referred to as "video RAMs" or "dual-ported RAMs" and are available from Texas Instruments (64K by 1 bit), NEC (64K by 4 bit), and AMD (64K by 4 bit).

As figure 13 shows, the video RAMs are conventional RAMs (refer to figure 8) with a 256-bit shift register added. When a row of memory (i.e., a scan line) is to be displayed, the video RAM accesses the entire row and stores the information into the shift register. The data can then be shifted out independently of the memory-fill rasterization operations (that is, the shift register is a "second port" out of the memory). This effectively reduces the number of display accesses from 256 to 1 for each scan line, and the display contention is reduced to practically nothing.

These video RAMs can be thought of as primitive forms of SLAMs. They can access scan lines, but only for the purpose of displaying the memory contents. Video RAMs cannot perform any useful polygon-fill operations on the scan lines.

Much has been made about these

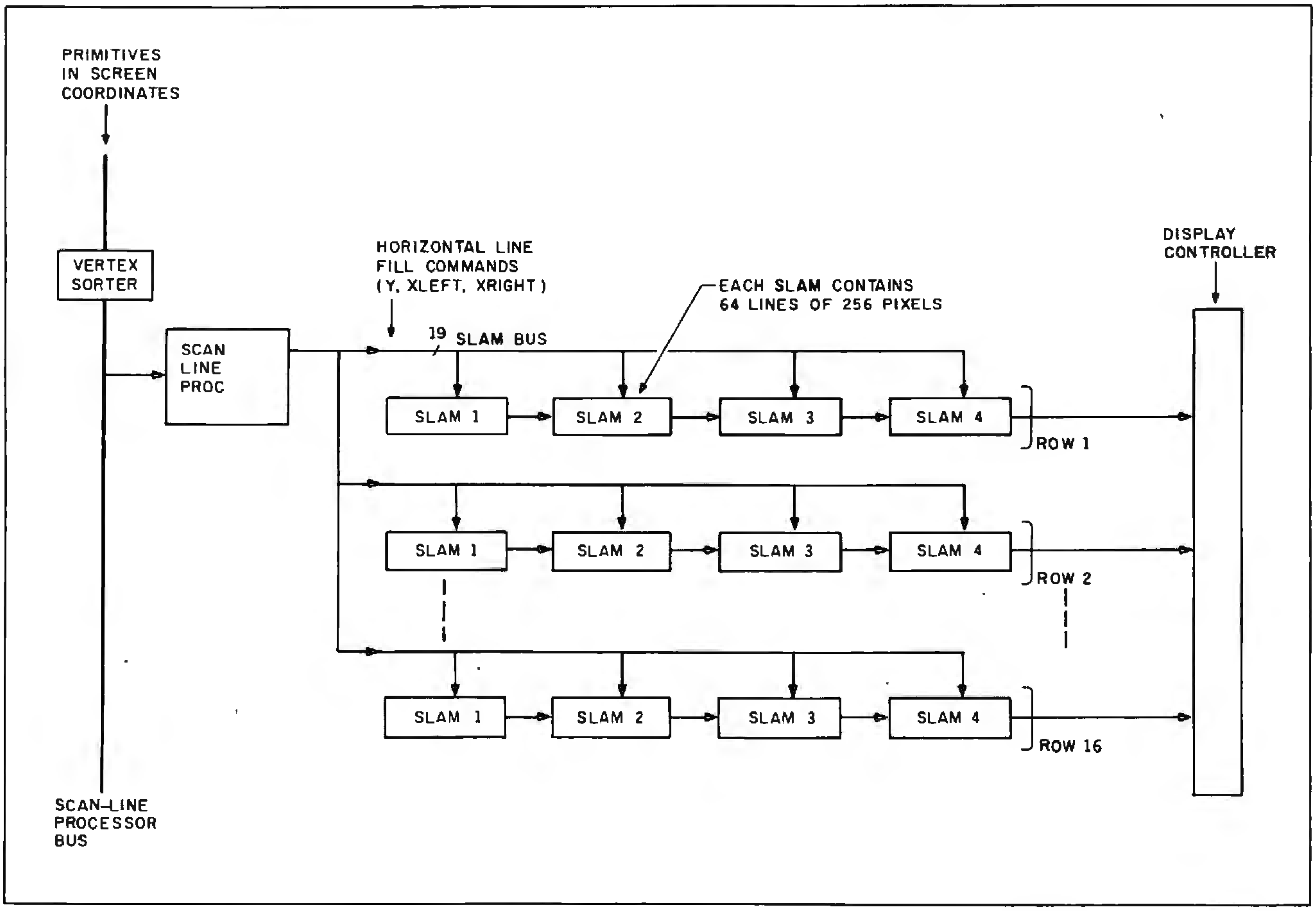

Figure 12: *A simple* SLAM *system of* 1024 *by* 1024 *pixels, in which conventional dynamic* RAMs *are replaced by* SLAM *chips.*

video RAMs as *the* solution to the raster-graphics performance problem. However, the preceding analysis indicates certain limitations. If the system is double buffered, these chips offer little or no advantage, since the image being displayed is on a different image memory from the one being filled, and there is no memory contention. If the system is not double buffered, they do offer, on the average, a doubling in performance because they eliminate contention for the image memory, but they do absolutely nothing to improve the rasterization problem (that is, they increase the bandwidth out of the memory but do nothing for the bandwidth into the memory).

While an improvement in performance by a factor of 2 is not insignificant, the major performance bottleneck occurs when the memory is being filled. It is there that systems can get performance increases on the order of 100 times to 1000 times or more, rather than 2 times. These performance improvements can be achieved by increasing the bandwidth to the memory (through the use of SLAMs, for example).

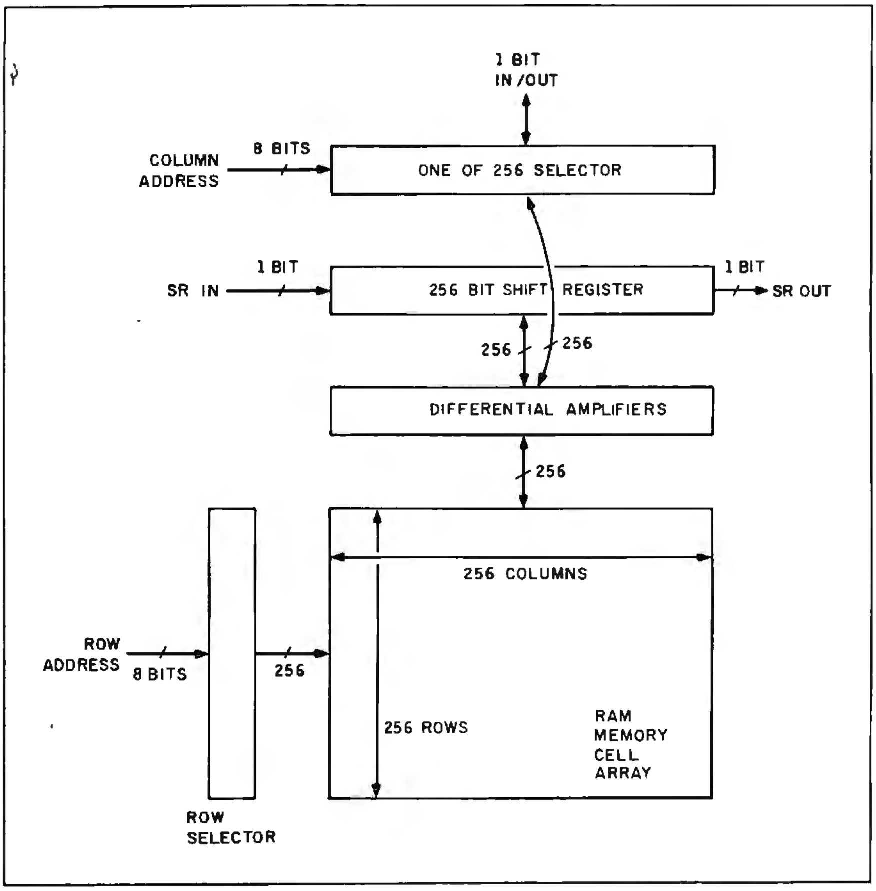

Figure 13: *Internal structure of a 64K-bit video* RAM, *similar to the conventional dynamic* RAM, *with the addition of a 256-bit shift register.*

Laser Printers and Other Raster Printers

In the end, no matter how beautiful images on a TV screen are, you need to take the image from the screen and generate a hard copy.

At first glance it would seem that laser printers and high-performance graphics displays have nothing in common. In fact, many of the rasterization techniques described above are used to rasterize images for laser printers. It is common to find printers that have a higher pixel rate than 30-hertz TV displays.

For example, a 512- by 512-pixel TV image contains 262,144 pixels and has a pixel rate of 8.1 megahertz. A 60-page-per-minute laser printer with a resolution of 300 dots per inch contains 8,415,000 pixels and has a pixel rate of 8.4 megahertz. Furthermore, each page imaged by a laser printer is usually different from the previous one. Compare this with displays that often show the same image for many hundreds of frames (a few seconds).

Fast rasterizing architectures are as important for raster printers as they are for displays. Many times controllers for laser printers are slower than the printer that they drive because they cannot rasterize fast enough. For example, Apple's recently introduced LaserWriter is advertised as printing 8 pages per minute. Indeed, the printer engine is capable of printing 8 pages per minute, but the controller cannot rasterize images that fast. Thus, the effective throughput is 2 or 3 pages per minute for pages of moderate complexity. Some pages of higher complexity take minutes to calculate and print.

Summary

The process of generating a raster image (for display or printing) is composed of many stages, each of which can be a potential bottleneck of performance. The step of converting graphical objects into pixels (rasterization) appears to be the most difficult to perform quickly and inexpensively. A new smart memory called a SLAM promises to ease this bottleneck by accessing hundreds to thousands of pixels simultaneously and thus proposes to provide a substantial performance improvement over conventional architectures. Combined with moderate cost, these new highly parallel graphics architectures built in VLSI could allow real-time graphics performance for personal computers in the near future. ■

Editor's note: Readers interested in further details are encouraged to write the author for a reprint of a scientific paper describing the SLAM *concept in more detail.*

HIGH-RESOLUTION PRINTER GRAPHICS

BY MARK BRIDGER AND MARK GORESKY

You can address the individual dots used to generate dot-matrix characters

ONE OF THE GREATEST frustrations in doing graphics on a microcomputer is the rather low resolution of the usual microcomputer monitor. The standard IBM Personal Computer color-graphics adapter and monitor display a maximum screen size of 640 by 200 pixels (picture elements); other computers and configurations do somewhat better, perhaps as much as 720 by 350 pixels. It is difficult to draw horizontal lines fast enough to keep the image from flickering. And there are limits to the amount of screen memory available on standard graphics boards.

Many dot-matrix printers are capable of printing individual dots at a much higher resolution than the typical CRT (cathode-ray tube) screen can display them. The Epson FX-80 and the IBM graphics printer are capable, for example, of printing 240 dots per inch horizontally (1920 dots per line) and 216 dots per inch vertically—the latter by printing a line of graphics, advancing the paper one-third of a dot, printing another "interlaced" line of graphics, etc. Other printers can perform similar feats. To use this capability you need to figure out how to "fire the pins," and you need enough extra memory to record where all the dots are to go. This article will show you how to draw some lines and curves on your printer with a resolution of up to 1600 by 640 dots.

SETTING UP THE "PRINTER SCREEN"

The first problem is memory. If you think of a dot as being either on or off, to use an analogy with the screen display, then encoding 1600 by 640 dots, or 1,024,000 points, requires that many *bits* of information. If you divide by 8 to convert bits to bytes, then the process requires 128,000 bytes, or nearly 128K bytes of memory. Somehow, you must set aside that much memory to record this image. Unfortunately, this is not easily done in BASIC, so we must look elsewhere.

The most widely used microcomputer language that allows fencing off this much memory is Pascal, and because Turbo Pascal lets you point to nearly all available memory without having to give explicit addresses, it is the easiest language to use.

Let's set up two 64K-byte memory areas that represent the even lines and the odd lines of a picture. Each of these areas is represented by the following Pascal data type:

```
Type data_type = array[0..1599,
  0..39] of char;
```

This type of variable is a doubly indexed 1600 by 40 array of characters; since one byte represents each character, this multiplies to about 64K bytes.

Now let's declare the variables that are to reserve this space:

```
Var Evenmap, Oddmap:
   ^data_type;
```

(continued)

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The "^" defines a pointer. When you actually create these variables during program execution, using the command New, the computer sets aside two blocks of free memory and automatically reserves them for your use. Each of the variables Evenmap and Oddmap "points" to the beginning of one of these blocks, and you need never concern yourself with exactly where in memory these blocks reside.

How a Dot-Matrix Printer Draws Dots

The print head of a dot-matrix printer normally has seven or more wires, arranged vertically; the most common number is nine. (Eight are used to draw most of the characters, while the ninth is used to draw the bottoms of the g and y characters and to underline.) When typing letters, the printer receives the ASCII code of the character—a number between 0 and 255. As the print head moves across the page, it extends certain wires, depending on the pattern stored in the printer's memory for that character, and the head strikes them against the paper. Usually from 9 to 12 such columns of dots are needed to make a character.

You want to be able to tell the printer directly which wires to fire; in other words, you want to bypass that part of the printer's memory that stores the patterns for the printing of usual characters (letters, numbers, etc.)—you want to do *bit-mapped* graphics. Most printers support this; it is usually called graphics mode. Let's try to address a particular dot on the page.

First, since the wires on the print head are not that close together, you can make use of tiny partial linefeeds to double the number of vertical dots. Table 1 contains a diagram of how it works. The characters represent dot positions on the page; the 1s represent the dots that you actually want to draw and the 0s represent the dot positions you want to skip. To get maximum resolution, you want the dots to be as close to each other as possible, both horizontally and vertically. Getting them close horizontally is accomplished by means of a simple printer command. To get them close vertically, you must divide the picture into the even rows (0, 2, 4, etc.) and the odd rows (1, 3, 5, etc.), as shown in table 2.

When the printer is in graphics mode, the printer prints, for each byte you send it, any pattern of eight vertical dots you specify. The strategy in table 2 is to do the following:

1. Send the printer the 10 bytes that specify the 10 columns represented by the even rows.
2. Instruct the printer to do a carriage return plus a linefeed of one-half a vertical dot.
3. Send the printer the 10 bytes that specify the 10 columns represented by the odd rows.
4. Instruct the printer to do a carriage return plus a linefeed of 7½ vertical dots, preparing it to draw more sets of even and odd rows if there are any.

In more ambitious applications you can have as many as 1600 columns across instead of just these 10. The array pointers Evenmap and Oddmap store this information for the printer. Each represents 1600 columns; each column is 40 bytes or 320 dots high. Looked at another way, there are 320

(continued)

Table 1: *This table shows the dot positions on the page. The 1s represent dots that you actually want to draw; the 0s, dot positions you want to skip over.*

0	1	0	0	0	0	0	0	0	0	0
1	0	1	0	0	0	0	0	0	0	0
2	0	0	1	0	0	0	0	0	0	0
3	0	0	0	1	0	0	0	0	0	0
4	0	0	0	0	1	0	0	0	0	0
5	0	0	0	0	0	1	0	0	0	0
6	0	0	0	0	0	0	1	0	0	0
7	0	0	0	0	0	0	0	1	0	0
8	0	0	0	0	0	0	0	0	1	0
9	0	0	0	0	0	0	0	0	0	1
10	0	0	0	0	0	0	0	0	0	1
11	0	0	0	0	0	0	0	0	1	0
12	0	0	0	0	0	0	0	1	0	0
13	0	0	0	0	0	0	1	0	0	0
14	0	0	0	0	0	1	0	0	0	0
15	0	0	0	0	1	0	0	0	0	0

Table 2: *This table shows the distribution of the various print dot positions between even and odd rows.*

Even:	Odd:
0 1 0 0 0 0 0 0 0 0 0	1 0 1 0 0 0 0 0 0 0 0
2 0 0 1 0 0 0 0 0 0 0	3 0 0 0 1 0 0 0 0 0 0
4 0 0 0 0 1 0 0 0 0 0	5 0 0 0 0 0 1 0 0 0 0
6 0 0 0 0 0 0 1 0 0 0	7 0 0 0 0 0 0 0 1 0 0
8 0 0 0 0 0 0 0 0 1 0	9 0 0 0 0 0 0 0 0 0 1
10 0 0 0 0 0 0 0 0 0 1	11 0 0 0 0 0 0 0 0 1 0
12 0 0 0 0 0 0 0 1 0 0	13 0 0 0 0 0 0 1 0 0 0
14 0 0 0 0 0 1 0 0 0 0	15 0 0 0 0 1 0 0 0 0 0

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SIEVE	0:13.92	0:15.26
FIBONACCI	0:53.49	1:49.74
30X30 MATRIX (8087)	0:08.84	0:19.28
FP OPERATIONS	0:52.12	0:31.75
FP OPERATIONS (8087)	0:01.97	0:06.21
SYNTAX CHECKING EDITOR	YES	NO
MULTIPLE WINDOW EDITING	YES	NO
EDITOR FILESIZE LIMIT	MEMORY SIZE	64K
COMPILE ERROR CALLS EDITOR	YES	YES
LINKER	YES	NO
PRODUCES .EXE FILES	YES	NO
EXECUTABLE CODE SIZE LIMIT	DISK SPACE	64K
DOS ACCESS FROM EDITOR	YES	NO
DOS ACCESS FROM PROGRAMS	YES	LIMITED
8087 SUPPORT STANDARD	YES	NO
COPY-PROTECTED DISK	NO	NO
COST WITH 8087 SUPPORT	$80.88	$109.90

Source: Software Resources, Inc.
Sieve program from BYTE, January 1983.
Fibonacci program from Dr. Dobb's Journal, February 1985.
Matrix program from BYTE, October, 1982.
FP Operations program from BYTE, May 1985.
Turbo Pascal without 8087 uses only 6-byte accuracy for type REAL; M2SDS with or without 8087 uses 8-byte accuracy.
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even rows and 320 odd rows. Each row is 1600 dots wide, and the printer will print eight even or eight odd rows in each pass. Note that these rows form a natural unit totaling 16 rows; let's call such a unit a printer line.

How to Locate a Dot on the Page

Let's write a procedure—Pset(x,y, color)—that draws a point of coordinates x and y in the proper place in one of the two arrays. The coordinates x and y denote the point's column and row (measured from the upper left-hand corner), respectively. The variable color can be equal to either 0 or 1: 0 means erase any point existing at that location; 1 means insert a point there. [*Editor's note: All programs shown here are available for downloading on* BYTE*net* Listings. *Before November 1 call* (617) 861-9774. *Afterwards, call* (617) 861-9764.]

See listing 1 for the procedure Pset. Start at the line that reads color := color mod 2. First the procedure ensures that color is in the correct range by applying a mod 2 to it. (When K and N are whole numbers, K mod N finds the remainder you get when you divide K by N. When you divide by 2, you can get a remainder of only 0 or 1, depending on whether K is even or odd, respectively.) Next, you determine which printer line you're in by dividing the row number by 16 (y div 16). When you know this line number, you can determine which vertical dot *within* that line you're in; this is *height*. Finally, y mod 2 tells you whether your dot is in an even or an odd row.

For example, suppose you want to print a dot in column 1173, row 554. Then x equals 1173 and y equals 554. 554 div 16 equals 34, so you are in the 34th printer line. 554 mod 16 is 10 and 10 div 2 is 5, so the height of the dot within the printer line is 5; since 554 is even, you are in the array pointed to by Evenmap. The program now calls on the procedure Change to insert this point into the correct position in memory.

The problem now, and the reason Change is so complicated, is that

(continued)

Listing 1: *Epson* FX-80 *procedures in disk file* Printpak.pas.

```
const
  across = 1599;    (** replace with 1249 for Prowriter **)
  down   = 39;

type
  data__type = array[0..across, 0..down] of char;
  mask__array = array[0..7] of byte;

var
  Evenmap, Oddmap: ^data__type;
  M, R: mask__array;

procedure Init__mem;
var I,J: integer;
begin
    new(Evenmap); new(Oddmap);       {sets aside space in memory for arrays}
    for J := 0 to down do
      for I := 0 to across do
        begin
          oddmap^ [I,J] := chr(0);    {initializes both arrays}
          evenmap^ [I,J] := chr(0)    {all bytes = 0}
        end
end;    {Init__mem}

procedure Printout;                  {Output to EPSON FX-type printer.}
var  n__lo, n__hi:byte;              {See listing 2 for Prowriter Printout.}
  i,j : integer;

begin {Printout}
  n__hi:= (across+1) div 256;        {Part of number of graphics bytes coming}
  n__lo:= (across+1) mod 256;        {Rest of number of graphics bytes coming}
  for J := 0 to 39 do
    begin
      write (Lst,chr(27),'Z',chr(n__lo),chr(n__hi));
                                     {Enter graphics mode; give # bytes coming}
      for I := 0 to across do write(Lst, evenmap^ [I,J]); {print even row}
      write(Lst,chr(13));                   {carriage return}
      write(Lst, chr(27),'3',chr(1));       {set linefeed for 1/3 dot down}
      write(Lst, chr(10));                  {do linefeed}
      write (Lst, chr(27),'Z',chr(n__lo),chr(n__hi));    {graphics mode again}
      for I := 0 to across do
        write (Lst, oddmap^ [I,J]);         {print odd row}
      write(Lst, chr(13));                  {carriage return}
      write(Lst,chr(27),'3',chr(22));       {start next line 7 1/3 dots down}
      write(Lst, chr(10));                  {linefeed}
    end
end;  {Printout}

procedure PixelMasks;
var I: integer;
begin
    M[7]:= 1;
    for I:= 6 downto 0 do M[I]:= 2*M[I+1];
    for I:= 0 to 7 do R[I]:= 255 - M[I]
end;  {Pixelmasks}

procedure Change (var Char__byte: char; color, height:integer);
{changes given byte from present value to given value = color}
var  old: integer;
begin
  Old := ord(Char__byte);
  case color of
    1: old:= old OR M[height];       {insert set bit in correct place}
    0: old:= old AND R[height]       {using appropriate pixel masks}
```

(continued)

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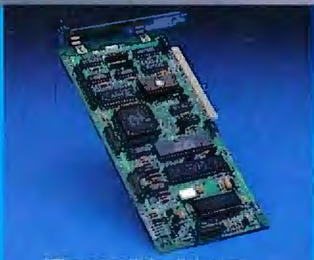

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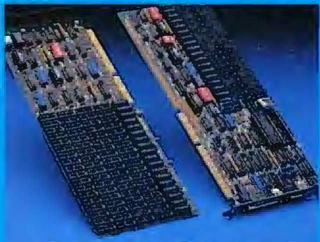

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```
    (*****************************************************
    For the Prowriter these last two lines should be replaced by
    1: old:= old OR M[7 - height];
    2: old:= old AND R[7 - height]    {See text for details.}
    *****************************************************)
    end;
  Char_byte:= chr(old)
end;  {Change}
procedure Pset (x,y,color : integer);
{Writes the dot at position (x,y) into memory arrays}
var l,line,height : integer;
begin {Pset}
    Plot(x * 2 div 5, y * 5 div 16, white); {draw dot on screen}
    { *****************************************************
      This multiplies x by the ratio of screen width to printer width,
      multiplies y by the ratio of screen height to printer height.
      For the Prowriter this last line should be replaced by:
      Plot(x div 2, y * 5 div 16, white);
      ***************************************************** }
    color := color mod 2;
    Line := Y div 16;                 {vertical position of pixel consists of a line}
    height := (Y mod 16) div 2;       {number between 0 and down; and a height }
                                      {between 0 and 15, divided into}
                                      {even-odd groups}
    if y mod 2 = 0 then change(evenmap^ [x,line],color,height)
                   else change (oddmap^ [x,line],color,height)
end; {Pset}
```

Listing 2: Printout *procedure for Prowriter.*

```
procedure Printout;                       {for Prowriter}
var wrd : packed array [1..4] of char;
  a,b,i,j,k : integer;
begin {Printout}
  writeln (lpt1,'                              ');  {clear printer buffer}
  writeln (lpt1,'                              ');  {= 50 bytes}
  writeln (lpt1);                         { + carriage return}
  a := across + 1; l := 4;                {a = number of graphics bytes}
  repeat
    b := a mod 10; a : = a div 10;        {get next digit (= b)}
    wrd [l] := chr(b + ord( '0'));        {insert as a character in string: wrd}
    l := l - 1
  until l = 0;                            {wrd = digits of across}
  writeln (lpt1, chr(27),'P');            {set pitch for proportional spacing —
                                            the highest horizontal density}
  for J := 0 to down do
      begin
        write (lpt1, chr(27),'S',wrd);          {enter graphics mode}
        for l := 0 to across do
          write (lpt1, evenmap^[l,J]);          {print even rows}
        writeln (lpt1, chr(27),'T','01');       {start next line ½ dot down}
        write (lpt1, chr(27),'S',wrd);          {graphics mode again}
        for l := 0 to across do
          write (lpt1, oddmap^[l,J]);           {print odd rows}
        writeln (lpt1,chr(27),'T','15');        {start next line 7½ dots down}
      end
end;  {Printout}
```

turning on a point involves changing a single bit within a byte. Computers are generally not equipped to do this easily. Remember that each byte controls eight vertical dots, and you want to change *only one* of them. This is most quickly done with bit masks and the logical operations AND and OR. See the text box on bit manipulation, "Bits AND/OR Pieces," on page 225. (Note that in the PixelMasks procedure, the leftmost bit in a byte is called the zeroth bit, while the rightmost bit is the seventh.)

If you want to insert a 1 in the third bit, you use the mask M[height], where height equals 3, with the logical OR operation. The code that inserts this 1 into the byte Old is simply:

Old:= Old OR M[height]

M[height] is a byte made up of all zeros except for a 1 in bit height. If Old is 01000010 and height is 3, then Old becomes the byte (01000010 OR 00010000) = 01010010.

If you want to insert a 0 into this same byte, you use the mask R[height] together with the logical AND operation:

Old:= Old AND R[height]

Here, R[height] is a byte made up of 1s except for a 0 in bit height. If Old is 01111101 and height is 7, then Old becomes the byte (01111101 AND 11111110) = 01111100.

Note that you write to printers using Pascal's Write and Writeln procedures, and these procedures expect to be given a character. This is why you should set up your arrays as character arrays and why the last command in the Change procedure converts the byte into a character.

Some Printer Differences

The eight vertically arranged print pins on most printers correspond to the eight bits in a byte. On the Epson FX-80 and many other printers, the high-order bits—those in the left half of the byte—correspond to the upper pins; the low-order, or rightmost, bits correspond to the lower pins. Thus, the byte 10000010 causes the top pin and the next-to-the-bottom pin to make dots on the paper. On the other hand, for the Prowriter and several other printers, the exact opposite is true—the *leftmost* bit causes the *bottom* pin to fire. Thus, if you want to insert a 1 in the third bit for a Prowriter, you OR with M[7-height] where height equals 3. To avoid confusion we have indicated the corrections necessary to handle the Prowriter properly (see listing 2). If you have a different printer, you should check your manual for the correct pin assignments. (The Prism printer, for example, uses only seven pins.)

Another important difference between printers is in how close you are allowed to print the dots horizontally and vertically. In the Epson quadruple-density graphics mode, available only on the FX, RX, and IBM models, the printer prints 240 dots per inch or 1920 dots across an 8-inch page. Because of restrictions on the size of arrays (64K-byte maximum), the examples in this article draw only 1600 dots. (We can draw more, but at the expense of some vertical rows.) The older Epson MX prints only 960 dots across the page. For the Prowriter, the highest density possible is in proportional mode, where you can get 160 dots per inch or 1280 per line—we use 1250 in our examples.

Each dot on a dot-matrix printer is approximately 1/72 inch in diameter. The Epson FX-80 permits linefeeds of ⅓ dot, which results in a theoretical vertical density of 216 dots per inch. The Prowriter allows ½-dot linefeeds, or a vertical density of 144 dots per inch. In the examples in this article, we use the Epson ⅓-dot linefeeds as if they were ½-dot; this works fine, undoubtedly due to the inherent inaccuracy of paper advance.

Once again, you must consult your printer manual if you have a different printer. The Prism does not seem to support fractional linefeeds at all, while the Mannesmann Tally achieves them by raising or lowering the actual print head ½ dot.

ECHOING ON THE SCREEN

We now have the complete setup for drawing a dot in "printer" memory. Returning to listing 1, note the call to the procedure Plot. Plot is a Turbo Pascal procedure that draws a dot on the actual screen for each point you draw in memory. However, the scale for the printer is different from the scale for the screen: 1600 by 640 dots for the printer (1250 by 640 dots for the Prowriter) versus 640 by 200 dots (pixels) for the screen. For the Epson FX-80 you rescale by multiplying the column and row, respectively, by 640/1600 (2/5) and 200/640 (5/16). For the Prowriter you multiply by 640/1250 (approximately ½) and 200/640 (5/16). Since real-number multiplication is time-consuming (unless you have an 8087 chip) and since Plot requires integer parameters anyway, you

(continued)

BITS AND/OR PIECES

Suppose you have two bytes, each represented as eight binary bits: Byte1 = 10111010 and Byte2 = 00110011. To make calculation simpler later on, let's call the first bit on the left of each byte the zeroth bit; the next is the first, then the second, etc. Thus, the zeroth bit of Byte1 is 1, the first is 0, and the seventh, or rightmost, bit is 0. When you OR Byte1 and Byte2 together, you produce a new byte, Byte3. If either of the corresponding bits, for example the zeroth bits of Byte1 and Byte2, is a 1, then you make the corresponding bit of Byte3 a 1; otherwise, it is a 0. Thus, the zeroth bit of Byte3 is a 1 since Byte1 has a 1 in the zeroth position. The first bit of Byte3 is a 0 since neither Byte1 nor Byte2 has a 1 in that position.

```
Byte1 = 1 0 1 1 1 0 1 0
Byte2 = 0 0 1 1 0 0 1 1
Byte3 = 1 0 1 1 1 0 1 1
Byte3 = Byte1 OR Byte2 =
  10111011.
```

If you perform an AND on the two bytes, the process is similar, except that you put a 1 in Byte3 only if *both* corresponding bits are 1. Let's let Byte4 = Byte1 AND Byte2.

```
Byte1 = 1 0 1 1 1 0 1 0
Byte2 = 0 0 1 1 0 0 1 1
Byte4 = 0 0 1 1 0 0 1 0
Byte4 = Byte1 AND Byte2 =
  00110010
```

Suppose now that you have a byte B = 10011001 and you want to change the second bit from a 0 to a 1. If you have a byte M2 that is all 0s except for a 1 in this second position (i.e., third place from the left), then you can execute

```
B OR M2 = 10011001 OR 00100000
  = 10111001
```

This accomplishes your purpose. You need eight different masks of this type to handle each possible bit position. Note that M2 = 00100000 (binary) = 20 (hexadecimal) = 32 (decimal); also, $32 = 2^{(7-2)}$. All other such masks are powers of 2 also. This explains how M, the array of eight different pixel masks, is constructed in the procedure PixelMasks (see listing 1).

To turn off the fourth bit of B (i.e., change it from a 1 to a 0), you can AND it with a byte R4 that is all 1s except for a 0 in the fourth position (the reverse type of mask from M2):

```
B AND R4 = 10011001 AND 11110111
  = 10010001
```

In this case R4 = 11110111 (binary) = F7 (hexadecimal) = 247 (decimal). The procedure PixelMasks also constructs the array R of eight different reverse masks. The relation between the masks of the two types is easy to see. For example, consider M[3] = 00010000 = 16, and R[3] = 11101111 = 239. Then

```
R[3] = 11101111 = 11111111 - M[3]
  = 255 - M[3]
```

Thus, you get the reverse pixel masks from the normal pixel masks by subtracting the normal ones from 255.

One great advantage of pixel masks is that they are fast. Once created, you can use them over and over without any time-consuming computation. You can use pixel masks in regular screen graphics also; if you use color, you will need several other sets of masks that do two bits at a time, since a choice of one out of four colors requires two bits.

can do this quite neatly using integer multiplication and div:

Plot(x * 2 div 5, y * 5 div 16, white)

For the Prowriter:

Plot(x div 2, y * 5 div 16, white)

This is still somewhat wasteful since it draws some dots on top of others, but it is sufficient for this example.

How to Print the Dots

In theory all we have to do is send these bytes to the printer. However, many printers are fussy and don't like to be in graphics mode—in fact, they'll only stay there for one line at a time. Furthermore, each time you invoke graphics mode you have to tell them how many graphics bytes to expect on that line; if you send them more, they start printing regular characters.

Let's do a brief rundown on the Epson FX-80 graphics Printout procedure (see listing 1). Lst is Turbo Pascal's name for the printer. The Epson FX-80 instruction to enter quadruple-density graphics mode is Escape (chr(27)) followed by Z (on the MX, replace Z with L). Then the printer needs to receive the number of graphics bytes it should expect as a sequence of two characters, which are determined as follows:

Byte #1 = "n_lo"
(# of bytes mod 256)
Byte #2 = "n_hi"
(# of bytes div 256)

(This information should be easy to obtain from your printer manual under "Graphics Mode.")

Procedure Printout has two nested loops; the big one controls the printer lines, while the smaller sends out the character bytes within each printer line. Recall that a printer line consists of one even and one odd group of 1600 bytes. For each of these we must, as just mentioned, reenter graphics mode and give the byte count. The command write(Lst, chr(13)) is simply a carriage return.

The only other lines of interest are the paperfeeds. The Epson FX-80 won't do a linefeed of ½ dot but rather works in multiples of ⅓ dot. Since even Epson disclaims any great accuracy for such a tiny linefeed, we tried various combinations such as ⅓ and 7⅔, ⅔ and 7⅓, etc. The best image seemed to result from using ⅓ and 7⅓ (22/3).

Now let's take a look at the Prowriter graphics Printout procedure (see listing 2), since the Prowriter works a little differently. First, you should clear out the 50-byte printer buffer by writing 50 blanks—we've never seen the necessity of this, but it is suggested as a precaution. Next, you should report the number of graphics bytes the printer is to expect (= across + 1) by sending a string whose characters are the *decimal* digits of this number. These are computed by the small loop (from a: = across + 1 through until l = 0;). The rest of the code is the same as the Epson FX-80's except for the different printer instructions (escape sequences).

The Testcurve Program

To demonstrate how these procedures work, listing 3 contains a driver program that sketches the simple parabola $y = x*x$ (see figure 1). The heart of this program is the procedure Plotcurve, which illustrates the scaling and coordinate manipulation necessary to draw "computer pictures." Since the origin is in the upper left-hand corner and the y-coordinate is measured downward, you are essentially plotting y = 639 – (x – 25)*(x – 25). x should go from 0 to 50; since the width of the screen is *across* (1599 or 1249), you round *across* to the nearest 50 (width: = across – (across mod 50)) and let I go from 0 to width. The scale factor scaler is width/50 and x equals I/scaler or (I/width)*50. Thus, when I equals 0, x is 0; when I equals width, x is 50. Then you use Pset to graph your points:

Pset(I, trunc(639 – (I/scaler – 25)*
(I/scaler – 25)), 1)

Note that you must truncate (trunc) since Pset requires integer parameters.

Connecting the Dots

The procedure Plotcurve draws a curve by computing each point sepa-

(continued)

Listing 3: *Program to test printing procedures. It draws a parabola: $y = x*x$. Note the* $I *directive to include the routines in* Printpak.pas *(see listing 1).*

```
Program Testcurve;
{$I printpak.pas}        {Include printer procedures listed above.}
var ch: char;
  Procedure Plotcurve;
  var I, width: integer;
       scaler: real;
  begin {Plotcurve}
    width: = across - (across mod 50);
    scaler: = width/50;
    for I: = 0 to width do
      Pset(I, trunc(639-(I/scaler - 25)*(I/scaler - 25)),1)
  end;  {Plotcurve}
begin {Testcurve}
  Init_mem;
  PixelMasks;
  HiRes; HiResColor(7); {draw in 640- by 200-dot mode}
  Plotcurve;
  write('Continue (y/n)? ');
  readln(ch);
  if ch = 'y' then Printout;
  TextMode(BW80)
end.  {Testcurve}
```

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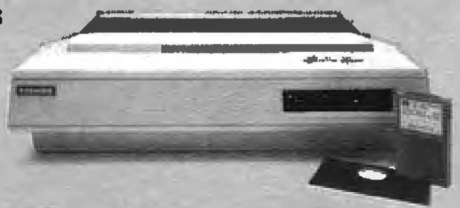

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rately and then plotting it. Although this sufficed for a simple demonstration, it has two major shortcomings. First, it can skip points. For example, suppose y equals 5 when x is 1, and y equals 10 when x is 2. Then there is a vertical gap of four dots between the points (1,5) and (2,10). (This didn't happen on the parabola graphic because x went from 0 to 50 in 1599 steps, so each step represented an x change of about 0.03. Thus, even at the steepest part of the curve, y

(continued)

Listing 4: *Bresenham's line-drawing algorithm. (The Pascal implementation is courtesy of Professor Richard Rasala of Northeastern University.)*

```
Procedure Pixel_Line(x1,y1,x2,y2:integer);
var x, y, z, a, b, dx, dy, d, deltap, deltaq: integer;
begin
  dx:= abs(x2 - x1);
  dy:= abs(y2 - y1);
  If dy <= dx then {Slope <= 1}
    begin
    x:= x1; {initialize x}
    y:= y1; {initialize y}
    z:= x2; {set sentinel in x-direction}
    {Now set x-increment}
    If x1 <= x2
      then a:= 1 {x increases}
      else a:= -1; {x decreases}
    {Now set y-increment}
    If y1 <= y2
      then b:= 1      {y increases}
      else b:= -1;    {y decreases}
    {Initialize decision function and its deltas}
    deltap:= dy + dy;
    d     := deltap - dx;
    deltaq:= d - dx;
    {Locate and plot points}
    Pset(x,y,1);     {First point}
    while x <> z do begin
        x:= x + a;
        if d < 0
          then d:= d+ deltap
          else begin
            y:= y + b;
            d:= d + deltaq
            end;    {else}
        Pset(x,y,1);
        end   {while}
  end   {Case: if dy <= dx}
else    {dx <= dy so view x as a function of y}
  begin
    y:= y1;   {initialize y}
    x:= x1;   {initialize x}
    z:= y2;   {set sentinel in y-direction}
    {Now set y-increment}
    If y1 <= y2
      then a:= 1       {y increases}
      else a:= -1;     {y decreases}
    {Now set x-increment}
    If x1 <= x2
      then b:= 1       {x increases}
      else b:= -1;     {x decreases}
    {Initialize decision function and its deltas}
```

(continued)

```
        deltap: = dx + dx;
        d      : = deltap - dy;
        deltaq: = d - dy;
        {Locate and plot points}
        Pset(x,y,1);      {First point}
        while y < > z do begin
          y: = y + a;
          if d < 0
            then d: = d+ deltap
            else begin
              x: = x + b;
              d: = d + deltaq
              end;      {else}
          Pset(x,y,1);
          end  {while}
        end  {else}
    end;       {Pixel_line}
```

changes only about 1.5 dots per change in *x*—hardly visible at over 200 dots per inch.)

Second, this point-by-point calculation takes time. Even when the curve is smooth or nearly straight, every point must be calculated. For curves from simple functions this doesn't produce too much overhead, but for complicated mathematical equations or for curves produced by rotating images, this "overcalculation" is unacceptably slow.

The solution to both of these problems is to compute fewer points and to join the points computed with simple, easy-to-calculate curves. For most purposes these simple curves can be taken to be straight lines. If you only compute every fifth point and you connect the points by lines, there is a considerable time savings if point computations are reasonably complex and the line-drawing algorithm is fast. Furthermore, this solves the problem of gaps, since, in the example above, the points (1,5) and (2,10) would be joined by a small line segment "filling in" the missing four points.

The problem, then, is finding a fast line-drawing algorithm. Trying to find the equation of the line joining two points and then plotting it requires a considerable amount of real-number (decimal) arithmetic. This kind of arithmetic, especially multiplication and division, is quite slow in comparison with whole-number manipulation. Furthermore, since the coordinates of points on the screen (or printer page) are always integers—column and row numbers—you would naturally hope for a whole-number algorithm. Fortunately, there is one, called the Bresenham Line Algorithm (named for its inventor, J. E. Bresenham). It not only computes the points on the line connecting any two screen points, using whole-number arithmetic, but it accomplishes this feat *without using either multiplication or division!* Listing 4 contains a Pascal implementation of it. The procedure call is Pixel_line(x1,y1,x2,y2,color) where x1,y1 and x2,y2 are the endpoints of the line. For an easy-to-read description of the theory behind Pixel_line, see *Fundamentals of Interactive Computer Graphics* by James D. Foley and Andries Van Dam (Addison-Wesley, 1982).

Sometimes, when speed is even more important and points are very time-consuming to compute, you must cut down radically on the number of points calculated. Joining the points by straight lines will usually produce a figure that is too polygonal in appearance. In figure 1, the points are joined by curved pieces called *splines*, for which there are now very fast computational algorithms. There is some discussion of splines in Foley and Van Dam's book, but the

(continued)

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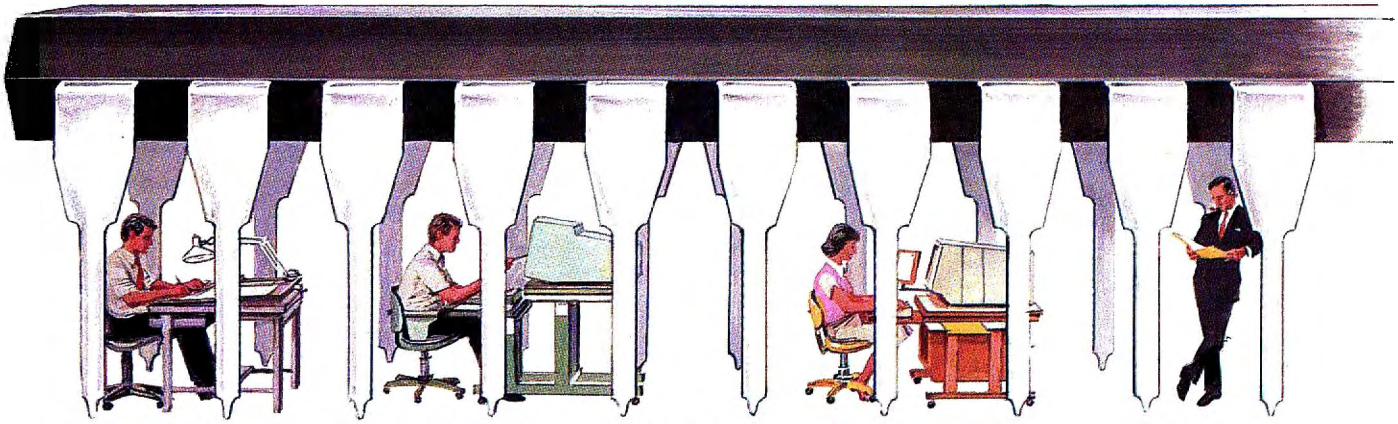

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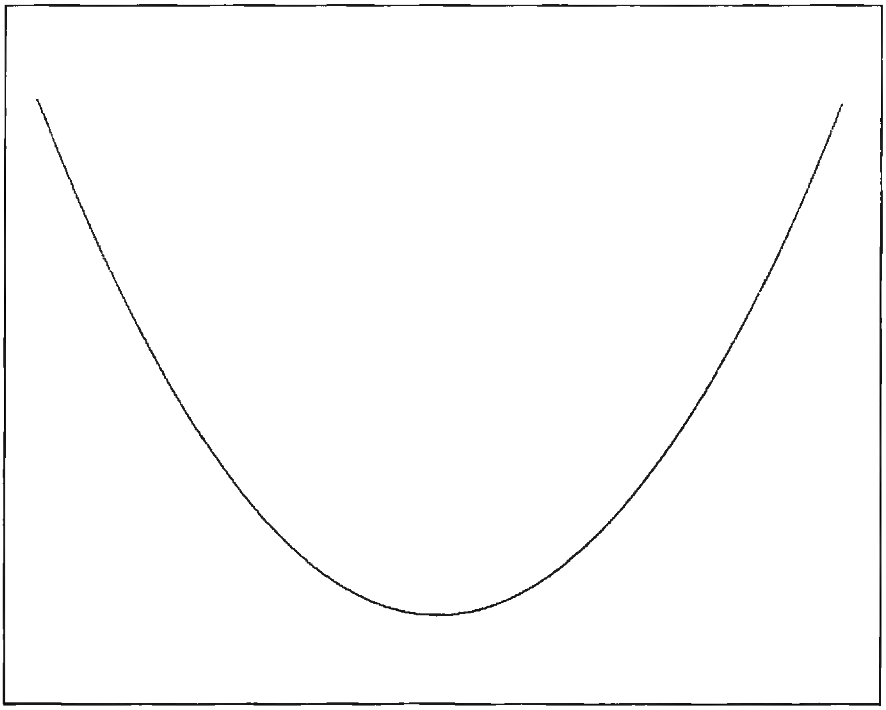

Figure 1: *High-resolution plot of a parabola* ($y = x*x$) *created on an* Epson FX-80 *printer.*

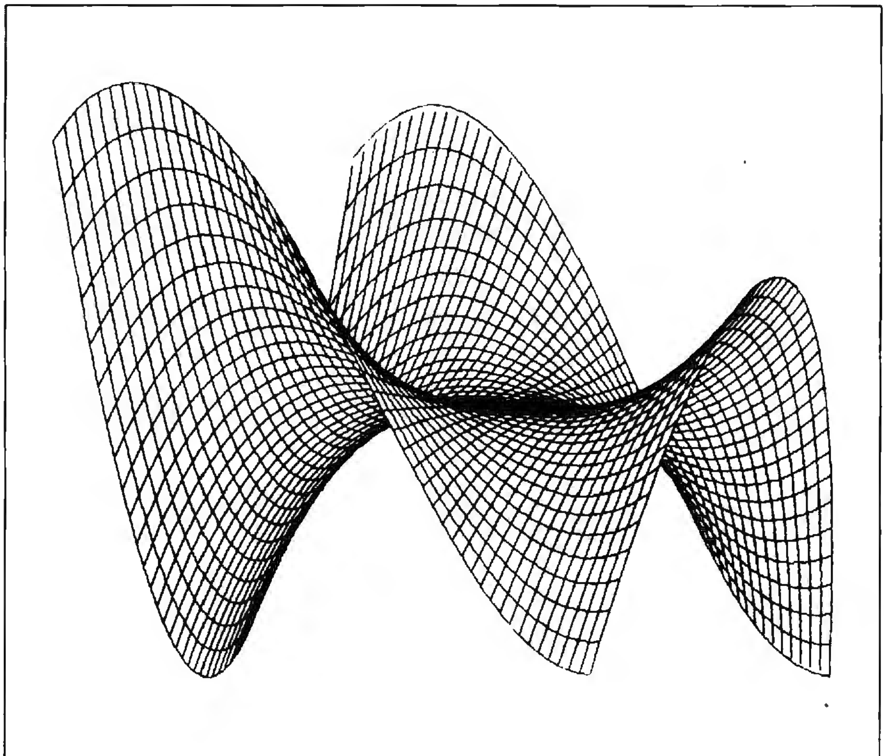

Figure 2: *High-resolution plot of the surface* $z = x^3 - 3xy^2$ (1600 *by* 640 *dots prepared using the* Epson FX-80 *printer and the* Bridge *Software* Math Utilities).

There are clever ways of getting even more speed out of the line drawing—especially for lines of small slope—by exploiting block moves of bytes.

most efficient algorithms are to be found in the current technical computer science journals.

FURTHER APPLICATIONS AND EXTENSIONS

Armed with procedures for drawing points and lines on the screen and on the printer, you can implement procedures for making very complex high-resolution pictures. It is possible, given enough memory, to set aside more pairs of arrays to increase further the image size you can print. This is the reason to use dynamic variables, the ones with the "^".

It is also possible to print your picture sideways, but this requires a restructuring of the procedure Change so that it addresses the points correctly.

Finally, you can use pixel masks to draw points on the graphics screen as well as the printer. The point and line-drawing procedures included in BASIC and Turbo Pascal, for example, are implemented by combining color and monochrome pixel masks with some version of Bresenham line drawing. There are clever ways of getting even more speed out of the line drawing—especially for lines of small slope—by exploiting *block* moves of bytes.

Figure 2 shows a surface plotted by an Epson FX-80 printer with a resolution of 1600 by 640 dots. It indicates the complexity of drawing possible with this method of printer addressing. ■

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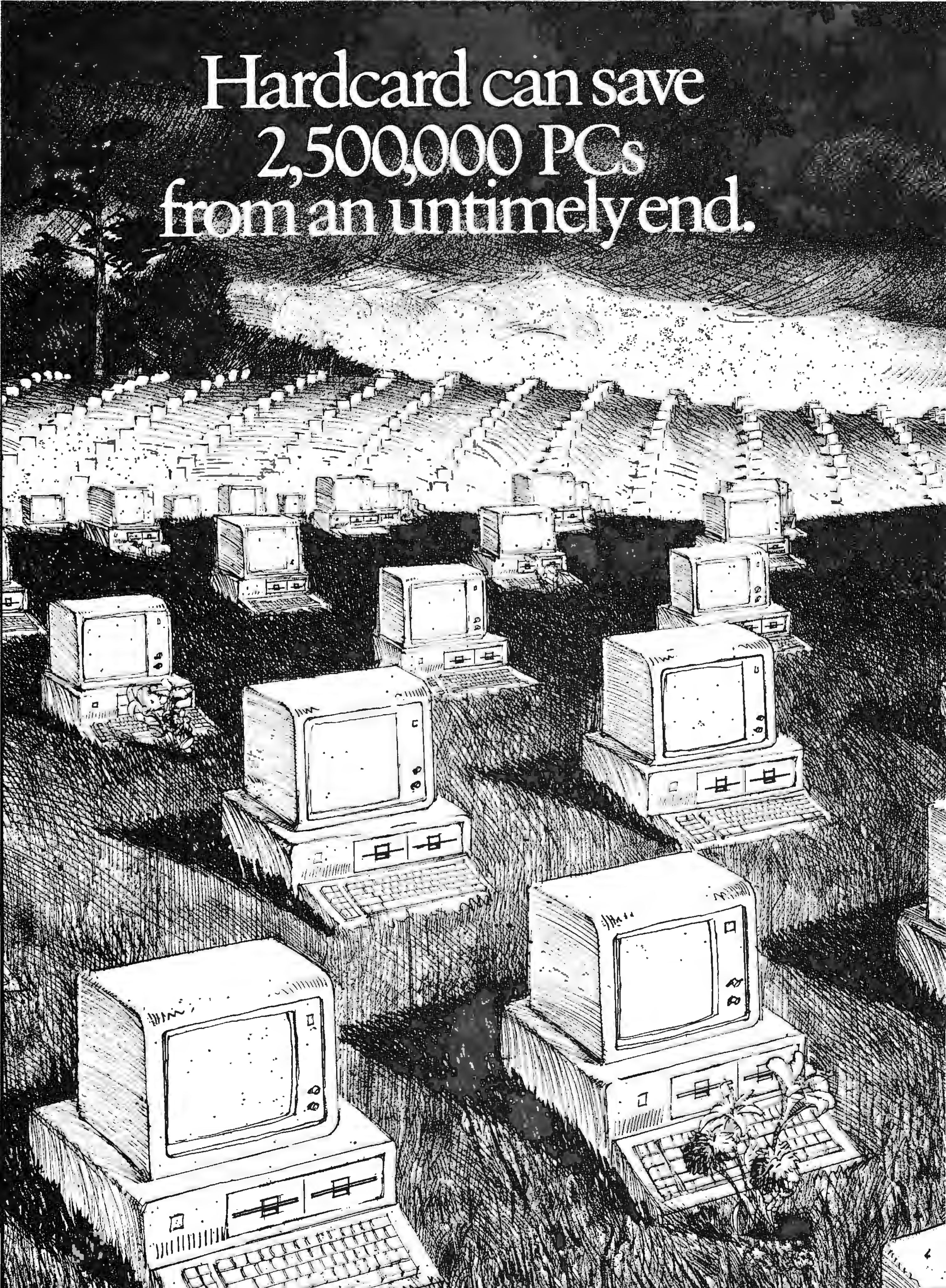
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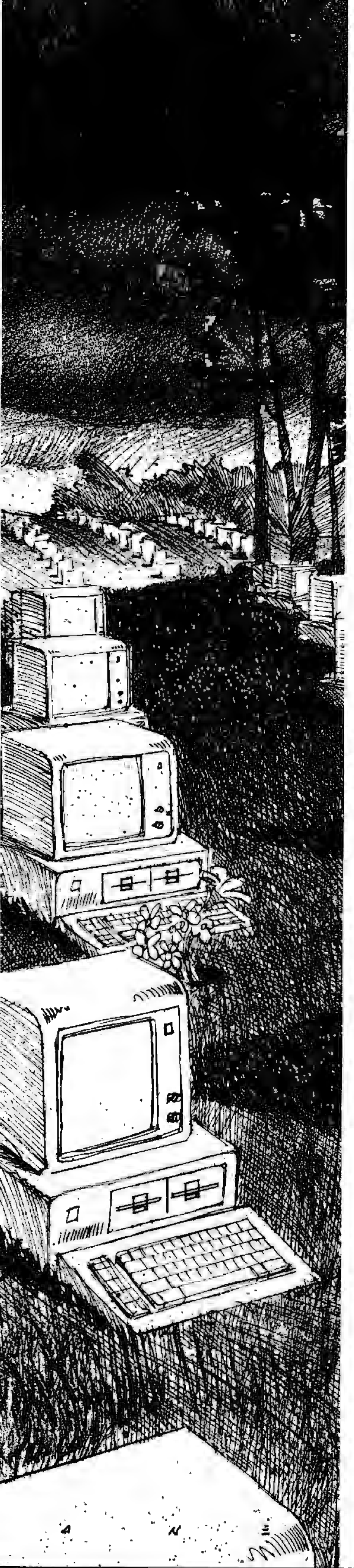

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THE μPD7281 PROCESSOR

BY TOM JEFFERY

A non–von Neumann chip designed for high-speed parallel processing of images

THE TRADITIONAL COMPUTER, as formalized by John von Neumann, has a central processing unit (CPU) that accesses instructions residing in the memory with the data. But fetching an instruction from memory, decoding the instruction, fetching data from memory, and storing results, over and over, instruction after instruction, pixel by pixel, slows a system down. For image processing, the fact that similar operations are repetitively performed on all the data suggests some kind of parallel solution. Several processors could be set to work, each handling a part of the problem. But experiments in this direction tend to run into the same bottlenecks: memory access for instructions and data. Furthermore, the additional hardware and software overhead required to control and synchronize the processors may even slow the system down.

These bottlenecks are called the von Neumann bottlenecks: an unfitting tribute to the father of the digital computer. They can be stretched, but they can't be avoided. Computer theorists have begun looking outside the bottle. Two "non–von Neumann" strategies for getting out are *pipelining* and *data-flow architecture*.

NEC Electronics has developed a microprocessor chip based on these principles, the μPD7281. Designed primarily as an image-processing chip, the μPD7281 uses pipelining and data-flow architecture to allow processing of image data (such as enlarging, shrinking, and enhancing images) at high speed—5 million instructions per second (MIPS).

INTO THE PIPELINE

Pipelining increases throughput by using a processor's resources more fully. In a pipelined system, the processor starts working on the next step of the problem before it has finished with the last step. To some degree, many von Neumann–style processors use pipelining. For example, prefetch registers are a form of pipelining. At the same time as one instruction is being executed, the next instruction can be brought into the CPU from memory. Now, the additional time required to fetch an instruction is effectively zero; that operation takes place while the CPU is busy elsewhere.

The μPD7281 is thoroughly pipelined, inside and out. Inside, the μPD7281 is basically a pipeline with a loop in it (figure 1). The loop consists of several "blocks," or working areas. As soon as a block completes its work, it passes the results to the next block and takes more data from the previous block. The loop allows data to pass through the system as many times as necessary. Like an assembly line, each station is always busy; an individual product may take all day to be built, but the factory doesn't wait for one product to be finished before starting the next.

When μPD7281s are used together, they are arranged in a straight pipeline (figure 2). Data goes in one end and comes out the other. Each chip passes its output directly to the input of another chip. There is no interface hardware at all. Each μPD7281 has a module number, which identifies the particular data that it processes.

The delay between entering a set of figures and getting the answer for those figures depends on the problem. However, once the pump has been primed, if the pipeline is kept full (i.e., if you continuously input data), you can get an answer every 200

(continued)

Tom Jeffery is a technical writer for NEC *Electronics* Inc. (401 Ellis St., *Mountain View*, CA 94039).

nanoseconds (ns) at 10 megahertz (MHz).

DATA-FLOW ARCHITECTURE

The second and really radical innovation for the μPD7281 is its data-flow architecture. Von Neumann architecture is program-driven and runs on more or less sequential instructions that manipulate data. Conversely, data-flow architecture is data-driven and runs on "tokens," which are packages containing both instructions and data. In the μPD7281, a token consists of 16 bits of data (plus sign and control bits) and a varying amount of identification (ID) and instructions. These packages flow into the μPD7281 and along the pipeline. They do not have to be fetched. In general, they can be input in any order because they contain their own ID and operational information. The processor performs operations when all the necessary data is present.

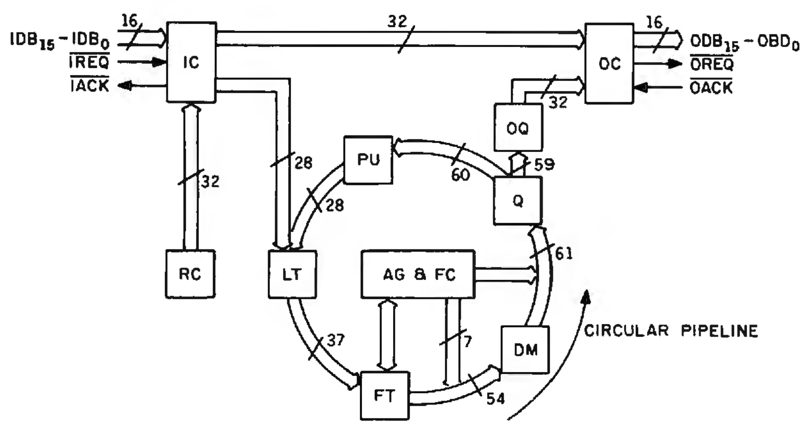
For a simplified example, think of adding two numbers. In most computers (von Neumann architecture), you write a program that says "Add A to B and put the result in C." To execute the program, the computer gets the first instruction, which tells it to get A. The next instruction tells it to get B. The next tells it to add them. The next tells it where to store the result. That's four instruction fetches: two data fetches, one addition, and one data store.

In a data-flow machine, your program says the same thing, "Add A to B and put the result in C." The host processor puts the A data in a token marked "A," puts B in a token marked "B," and sends these to the data-flow machine whenever it wants, in whatever order it wants. The answer will be output, labeled "C." No instruction fetches, no data fetches. And the pipeline spits out answers as fast as you can shove in the data.

Data-flow "programs" are easily represented as flow graphs, in the same way that conventional, sequential programs are represented by flowcharts. In a flow graph, the lines—"arcs" or "links" in mathematical terms—represent the flow of tokens, and the boxes, or "nodes," represent operations on the tokens. As you can see from figure 3, flow graphs express the nonsequential, parallel nature of the data-flow concept. Operations are performed as tokens arrive along links at a node. The order in which the operands arrive does not matter.

These concepts may be easier to explain by looking at the chip in more detail (refer to the block diagram of the μPD7281 in figure 1). The μPD7281 is connected to the outside world by two 16-bit buses, an input and an output bus. Behind these buses are an input controller and an output controller. The input controller puts two 16-bit words together into a single 32-bit token. It then checks the token to see if it is addressed to this μPD7281. Each μPD7281 has a 4-bit address or module number. Each input/output (I/O) token has a module number, the address of the μPD7281 it wants to go to. If the module number on the token is different from the module number of the present μPD7281, the input controller passes the token unchanged straight to the output controller. This takes only one clock cycle, making the μPD7281 practically transparent to a token that is not addressed to it. The input and output controllers are analogous to the doors of a hospital. The "In" door and the "Out" door are close together, so if you are in the wrong building, you can go right on to the next one.

The μPD7281 uses a two-line handshaking system. When a processor wants to output a token, it signals on its $\overline{OREQ}$ (output request) line. If it can accept, the receiving processor signals on its $\overline{IACK}$ (input acknowledge) line. The input controller uses



LEGEND

IC: Input Controller. Controls input data tokens and determines whether or not an input data token should be sent to the circular pipeline for processing.
OC: Output Controller. Controls output data tokens.
LT: Link Table [128 words x 16 bits]. Stores instruction parameters.
FT: Function Table [64 words x 40 bits]. Stores instruction parameters.
DM: Data Memory [512 words x 18 bits]. Stores constants or temporary data.
Q: Queue [48 words x 60 bits]. FIFO queue. Data Queue: 32 words x 60 bits. Generator Queue: 16 words x 60 bits.
PU: Processing Unit. Executes logical, arithmetic, and bit operations.
OQ: Output Queue [8 words x 32 bits]. FIFO queue for the output tokens.
AG&FC: Address Generator and Flow Controller. Generates addresses for DM and controls the flow of tokens.
RC: Refresh Controller. Generates refresh tokens for internal DRAMs.

Figure 1: *The internal architecture of the μPD7281, a pipeline with several blocks, or working areas, in a loop. The numbers represent the bit width of the path between blocks.*

the handshake signals to control access to the μPD7281. If the internal pipeline is full, it holds back until there is a place for a new token.

Tokens that are accepted by the input controller are stripped of their module number, now unnecessary. A token undergoes many format changes as it passes through the μPD7281, as you can see by looking at the changing width of the pipeline bus and the token formats in figure 4.

The first block in the pipeline is the link table, a 128- by 16-bit RAM (random-access read/write memory). The contents of the link table are downloaded from the host system. They are part of the μPD7281 "program"; specifically, they represent the links in the data flow graph. The ID field of the token addresses a location in the link table. The contents of that location are an address in the function table. This address, a new ID, and a few stray bits of code are attached to the data, and the new token is clocked into the next block, the function table.

The function table is a 64- by 40-bit RAM. The contents, accessed by the function-table address from the link table, are the other part of the μPD7281 program. They represent the nodes of the flow graph. Here the token picks up 40 bits of instruction

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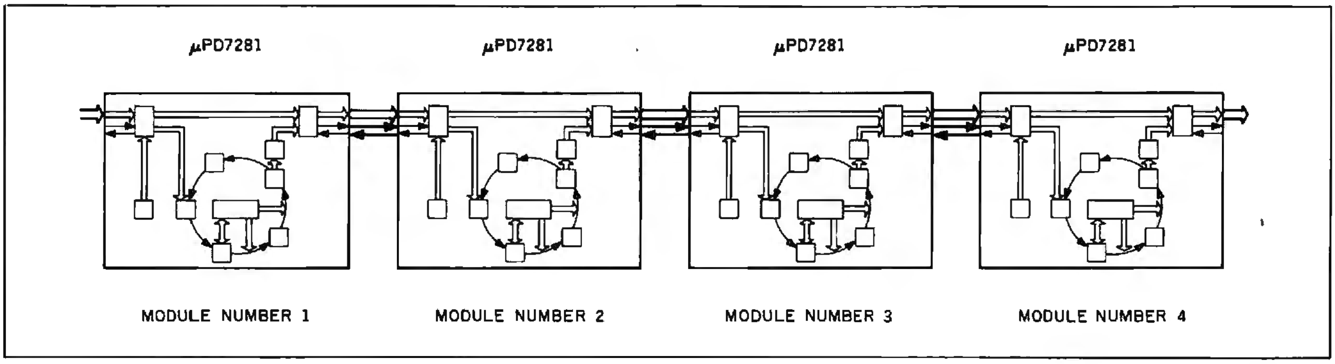

Figure 2: *When several μPD7281 chips, each with an internal pipeline, are connected together, they form a larger pipeline. Data, in the form of tokens, flows into the input of the first μPD7281, circulates through the internal pipeline, then passes out to the next μPD7281. This four-stage pipeline may work on up to 28 different tokens at a time.*

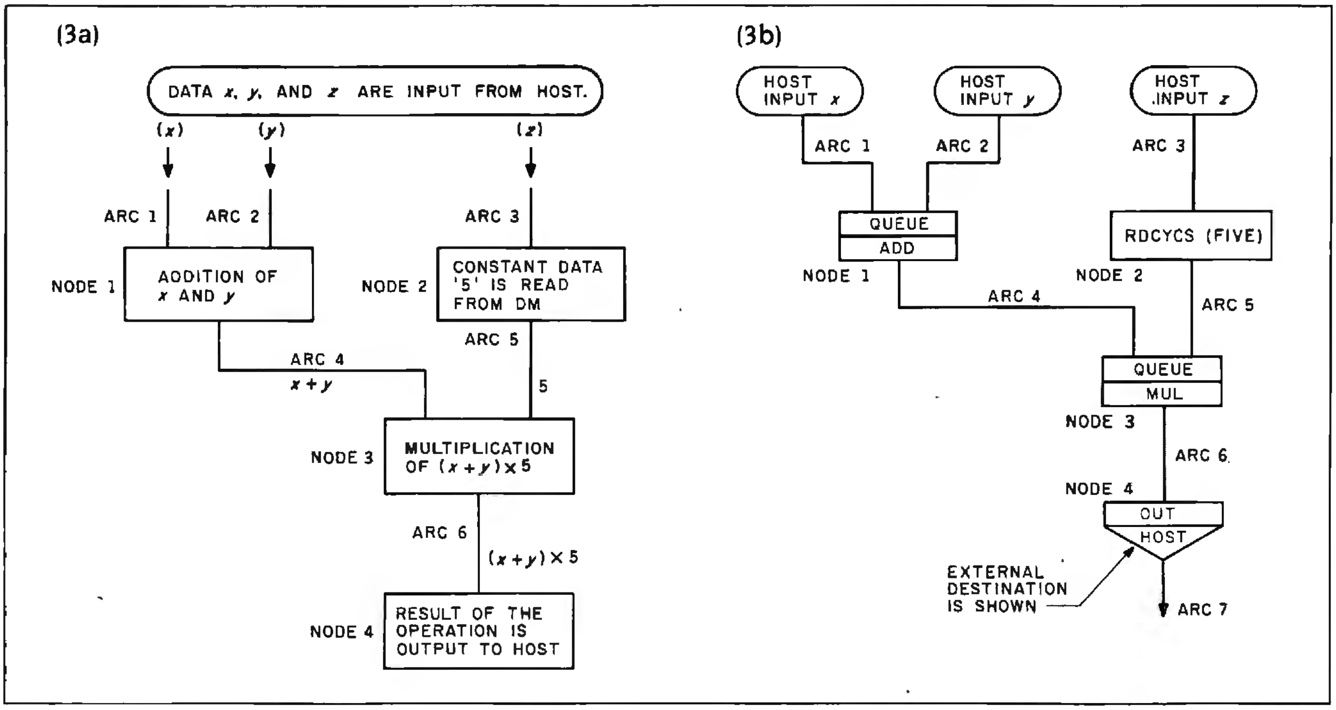

Figure 3: A *flow graph* (3a) *of the operation* 5(x + y) *as shown in* 3b. *When more than one token is expected at a node (as in* NODE1 *and* NODE3), *the node queues the first token until the second token arrives.*

codes, in the form of a function-table left field (processing-unit code), function-table right field (address-generator-and-flow-controller code), and function-table temporary field (counters and miscellaneous).

To continue the hospital analogy, the link table is akin to the receptionist. (Picture yourself in the role of patient-token.) It takes your ID and tells you who to see in the function table. The function table acts as the doctor who prescribes your operation. At the function table you get your orders for treatment to carry to the next blocks.

The address generator and flow controller comes into play if the operation to be performed, as determined by the function-table right field, involves more than one token. It acts as the back office, the secretary who knows where everything is. This block allows tokens to read from or write to sequential blocks of data memory (address-generator functions). And it queues tokens that are waiting for a second operand to perform their operation (address-generator-and-flow-controller function). That is, it tells you where to wait, where to get what you need, and where to leave your specimens.

The data memory is a 512- by 18-bit RAM that holds the first operand of a two-operand function until the second arrives. It also acts as general-purpose temporary storage and an I/O buffer. It operates under the control of the address generator and flow controller. The data memory is the hospital's files. You pick up or leave data about your case here. The address generator and flow controller will keep track of it. Then you go to the queue. The queue is the waiting room.

The queue is 48 by 60 bits of RAM configured as two first-in/first-out queues. The data queue, 32 tokens

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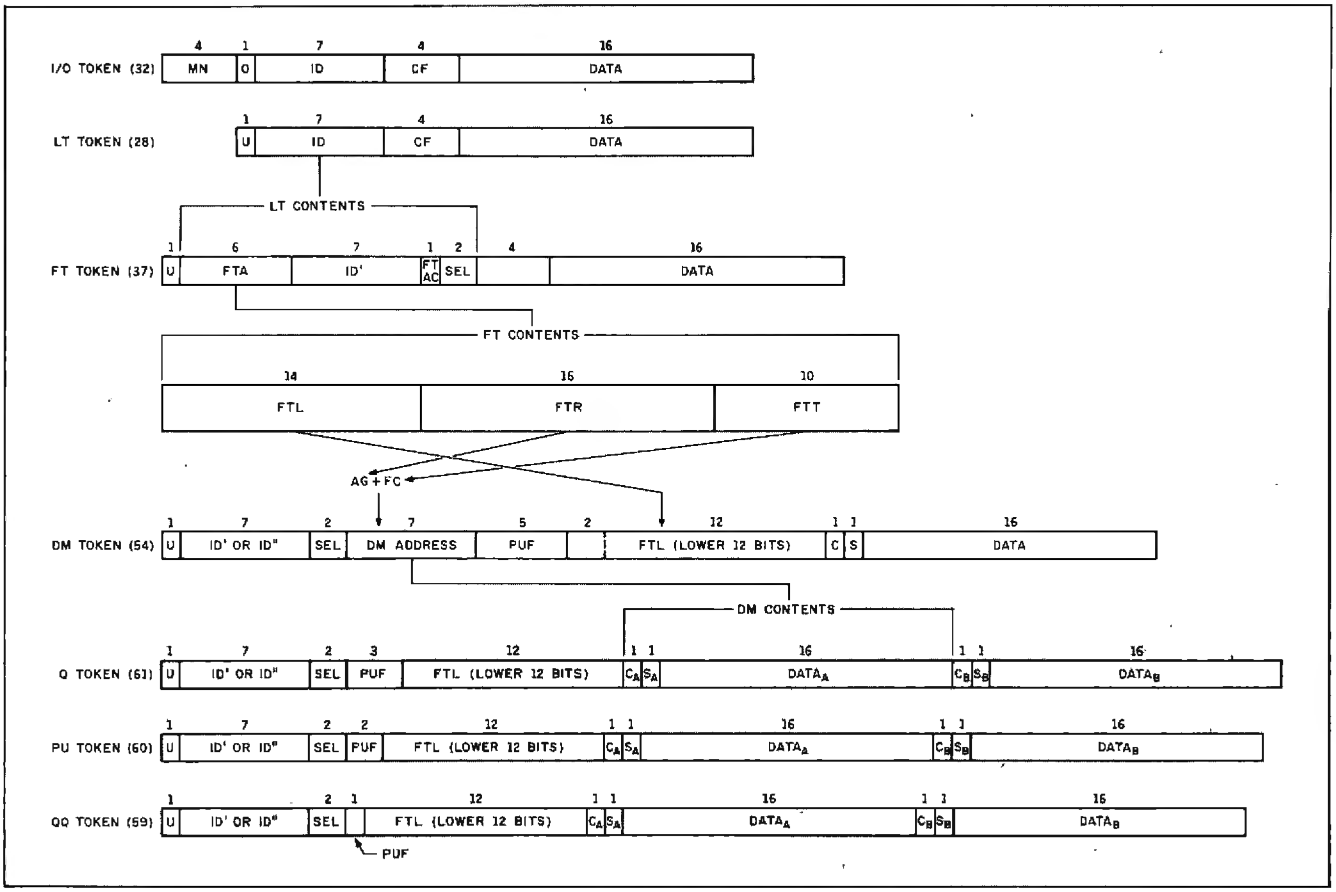

Figure 4: *As a token flows through the blocks of a μPD7281, its format changes. An I/O token has a module number, an ID, a control field, and 16 bits of data. At the link table, the module number is discarded, and the ID is expanded into a function-table address (FTA), a new ID (ID'), a function-table right control (FTRC) bit, and a select (SEL) bit. At the function table, the FTA expands into a function-table left field (FTL), a function-table right field (FTR), and a function-table temporary field (FTT). The FTL controls the processing unit. The FTR controls the address generator and flow controller (AG&FC). The address generator and flow controller supplies a data-memory (DM) address, which accesses another 18 bits of data, such as another token from the data-memory queue. The processing-unit field (PUF) specifies either a refresh token (in a queue token), a read/write token (in a processing-unit token), or neither (in an output queue token), and decreases accordingly in size.*

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long, holds tokens bound for the processing unit or the output. The 16-token generator queue holds tokens to be copied. The queues provide slack in the pipeline. Since the processing unit takes longer to process some instructions than others, the queues are necessary to keep slower operations from excessively backing up the processor pipeline. They do not release tokens to the output queue or the processing unit until these blocks are free. A subtle algorithm controls their operation. The data queue has priority over the generator queue if there are eight or more tokens in the data queue. This restricts the generator queue tokens, which are more dangerous because they in turn create more and more tokens and thus have the greater potential for causing pipeline overflow. The data queue has a restrict/inhibit mode to inhibit the input controller from accepting new tokens when the data queue has more than 24 tokens.

When one or two tokens are ready in the queue, they get passed to the processing unit. This is like the ALU (arithmetic and logic unit) of a von Neumann microprocessor, with a very rich instruction set. It performs the usual logic, arithmetic, and compare functions, including the 200-ns 17-bit signed multiply or divide, and many extras, such as a barrel shift (1- to 16-bit shift in one 200-ns cycle) and double-precision adjust. It also performs the token-generating functions, which make copies of a token. These operations are specified by the contents of the function-table left field. Since they are specified separately, a token can have both address-generator-and-flow-controller instructions and processing-unit instructions. These instructions are listed in table 1.

After your operation in the processing unit, you go back into the pipeline at the link table. You now have a new ID, specifying a new course of treatment. You keep going around until the link-table contents specify a function-table address whose contents in turn call for the token to be output, that

(continued)

Table 1: *The µPD7281's instruction set. A single token may include address-generator-and-flow-controller instructions and processing-unit instructions.*

Address-Generator-and-Flow-Controller Instructions

Mnemonic	Instruction
QUEUE	queue
RDCYCS	read cyclic short
RDCYCL	read cyclic long
WRCYCS	write cyclic short
WRCYCL	write cyclic long
RDWR	read/write data memory
RDIDX	read data memory with index
PICKUP	pick up data stream
COUNT	count data stream
CONVO	convolve
CNTGE	count generation
DIVCYC	divide cyclic
DIV	divide
DIST	distribute
SAVE	save ID
CUT	cut data stream

Processing-Unit Instructions

Mnemonic	Instruction
OR	logical OR
AND	logical AND
XOR	logical EXCLUSIVE-OR
ANDNOT	logical INVERT first operand then AND [A AND B]
NOT	invert
ADD	add
SUB	subtract
MUL	multiply
NOP	no operation
ADDSC	add, shift, and count
SUBSC	subtract, shift, and count
MULSC	multiply, shift, and count
INC	increment
DEC	decrement
SHR	shift right
SHL	shift left
SHRBV	shift right with bit reverse
SHLBRV	shift left with bit reverse
CMPNOM	compare and normalize
CMP	compare
CMPXCH	compare and exchange
GET1	get one bit
SET1	get one bit
CLR1	clear one bit
ANDMSK	mask a word with logical AND
ORMSK	mask a word with logical OR
CVT2AB	convert two's-complement to sign-magnitude
CVTAB2	convert sign-magnitude to two's-complement
ADJL	adjust long (for double-precision numbers)
ACC	accumulate
COPC	copy control bit

Generate Instructions

Mnemonic	Instruction
COPYBK	copy block
COPYM	copy multiple

(continued)


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SETCTL	set control field)
Output Instructions	
Mnemonic	**Instruction**
OUT1	output 1 token
OUT2	output 2 tokens

Listing 1: *Assembly-language listing of the flow graph in figure 3. Lines 1 through 4 constitute the declaration field; lines 5 through 15, the instruction field.*

```
 1   EQUATE      HOST = 0;
 2   MODULE      EXONE = 8;
 3   INPUT       ARC1, ARC2, ARC3;
 4   OUTPUT      ARC7;

 5   LINK        ARC4 = NODE1 (ARC1, ARC2);
 6   LINK        ARC5 = NODE2 (ARC3       );
 7   LINK        ARC6 = NODE3 (ARC4, ARC5);
 8   LINK        ARC7 = NODE4 (ARC6,      );

 9   FUNCTION    NODE1 = ADD, QUEUE (QUE1, 1);
10   FUNCTION    NODE2 = RDCYCS     (FIVE,  1);
11   FUNCTION    NODE3 = MUL (Y), QUEUE (QUE2, 1);
12   FUNCTION    NODE4 = OUT1       (HOST, 0);

13   MEMORY      QUE1 = AREA (1);
14   MEMORY      QUE2 = AREA (1);
15   MEMORY      FIVE = 5;
```

is, until your new ID says you are cured. At this time, a token goes to the output queue from the queue, instead of to the processing unit. The token is then fitted up with its module number and ID, and it leaves the μPD7281, in exactly the same format as it entered, via the output controller.

Because the output tokens have the same format as the input tokens, interfacing μPD7281 to μPD7281 is simplicity itself. The 18 output lines from one processor go to the 18 input lines of the other (ODB$_0$ through ODB$_{15}$ to IDB$_0$ through IDB$_{15}$, $\overline{\text{OREQ}}$ goes to $\overline{\text{IREQ}}$, and $\overline{\text{OACK}}$ goes to $\overline{\text{IACK}}$). The only additional hardware required is a 4-bit module-number register for each μPD7281 to set the module number at RESET.

The interface to memory is a little more difficult. The concept of external memory addresses is alien to data-flow architectures. The configuration shown in figure 5 requires a memory-bus interface to deal with the world outside the pipeline. This arrangement makes the memory look like a special kind of μPD7281 that accepts tokens addressed to it and passes others back to the beginning of the pipeline. Now the pipeline has looped back on itself, like the internal pipelines. Wheels are thus contained within wheels. To the memory, the interface should look more like a DMA (direct memory access) controller. It could also control a display processor and handle the host CPU interface. NEC has plans for just such a memory interface, called the MAGIC (memory address generator and interface controller) chip.

The μPD7281 pipeline is not designed to operate independently. It requires a host system, but it is designed to run somewhat loosely linked to the host. Nominally, the host is required to download the software into the link and function tables and to start the processing. It should be able to monitor the results, probably with an interrupt system. Although we haven't discussed error handling, the host system can read the system state on an error condition. These concepts are built into the μPD7281 and are easily implemented.

Now that we have our multiprocessor system, composed of a host, memory, and a few μPD7281s, how do we program the μPD7281s? What language do we use? No high-level language is suited to deal with this kind of architecture. NEC has no equivalent of Occam, the language for INMOS's multiprocessing Transputer. The μPD7281 assembler, however, is really quite simple.

The assembler is based on the flow-graph concept. Listing 1 shows an assembly-language program based on the flow graph in figure 3. The EQUATE statement simply assigns a constant to a variable; in this case, the host address to 0. The MODULE statement assigns this section of code to a given μPD7281. The input tokens (ARC1, ARC2, and ARC3) and output token (ARC7) are declared in the INPUT and OUTPUT statements. Look at the flow graph and you can see the connection.

The LINK statements show what node (or function) every arc in the graph comes from and which arcs went into the node. For instance, the statement LINK ARC4 = NODE1 (ARC1, ARC2); means that the link ARC4 is the result of the the function NODE1 operating on links ARC1 and ARC2.

LINK statements generate link-table entries. The statement above puts the address of function NODE1 as the function-table address and the address of ARC4 in the ID' section of link-table addresses ARC1 and ARC2.

The FUNCTION statements show what instructions make up each function on the flow graph. So FUNCTION NODE1 = ADD, QUEUE (QUE1, 1) means that the node NODE1 performs an addition and uses the queue QUE1 to hold whichever operand comes first until the second one ar-

(continued)

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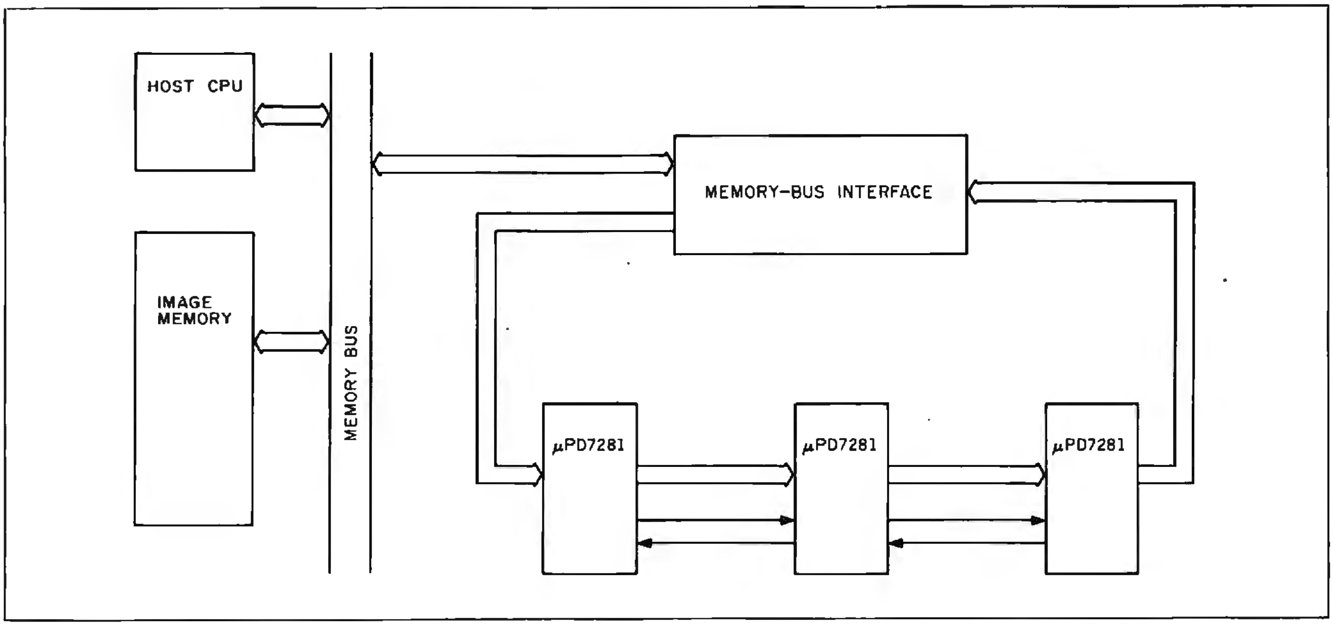


Figure 5: *Three μPD7281s in a pipeline loop with a memory-bus interface to external memory.*

rives at the node.

These statements become function-table entries. The ADD instruction goes in the function-table left field, and the QUEUE instruction goes in the function-table right field.

Data memory is allocated by the MEMORY statements. The area QUE1 is defined as an area to queue one operand. The location FIVE is set to 5.

That's pretty much it. The code is not particularly readable, of course. It looks a little like a string of declarations, and you wonder where the action is. The tokens supply that. The problem is that the program is a one-dimensional listing of the flow graph. Once you have the flow graph, the assembler is a snap, but no one would think of writing the assembler first, in the way that you might write a BASIC program without a flowchart.

Writing a program for more than one processor is a little more difficult. When I first comprehended the idea, I thought, "To program like that, you'd have to have more than one brain."

First of all, you must break the problem up between the processors. There are two ways to do this. One way is to break up the data. For example, in image processing, a 512- by 512-pixel image could be broken up into four quadrants of 256 by 256 pixels. Each quadrant would be worked on by a separate μPD7281, each with the same program. Since the processors are working independently, the processing time will be cut to a quarter of the time required by one μPD7281.

The other choice is to partition the algorithm. Since the link table, function table, and data memory are small, it isn't hard to imagine a program too large (more than 128 links and 64 functions) to fit on one μPD7281. A program of this size must be split up and put on different chips. For example, one μPD7281 shifts images, one sizes them, and one rotates them.

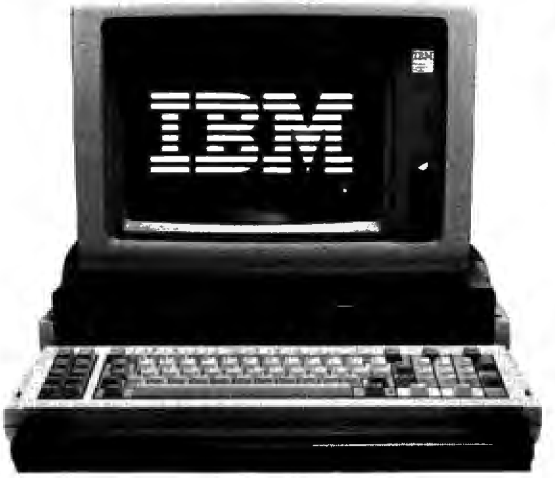
Routine partitioning is a little more tricky than data partitioning. The processes on each chip must be fairly well balanced, or the most heavily loaded chip will slow down the system. Of course, in the data-partition method the data must be partitioned equally. But if you are going to partition your program, you should do a simulation to ensure the balance.

This isn't the only problem you can run into when partitioning a problem among processors. When an early chip's routines run faster than a later chip, the tokens can pile up in the slower chip's data memory. This should be handled by routine balancing, but if it can't be avoided, a synchronizing token can be passed by the later μPD7281 back to the earlier to start and stop it.

Are there limits to the speed to be gained by adding processors? Of course. The fact that there are only 14 valid module numbers is one limit. Another is the memory bus. When a routine performs simple operations on many pieces of data, the memory bus is being used more than the μPD7281s. Adding more processors will fail to increase processing speed. This results in a state known as "bus neck." The system becomes memory-bus-bound, just like a von Neumann machine. The way to find the maximum number of effective processors is through simulation.

New software design techniques for this chip remain to be worked out. The most obvious would be a graphic assembler that codes directly from a flow graph.

It may even be possible to make a C or Pascal compiler for the μPD7281 that would translate your algorithm into the data-flow domain and optimize it for the best number of chips. ■



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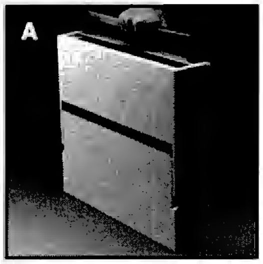

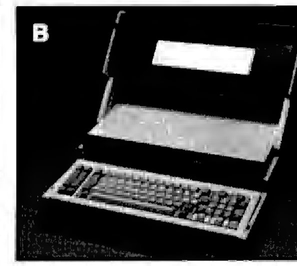

The Visual Commuter sells for only $699. The IBM monochrome monitor is optional.

It's a new concept. And if my hunches are correct, the new Visual Commuter will take years for others to copy.

By Joseph Sugarman, President

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It's lighter (only 18 lbs), flatter (only 3½" thick) and carries like a briefcase. In short, the Visual Commuter is a combination of all the good features of a portable computer (size, weight, portability), all the good features of a traditional desktop computer (full-size keyboard, 5¼" disks, full power) and none of the disadvantages of either.

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For all you technical people, listen to these specs. There's a 16-bit 8088 processor, 128K memory with parity, parallel printer port, serial ASYNC RS 232C port, Din connector RF modulator or composite video output for TV and composite video input monitors, RGB/direct drive output for high resolution monochrome or color monitors, IBM compatible color graphic support, support logic for 80x25 or 40x25 character display and LCD display, connector to IBM expansion unit, disk controller supporting two 5¼" disk drives, ANSI standard ROM-based terminal emulation, and ROM-based extended diagnostics. The dual disk drives are double sided-double density (360 Kbytes). The Commuter runs at the same clock speed as the IBM PC (4.77 MHz) but because of its new design, it runs between 8 to 10 percent faster.

ATTRACTIVE CASE

There's an attractive carrying case made by American Tourister that holds your software, your power cord, your documents and even our optional 1200 baud modem. The compatible Maxwell modem lets you communicate with other data banks. Made by the world's largest modem manufacturer, Racal-Vadic, it is normally a $500 value but our price is only $249 which includes a complete communications software package. There's also a toll free, online warranty service and a customer hotline to answer any of your technical questions.

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JUST A FEW THOUGH

Once we install the memory, you'll have to send the unit back to us to add more memory. So we ask that you estimate, in advance, the maximum power that you'll require for your needs. 128K memory is plenty for most applications but if you want to run Lotus Symphony, you'll need all 512K. Secondly, we ask that you act quickly. Although we have most of the product in stock right now, there's always the chance that we'll run out.

The Visual Commuter measures only 3½ x 15½ x 18" wide and comes complete with power cord (it only operates on standard AC current), the operating system (Micro-Soft's MS/DOS ver. 2.1) complete with basic and utilities, two beautifully written manuals, lid (without LCD display) and a limited 90-day warranty. There are service centers throughout the United States set up to service the unit in addition to the service-by-mail facility at Visual's home office near Boston.

I urge you to give the Visual Commuter a test. Order one from JS&A and use it for 30 days without risk. Plug in your IBM monitor and load any of the IBM software you currently have. See how the large keyboard matches the IBM perfectly and how its handle makes a perfect hand rest while typing or a comfortable handle for carrying the unit. See how convenient the unit is to take home or bring with you on a trip with its fold open LCD monitor. If you don't feel that the Visual Commuter is more than you expected, pack it up and ship it back within 30 days for a prompt and courteous refund including the $25 postage charge. You can't lose.

PERSONALLY USED

I have personally used the Visual Commuter. I have taken it with me on trips, set it up as a stand alone by plugging in my IBM monitor. I have run everything from Symphony™ to Wordstar®—from 1-2-3® to the Flight Simulator program. I strongly recommend the system.

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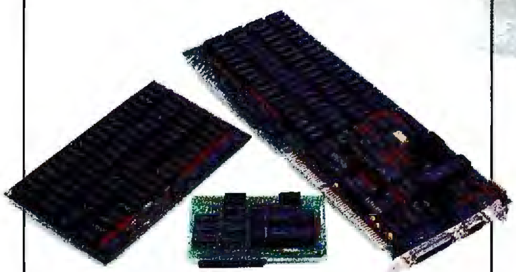

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REVIEW FEEDBACK 367

THIS MONTH'S FIRST REVIEW features the Data General/One. Initially announced on the November 1984 cover of BYTE, this computer has undergone some interesting changes and updates in the past 12 months. Its LCD screen was the focus of most of the first year's tinkering. Planned, but unavailable at the time of our product description, was the expansion chassis that lets you directly run 5¼-inch disks and add memory or other special-purpose cards. It also gives you the option of attaching a full-size, stationary CRT screen as part of an office "base system." Also changed was the system's basic memory configuration. It originally came with 128K bytes of RAM—now its standard memory is 256K bytes and that figure can go as high as 512K bytes. How well does it all work together? Reviewer Wayne Rash takes a close look at the Data General/One and comes to some interesting conclusions.

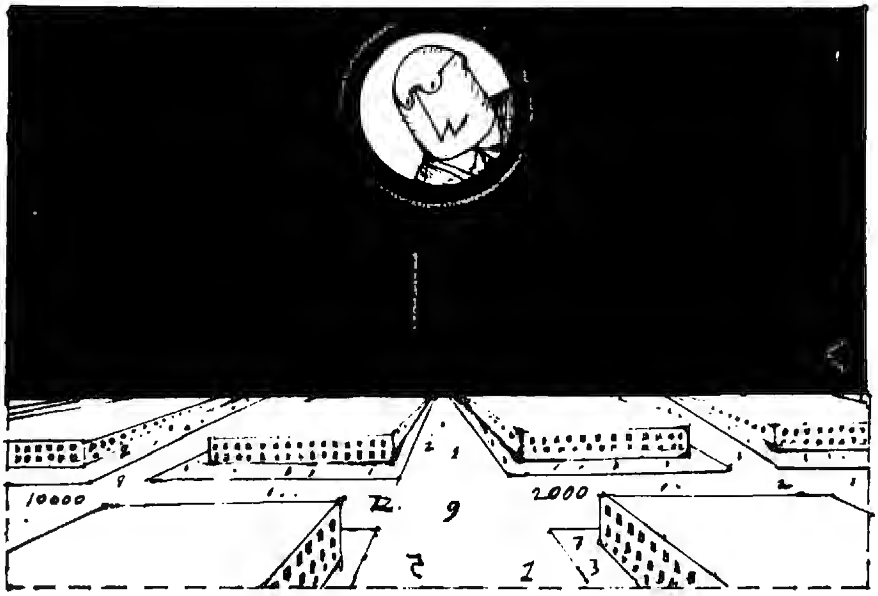
Next, Bruce Roberts looks at a versatile IBM PC work-alike, the Sanyo transportable MBC-775. Like the IBM Portable PC, the MBC-775 features two 360K-byte disk drives, 256K bytes of RAM, a color-graphics adapter, about the same number of expansion slots and peripheral connectors, and a detachable keyboard. Differences do exist, most noticeably in the Sanyo's color CRT (the IBM has a monochrome monitor) and its price, version of BASIC, design, and placement of physical components.

Our first software review of the month is an expansive look at five C compilers for the Apple Macintosh. Reviewer Tim Field concentrates on packages expressly designed for professional program-development applications, which narrows his choices to contenders from Manx Software Systems (Aztec C), Hippopotamus Software (Hippo-C), Consulair (Mac C), Megamax (Megamax C), and Softworks Ltd. (Softworks Macintosh C). Field tested each version of C eight different ways, relying for some tests on the BYTE benchmarks contained in the August 1983 issue on C. Which compiler you choose depends on how well the candidates score in the areas most important to you.

Magic/L from Loki Engineering is a descendant of FORTH and has recently been adapted for CP/M systems. Reviewers Michael Gilbert and Albert Woodhull report that the new language takes advantage of the fact that hardware constraints are much less confining now than when FORTH was newly introduced. What this means is that Magic/L can be more "wasteful" of memory to get around such idiosyncrasies of FORTH as the requirement for reverse Polish notation. Using forward notation makes a Magic/L definition look more like a program written in Pascal or C, and programmers who already know a conventional language could find Magic/L easier to learn than FORTH.

A fascinating product for designers and graphic artists is the IBM Professional Graphics System (controller card and display CRT). With this system you get 640- by 480-pixel graphic images in 256 colors, with a total palette of 4096 colors available. Reviewer and contributing editor Rik Jadrnicek applies his familiarity with computer-aided design to provide an in-depth look.

Finally, reviewer Wayne Rash puts in a second appearance looking at the Juki 6300 daisy-wheel printer. Rash comments that the Juki 6300 is a better clone of the Diablo 630 than the earlier Juki 6100; that product was merely plug-compatible, while the new unit uses the same ribbons and print wheels as the Diablo. Print quality is also high.



The Smartwriter laser printer from QMS Inc. of Mobile, Alabama, has much the same general profile as others built on the Canon engine. Outside dimensions and the configuration of such things as interface connections for most of these units fall pretty much in the same places from vendor to vendor in spite of minor cosmetic differences. You wind up being in danger of thinking they're more alike than they really are.

The Smartwriter seems very capable in the preliminary look we've taken. Aside from a black streak down the long axis of the printed page that may be the result of a defective cartridge, the print quality has been up to usual laser-printer standards. The font selection is as broad as or broader than any we've seen so far. However, a lot of the type styles are actually duplicates. What I mean is, if you want a particular font to print across both the 8½-inch dimension and the 11-inch dimension of a regular letter-size page, you need a copy of that font for each direction.

We ran into problems getting the Smartwriter to change fonts and orientation in its Epson-emulation mode. It would print a status message saying that the font we wanted was installed and ready for use but would obstinately refuse to produce print in any style but the factory-set default font. A call to the company informed us that the printer changes fonts with a lot less trouble if you use its ANSI X3.64-emulation mode for the changeover. I don't think this is the way the machine was designed to operate, since there's no mention of it in the manual. It can cause a lot of frustration until somebody sets you straight, but it's really more of an annoyance than a fatal flaw since it seems fixable with a bare minimum of information.

The documentation is otherwise good. You get lots of step-by-step instructions on which buttons to push and what you're supposed to be seeing in the status window at just about every turn. Additionally, the documentation was complete enough to give me the proper RS-232C pin assignments when I had to make a serial interface cable.

This printer and other representatives of the genre that we now have, or have on order, are going to bear close scrutiny in the months ahead.

Another relatively new arrival here is the Atari 520ST, and since a closer look (eventually a full review) is under development, I'm not going to anticipate the reviewer's comments to any significant degree. The almost total lack of applications software at this point is an obvious drawback, but we'll withhold judgment on that front until and unless Atari and the software developers start to show their wares. At the very least, however, putting almost completely naked hardware out in front of the public would seem to indicate that the company has a fairly high degree of faith in its users' curiosity and enthusiasm.

The GEM screen interface, graphics, and mouse are familiar elements to a fairly broad community by this time. The user interface seems to be through the mouse or the cursor-control keys. A good deal of thought seems to have gone into making the machine as fast as possible in responding to the user. You're not stuck in limbo while the machine grinds away, and you don't waste a great deal of time and energy in impatient fidgeting.

The keyboard has a full-feature design with cursor keys, numeric pad, and 10 function keys. Individual keys provide a greater-than-normal degree of resistance—requiring a harder-than-normal push for touch-typists. The external 3½-inch floppy-disk drive is quiet and, like the system itself, provides very fast response times. The 520ST lets you eject a disk at any point and has an ejection button on the front of the drive for that purpose. All in all, the 520ST has the look of a good machine. At the current low prices from both the manufacturer and the retailers, this computer could arouse significant interest at many levels.

—*Glenn Hartwig, Technical Editor, Reviews*

ILLUSTRATED BY MACIEK ALBRECHT

S·Y·S·T·E·M R·E·V·I·E·W

The Data General/One

A capable 11-pound portable

BY WAYNE RASH JR.

The Data General/One is both more and less than what I expected it to be. On the one hand, I expected it to be a capable clone of the IBM Personal Computer. On the other hand, I expected it to fit into a briefcase, operate on batteries, and function in nearly any environment. When considered on its own terms, the DG/One is an excellent machine, but it is not and cannot be all things to all users.

The single greatest point of contention regarding the DG/One is the LCD (liquid-crystal display) screen that Data General chose for the machine (see photo 2). While some people will complain simply because it is not a CRT (cathode-ray tube) unit, the screen *is* often difficult, and occasionally impossible, to use. On the other hand, the screen has been improved several times now. If you take its limitations into account, you might come to think that it performs adequately.

Despite this computer's vast physical differences from the IBM PC, it's very compatible with it. There are areas where compatibility is out of the question, of course. You will never get IBM PC expansion boards to work inside a machine like this, simply because there isn't room. Likewise, the 3½-inch disk drives will not take a disk from an IBM PC. However, both of these capabilities are available with the DG/One's optional expansion chassis discussed later.

Software compatibility is nearly complete, at least for business programs. If you want to run 5¼-inch disks, you will need the optional external 5¼-inch disk drive. I had some problems running Ashton-Tate's Framework due to incompatibilities between keyboards. Microsoft's Flight Simulator seems to run, but the screen display is rather strange. The benchmarks show the DG/One to run a little more slowly than the IBM PC, but the differences are not very noticeable, except in the spreadsheet benchmarks (see the "At a Glance" pages). Loading the test file using the DG/One version of Multiplan took three times as long as the same operation on the IBM PC.

HARDWARE

The computer measures 13½ by 11½ by 3 inches and should fit into a 4-inch thick briefcase with a little room to spare. The screen is built into the keyboard cover and will hold up to 80 columns by 24 lines of text.

You open the cover by pressing two latches at the front of the computer. When open, the cover reveals the keyboard, space for a function-key template, and the power switch. The screen itself is a frosty gray plastic that yields slightly to the touch. Even a light touch results in ripples of rainbow iridescence that follow your finger as it moves.

Although offered originally with a minimum of 128K bytes of RAM (random-access read/write memory), the DG/One now comes with 256K bytes of RAM as standard, expandable to 512K bytes.

The standard disk drives are double-sided quad-density 3½-inch units. Each one of these drives holds about 720K bytes of data, twice that of an IBM PC disk. Both drives are mounted on the right side of the machine.

You can get a DG/One with one or two drives. You can also add a third drive externally or in the expansion box. This external drive is a 5¼-inch unit, so you can transfer information to or from other computers. You should buy the dual-drive DG/One if at all possible. Backing up data on a single-drive system is inconvenient, especially when the drive holds 720K bytes. As of this writing, a hard disk is not available for the DG/One.

The rear of the machine has a cover that is hinged on the bottom of the computer and swings down to allow access to a pair of RS-232C serial ports, a modem connector, a pair of power connectors, and the connector for the expansion chassis. When the rear cover is opened, it locks into position

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to form a stand for the rear of the machine. This props up the computer in a correct typing position.

THE KEYBOARD

Frequently some compromises are made with portable computer keyboards, and the DG/One is no exception. In this case the keyboard is slightly smaller than that normally found on a desktop computer. The numeric keypad is superimposed on the keyboard itself, so some of the keys can have three functions. The keys are in their traditional locations, so touch-typists should be able to adjust. The smaller size takes some getting used to, however.

All of the special function keys from the IBM PC are present, although they appear along the top of the keyboard. Two keys not on the IBM keyboard are the Cmd key and the unlabeled key below it. Some programs, including Ashton-Tate's Framework, make use of these keys. In addition, pressing the Cmd key with the PgUp or PgDn keys adjusts the contrast of the screen.

Since the function keys are located at the top of the keyboard, the templates that accompany some IBM PC software will not work with the Data General machine. Someone anticipated this possibility, however, and special templates are available with software sold specifically for the DG/One. The templates are also designed so that you can pencil in your own information.

THE SCREEN

The LCD screen that allows the DG/One's great portability has also been its feature most complained about. Early models of this screen were difficult to use under the best of conditions. In less than the best of conditions, they were unusable. The screen has undergone several upgrades and now is vastly improved.

You can tilt the newer screen to achieve a comfortable viewing angle and to minimize reflections. A new matte surface also reduces reflections considerably. The proper lighting is still important, however, and you may find circumstances where viewing is difficult. I found that a light suspended directly above the computer produced excellent results.

In normal use, the text on the screen appears as dark letters on a gray background, the opposite of usual displays. Generally, this makes no difference, but with some programs the results can be odd. Microsoft's Flight Simulator, for example, does not look good reversed.

Data General took the trouble to preserve the aspect ratio of the IBM PC's screen, so your programs will appear as you expect them to. You don't have to worry about egg-shaped pie charts when you run Lotus 1-2-3, for example.

(continued)

Photo 1: *The Data General/One portable computer.*

Early computers with LCD screens were plagued with slow response times. Often, the screen would lag behind the keyboard by a few characters. I did not notice this on the DG/One. The programs I tried seemed to work at normal speed.

USING THE DG/ONE

Once you get used to the placement of the keys and the disk drives, the DG/One operates like any other floppy-disk-based IBM PC-compatible. To start the system, you place a disk containing the operating system into the front disk drive and turn on the machine. Inserting the disk locks the drive closed automatically.

You have to wait for a few seconds while the machine runs the diagnostic routines in ROM (read-only memory), and then the operating system boots from the disk. If you don't have a disk in the drive, the machine runs programs stored in ROM, including a communications package, a text editor, setup routines, and the diagnostics I mentioned earlier. You can use the text editor to create messages for the communications package. (Unfortunately, the ROM communications cannot send or receive disk files, so its communications capability is little more advanced than that of a simple dumb terminal program.)

Once the machine starts running the operating system, you're using a standard IBM PC-compatible computer running MS-DOS 2.11. You will probably notice the increased disk space when you look at your directory. The 720K-byte disks are a real benefit to the floppy-disk user. In some cases, programs that you might have had to run on a hard disk will run on floppy disks on the DG/One.

The 3½-inch disks are a real convenience, especially while traveling. You can put them into your shirt pocket, toss them into your briefcase, or stack a bunch of them up and then put a big rubber band around them (try doing that with 5¼-inch floppy disks).

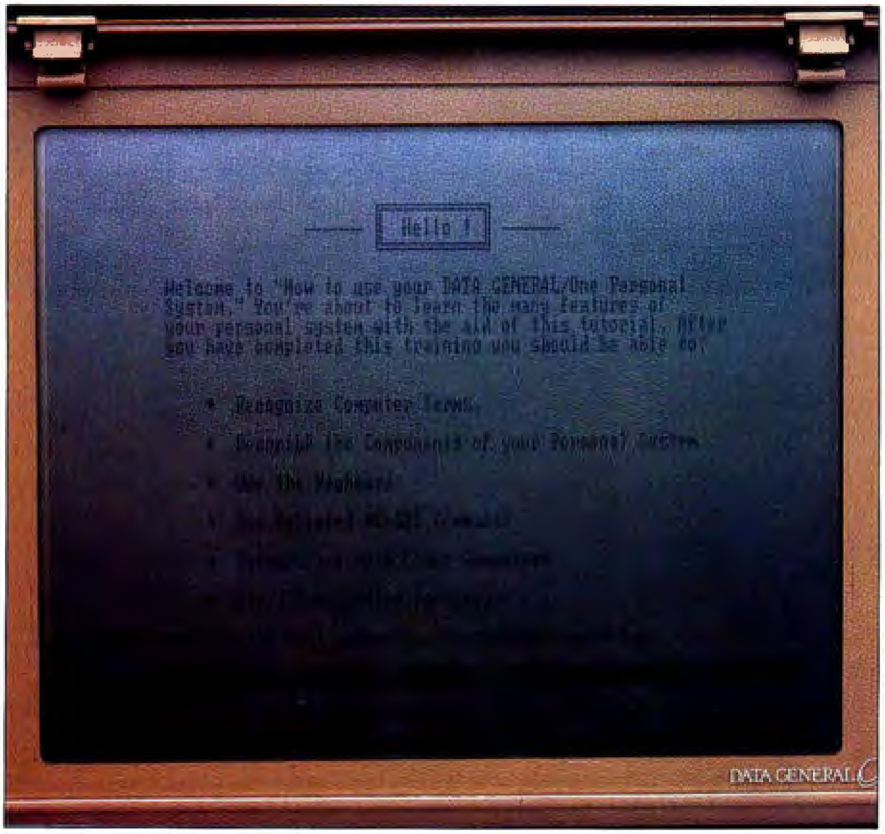


Photo 2: *In spite of improvements, the Data General/One's LCD screen can be difficult to read in some settings.*

EXPANDING THE DG/ONE

You have two options for expanding the DG/One. You can buy an external disk drive, or you can buy the expansion chassis (see photo 3), which also contains a disk drive. You cannot use both of these items at the same time. Of the two, the expansion chassis is the more useful. According to Data General, this chassis allows you to use circuit cards designed for the IBM PC. This would enable you to operate a color monitor, for example, or add memory or communications ports.

Inside the chassis, expansion cards are attached to a backplane with five slots (see photo 4). To the right is the disk drive; the power supply is behind that. One of the expansion slots is already taken by the disk-drive controller, leaving you four.

I found it difficult to insert IBM-compatible expansion cards into the slots. I had to bend the board's bottom locating tab to the rear with a pair of pliers to make the board go into the slot. The tiny screws that hold the boards in place are inadequate for the job. It is nearly impossible not to strip their threads when securing a board in place.

COMPATIBILITY

When a computer is as different from the IBM PC as the DG/One is and it's advertised as IBM PC-compatible, you tend to question the level of compatibility. The DG/One is highly compatible, but it is not completely compatible. Most programs that do not depend on special features of the IBM's keyboard or that work directly with the communications ports will run. IBM PC communications programs, such as PC-Talk, will not run on the DG/One. It appears that Data General has used a serial communications chip different from the one used by IBM and most of the makers of compatible computers. The implications of this for the traveler are significant. You can use WordStar to create

(continued)

AT A GLANCE

Name
Data General/One

Type
Portable computer

Manufacturer
Data General Corp.
4400 Computer Dr.
Westboro, MA 01580
(617) 366-8911

Size
13½ by 11½ by 3 inches;
11 pounds

Components
Processor: 80C88
Memory: 256K RAM standard; expandable to 512K
Mass storage: One or two 720K double-sided quad-density 3½-inch floppy-disk drives
Display: 80 by 24; graphics resolution of 320 by 200
Keyboard: Proprietary with numeric keypad superimposed

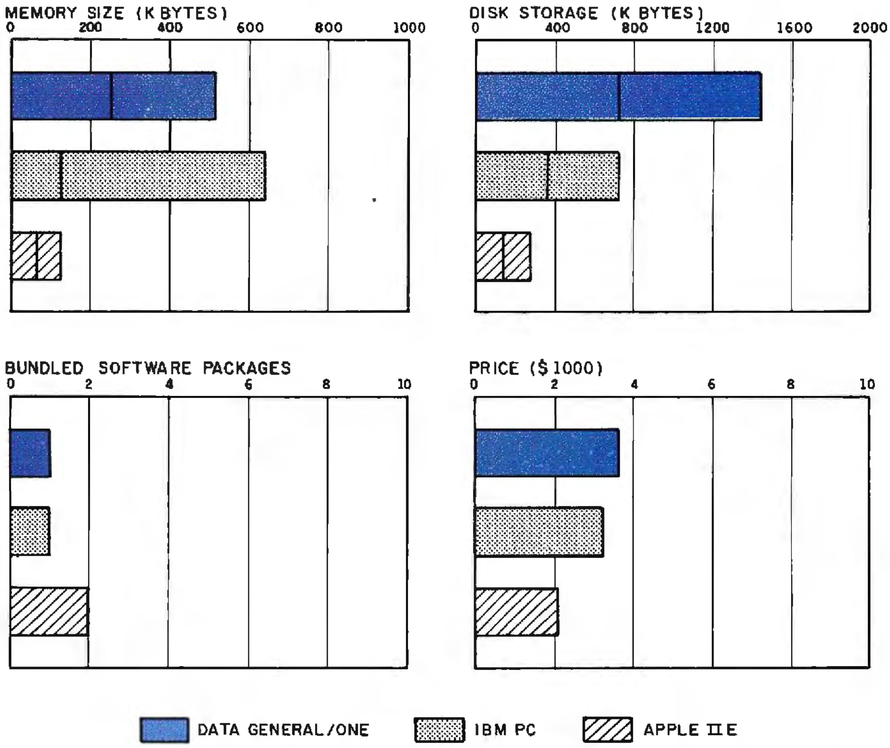
Communications
Two serial ports; built-in modem optional

Software
MS-DOS 2.11

Options
External 5¼-inch disk drive, expansion chassis with disk drive, built-in modem (300 or 1200 bps), battery, memory expansion, carrying case, thermal printer, GW-BASIC

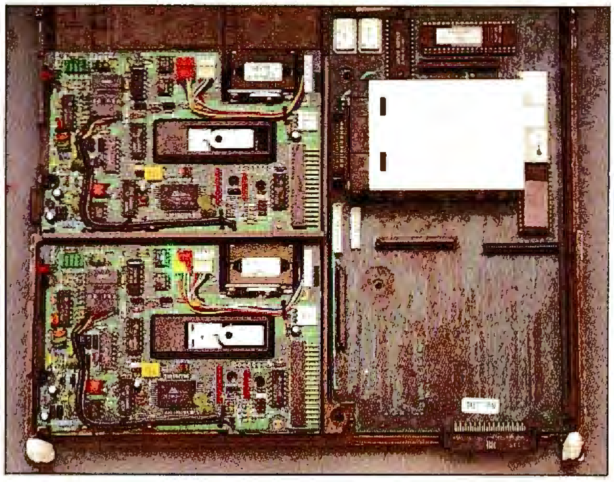
Documentation
Owner's manual, pocket reference guide

Price
$2995 (one drive)
$3495 (two drives)

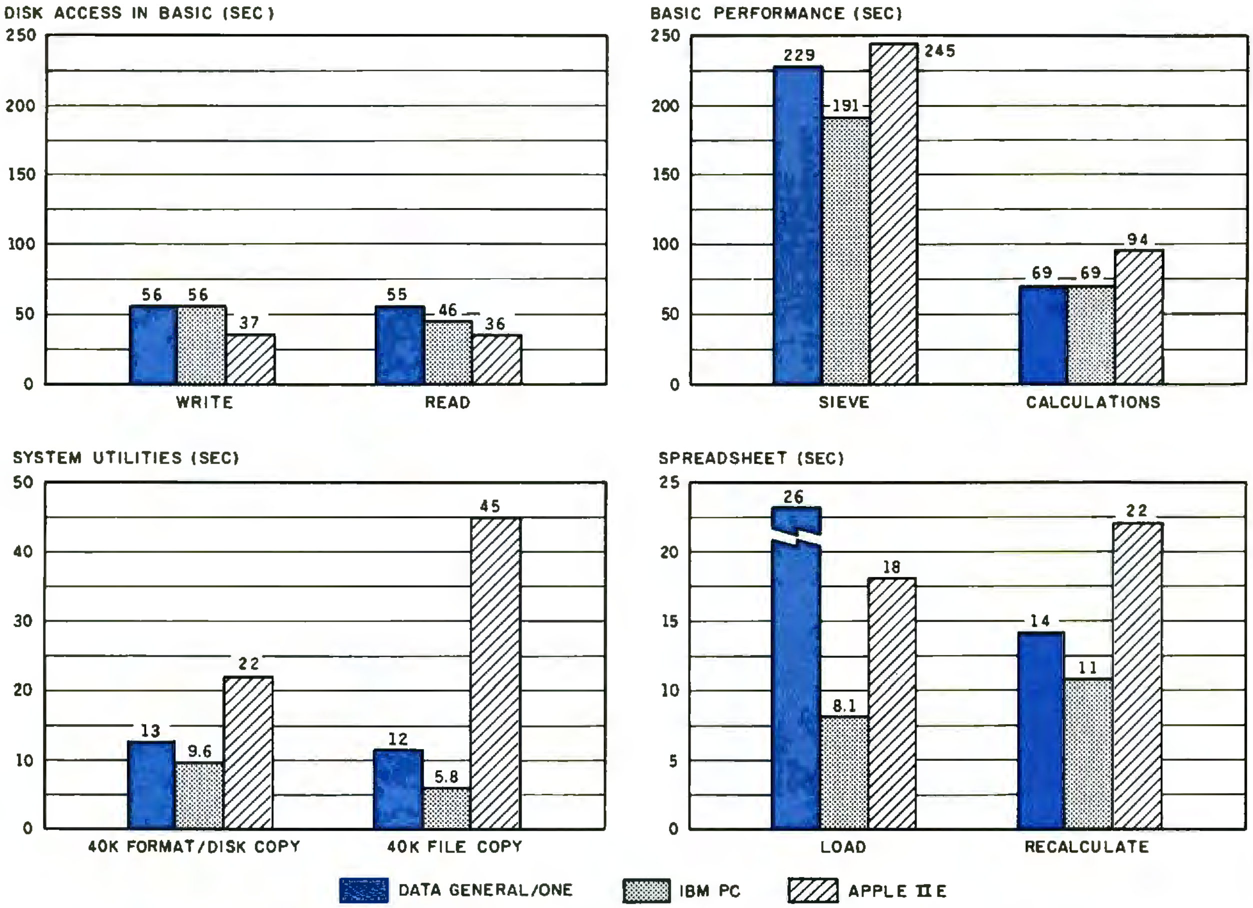


The Memory Size graph shows the standard and optional memory available for the three computers under comparison. The Disk Storage graph shows the highest capacity of one and two floppy-disk drives for each system. The Bundled Software Packages graph shows the number of software packages included with each system. The Price graph shows the list price of each system with two high-capacity floppy-disk drives, a monochrome monitor, a printer port and a serial port, 256K bytes of memory (64K bytes for 8-bit systems), and the standard operating system and BASIC interpreter for each system. Note that the Data General/One's printer and communications ports are both serial ports.

The rear of the DG/One contains the interface (right) for an optional 5¼-inch disk drive or expansion chassis.



Removing the DG/One's keyboard reveals its drives and controllers (left) and memory-expansion box (top right).



The graph for Disk Access in BASIC shows how long it takes to write and to read a 64K-byte sequential text file to a blank floppy disk. (For the program listings, see the June 1984 issue of BYTE, page 327, and the October 1984 issue, page 33.) In the BASIC Performance graph, the Sieve results show how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. In the same graph, the Calculations column shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. The System Utilities graph shows how long it takes to format and copy a disk (adjusted for 40K bytes of disk data) and to transfer a 40K-byte file using the system utilities. The Spreadsheet graph shows how long the computers take to load and recalculate a 25- by 25-cell Microsoft Multiplan spreadsheet where each cell equals 1.001 times the cell to its left. The tests for the Data General/One used MS-DOS 2.11 and GW-BASIC on 3½-inch 720K-byte floppy-disk drives. The tests for the Apple IIe were done with ProDOS. The IBM Personal Computer was tested with PC-DOS 2.0 and BASICA.

files while you travel, but you will have no way to send them to your office unless you buy a disk-based communications package specifically for the DG/One.

This could also affect word processors or other programs if they access directly the serial ports. There is no parallel port on the DG/One, although I presume that you could add one to the expansion chassis.

Data General also made many compromises with the DG/One's keyboard. As a result, some programs that work directly with the PC keyboard will not operate properly on the DG/One. An example of this is the IBM PC version of Framework. If you want Framework to operate properly, you have to buy the Data General version from the company. I tried out this version of Framework and it performed as well as the IBM PC version.

Most other programs that I tried seemed to work properly, although you need to keep in mind problems with copy protection. The 5¼-inch expansion chassis and the external drive are not portable. Copy-protected software will have to remain at home while you travel, unless you buy it on 3½-inch disks. Since there is not a great deal of software available in this format yet, your choices can be quite narrow. Fortunately, some popular programs, such as MicroPro's WordStar, have avoided the scourge of copy protection.

Other than the problems I've mentioned, most business-oriented programs should run properly. The machine supports the same graphics as does the IBM. In addition, Microsoft's GW-BASIC is available for the DG/One. This should allow nearly any program written in BASIC for the IBM to run correctly.

SOFTWARE

At first glance, the DG/One's operating-system software looks like other IBM PC-compatible operating systems. It does have differences, however. For the most part, the differences reflect requirements of the machine that differ from those of the

(continued)

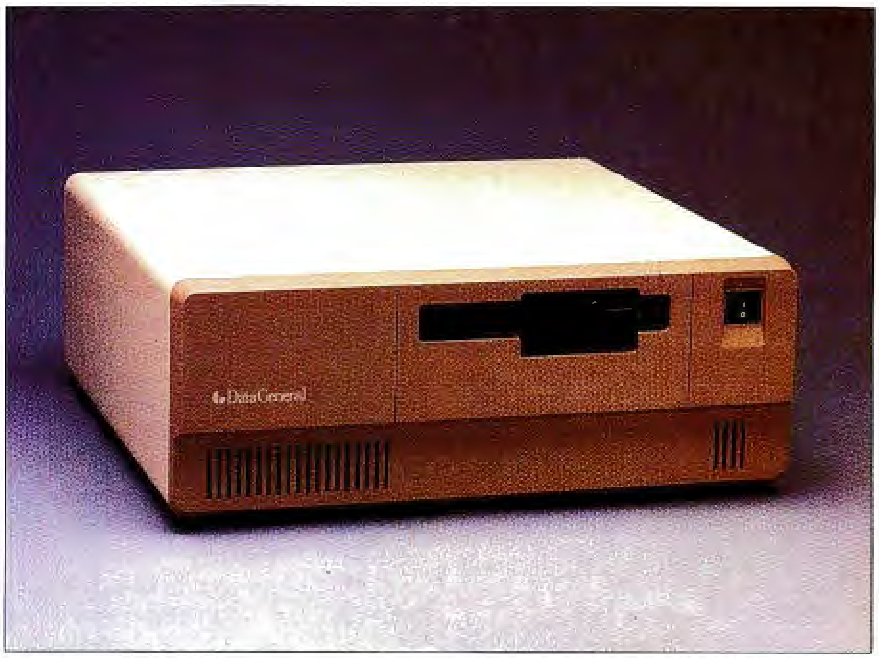


Photo 3: *The Data General/One's optional expansion chassis, which includes a 5¼-inch floppy-disk drive.*

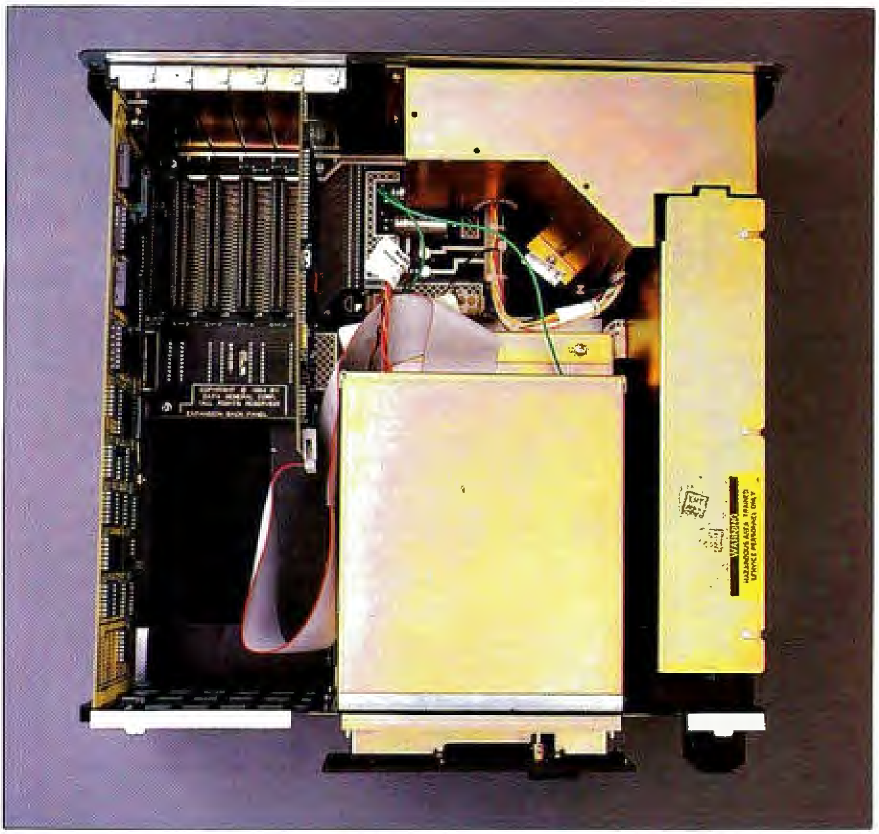


Photo 4: *The expansion chassis has five slots, one of which is taken by the disk-drive controller.*

IBM PC. The format command, for example, has provision for both 80-track and 40-track disks, but no provision for formatting a hard disk.

The system software also includes a RAM disk. This lets you assign a portion of memory as a virtual disk drive, which is especially useful if you have only one floppy-disk drive. You can accept the standard 180K-byte size of the disk, or you can specify some other size, depending on your needs and available memory. The virtual disk is loaded when the system boots. Since the memory has no battery backup, you need to make sure that you copy the contents of the virtual disk back to a real disk before you shut off the machine.

ACCESSORIES

Data General has a few items you can get with your DG/One that might make the machine more useful. You can get it without these options, but in some cases you'd be making a mistake. The rechargeable battery is the most obvious of these items. This computer will operate for as long as eight hours on battery power.

The built-in modem could be almost as necessary had Data General made the communications ports IBM-compatible. As it is, the modem works well, and you now have a choice of 300 or 1200 bits per second internally. The modem is Hayes-compatible. If you want, you also can connect an external modem to one of the serial ports on the DG/One's back panel.

You can get a set of acoustic connectors for the modem. These connectors theoretically enable you to use communications in places where there are no modular connectors, such as in a hotel room. Unfortunately, I could not get the cups to work, despite repeated attempts and calls to Data General.

You can use any serial printer with the DG/One. Of course, the size of most serial printers would seriously impair portability. For people who must print while traveling, Data General makes a thermal printer that is 12¼ by 4¼ by 3 inches—smaller than a box of tissues.

TRAVELING WITH THE DG/ONE

As a traveler's computer, the DG/One succeeds pretty well. It is small enough to carry on an airliner. I confirmed this by using a luggage gauge provided by Trans World Airlines, which showed it to be well within size limits. You may also be able to use it on the airplane, depending on which airline you choose.

You can put all of your accessories, some disks, and the manual in the DG/One's carrying case. This appears to be a sturdy case that will fit on nearly any conveyance. It should even fit under the window seats of a Boeing 727, usually a tight fit for luggage. There are two zipper compartments in the case. One compartment is fitted for the DG/One and the manual; the other holds the printer, some disks, the modem cups, and the power supplies. The case costs more than $100, which is a little steep for cloth luggage; however, unless you have something better, you might as well get it if you plan much travel.

The ability to operate on battery power for several hours makes the DG/One a much more useful machine than many of its competitors. You do not have to search around for an electrical outlet. You can run the software that you are used to using instead of unfamiliar versions with reduced capabilities.

RELIABILITY AND SERVICE

At first, the DG/One worked well for me. Unfortunately, it stopped operating during the final days of this review. As I write this, I still don't know the reason for the failure, and it may not be an indication of the reliability of the DG/One.

The service policies of the company,

(continued)

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NOW! FULL FEATURE, 20 CPS, LETTER QUALITY AT ONLY $374

If you have been searching for a letter quality printer you probably found the flood of claims and counterclaims were a real roadblock in your search. Not long ago, we were in the same position. We tried to determine which daisy wheel printer had all the features anyone could want, but would also appeal to the cost conscious buyer. Recently several manufacturers introduced printers that had features we were seeking. After a thorough assessment we eliminated all but one which precisely met our qualifications.

THE RESULTS ARE IN

We found the printer which has all the features anyone could want. We've named it the Aprotek Daisy 1120, a real heavy-duty workhorse printing at 20 characters per second. The manufacturer is Olympic Co. Ltd., a highly respected Japanese firm.

FEATURES GALORE

This printer has it all. To start with, it has a front control panel with indicators for Pitch Selection which allows for 10, 12, or 15 characters per inch (CPI) or Proportional Spacing. There is a Select (Online) button (with indicator) and a Line Feed button. You can also set Top-of-Form or Form Feed with the touch of the TOF button. Other front panel indicators include Power and Alarm.

To load a sheet of paper, simply place it in the feed slot and pull the paper bail lever. The paper feeds automatically to a 1 inch top margin and the carriage aligns to the selected left margin. In this manner, each page can have identical margins.

You can continue to use your computer while the Daisy 1120 is printing. The built in 2K buffer allows a page or two of concurrent printing and use of your computer for the next job. To really take advantage of your printer's optional features, the automatic Cut Sheet Feeder eliminates tiresome paper handling. Also available is the adjustable Tractor Feed option. *Compare our option prices!*

Best of all the Daisy 1120 is quiet: only 58 dB-A (compare with an average of 62-65 dB-A for others).

COMPLETE COMPATIBILITY

The Daisy 1120 uses Diablo® compatible printwheels. You can pop in a 10, 12, 15 pitch or proportional printwheel and use paper as wide as 14". At 15 CPI you can print 165 columns—a must for spreadsheet programs.

The Daisy 1120 uses the Diablo Hytype II® standard ribbon cartridges. Again universally available.

Not only is the hardware completely compatible, the control codes recognized by the Daisy 1120 are Diablo 630® compatible (industry standard). You can take advantage of all the great features of word processing packages and automatically use superscripts, subscripts, automatic underlining, bold-face (shadow printing) and doublestrike.

The printer has a set of rear switches which allow the use of standard ASCII as well as foreign character printwheels. Page length can be set to 8, 11, 12, or 15". The Daisy 1120 can also be switched to add automatic line feed if required.

THE BEST PART

When pricing a daisy wheel printer with all these features (if you could find one), you would expect to pay $600 or $700 dollars. The options would add much more, but our exhaustive research has paid off for you the computer user. We can now offer this printer for only $374. Order yours today!

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Try the Daisy 1120 for 2 weeks. If you are not satisfied for ANY reason we will refund the full price—promptly. A full 1-year parts and labor warranty is included. Another indication of quality and reliability.

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Trademarks: Diablo, Hytype II, 630-Xerox Corp; Apple II, II+, IIe-Apple Computer, Inc.; IBM PC-IBM Corp.

APROTEK
1071-A Avenida Acaso, Camarillo, CA 93010

If your machine fails, you have to send it back to Data General.

however, do affect the owner of a DG/One, and they are disturbing. In short, if your machine fails, you have to send it back to Data General. As far as I was able to tell, there is no provision for local service. One Data General representative told me that if you needed your computer quickly, you could simply trade for another one; however, you still have to ship the faulty one back to DG in Massachusetts.

This means that if your computer breaks, you're probably going to be out of business for a while. Even if you get one-day turnaround from the factory and you use a 24-hour courier service to carry it both ways, you're going to be down for three days. If the computer happens to break at the end of the week or on the weekend, you can count on being without one for five days. In either case, you can expect to be out more than $100 for shipping.

I should mention that the technicians who answered the phones at Data General tried to be helpful. They were certainly friendly, and they were concerned about the time I'd be without a machine. In spite of this, the only option for repair of a DG/One—until regional repair centers are established—seems to be sending it back to Data General.

Documentation

The documentation is fairly limited, but what there is appears to be well done. Every DG/One comes with an owner's manual and a quick-reference guide. Both of these items are designed to fit into the carrying case with the computer.

The owner's manual, well written and well illustrated, describes completely the operation of the computer. There are brief descriptions of the MS-DOS utilities, but little if any description of the internal workings of the computer. According to Data General, a complete guide to the operating system and an operating-system reference manual are available at extra cost. Also available at extra cost is a programmer's manual. None of these optional manuals were available for review.

Most users will find that the manual is sufficient, especially if they already have the MS-DOS reference books. I suspect that Data General felt that it would be pointless to ship a portable computer with enough documentation to reduce its portability. I still think that a more complete reference manual should be standard issue.

Conclusion

I really wanted to like the DG/One, but I found myself being slightly disappointed with it. The screen is a lot better than it was when it was introduced, and in some cases it's adequate, but it's still hard to read much of the time.

IBM PC compatibility just misses the mark, too. I realize that many compromises must be made in this sort of machine. These compromises reduce the level of compatibility. Whether or not the compromises made with the Data General/One are worth their cost depends very much on what you plan to do with the machine. The one compromise where the cost seems excessive is the change in the serial chip. This means that IBM PC communications software will not work with the DG/One. Since communications is an important function, especially the ability to send and receive disk files, you'll have to buy a package specifically for the DG/One.

Finally, there's the cost. Configured like the unit I reviewed, the computer costs almost $3700. That's a lot of money for a computer with only two floppy-disk drives.

In spite of its problems, the DG/One is a useful tool. Competitors on the horizon promise to be cheaper and better, but right now, this is the best choice I have seen for IBM compatibility in a laptop package. ■

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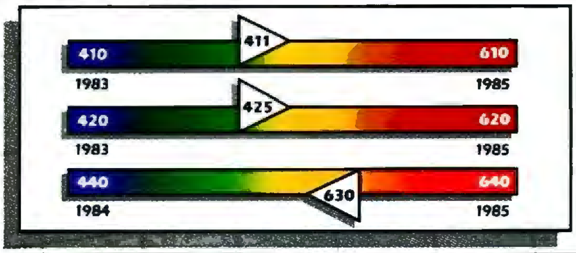

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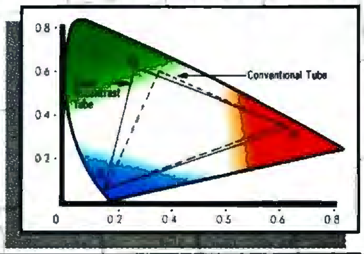

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100% compatible with IBM PC, XT, and AT® when used with the Taxan 555 board. $645.00 Suggested Retail

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Text Mode	16 Colors	16 Colors
320 X 200	4 Colors	4 Colors
640 X 200	1 Color	1 Color
Alphanumeric Text Resolution		
Character Sell	8 X 8	10 X 16
Scan Frequency	15.75 Khz	24.75 Khz

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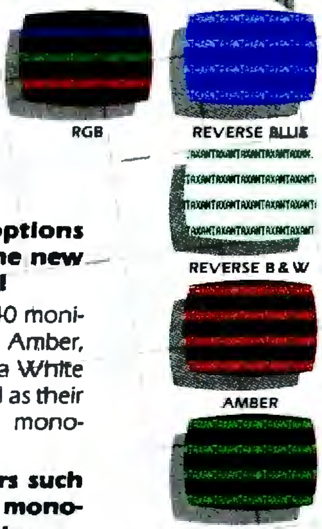

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Sanyo MBC-775

A portable IBM PC-compatible with built-in color monitor

BY BRUCE ROBERTS

Sanyo has probably carved out a larger piece of the American microcomputer pie than any other Japanese manufacturer. With the introduction of the Sanyo MBC-775 portable color computer (see photo 1), the company is tipping its hand as to the future direction of its computer products—full IBM PC compatibility, speed, low cost, bundled software, and color displays.

The MBC-775 is Sanyo's first transportable computer and appears quite compatible with the IBM PC. The portability of this system might be an issue, since it weighs close to 40 pounds.

Only one configuration is offered as compared to the many versions of Sanyo's MBC-550/555. The MBC-775 hardware includes two 360K-byte disk drives, 256K bytes of RAM (random-access read/write memory), a built-in 9-inch color monitor, and a detached keyboard (see photo 2). The system unit contains two IBM expansion slots and a parallel printer port.

The package price of $2599 includes MS-DOS 2.11, GW-BASIC 2.02, EasyWriter II, EasyMailer II, EasyPlanner, and EasyFiler.

DISPLAY

The first striking difference between the Sanyo MBC-775 and other IBM PC-compatibles is the built-in color screen. You might think of this Sanyo as an IBM Portable PC with a color screen rather than the familiar monochrome display. They are similar except for the Sanyo's color display, faster processor, and lower price. Both have a color graphics adapter, 256K bytes of RAM, two half-height 360K-byte disk drives, and about the same number of expansion slots and peripheral connectors.

I like the positioning of the MBC-775's screen better, since it is centered above the keyboard instead of positioned on the extreme left of the computer. The 9-inch screen is quite legible, but remember that color displays usually aren't as crisp as monochrome displays and most software does not make outstanding use of color displays.

I wouldn't recommend this color screen for full-time word processing because the characters are noticeably fuzzy and the screen is small. Although the Apple Macintosh has the same size screen, its higher resolution prevents eyestrain so you aren't distracted by the screen's size.

The Sanyo MBC-775 also suffers from a common portable computer ailment. If you set the unit on a desktop, the screen is much lower than your eyes so you tend to hunch over the keyboard and look down. You must reposition the computer to comfortably read the screen.

GRAPHICS CAPABILITY

Don't expect to have all 16 colors available at any time. Only the text modes let you display 16 colors. With medium-resolution graphics you get 200 rows of 320 pixels each in 4 possible colors. But those 4 colors include 1 that can be any of the 16 colors, plus either of two 3-color palettes, cyan/magenta/white or green/red/brown. This is why IBM's and Sanyo's BASIC demonstration programs tend to display these colors (see photo 3).

The 640- by 200-pixel high-resolution graphics mode is available only in black and white. Don't thank Sanyo; IBM is responsible for this design.

Sanyo says it has a 32K-byte video RAM, twice the 16K-byte memory of the IBM Color Graphics Adapter, but instructions on how to use it or the 6845 CRT (cathode-ray tube) controller chip were not included.

At the rear of the machine are three doors that pop open or close when you push on them. A DB-9 connector for an external RGB (red-green-blue) monitor and an RCA jack for a composite video monitor are provided behind the middle door, along with the horizontal- and vertical-hold controls.

Behind the right door (viewed from the rear) is the power-cord socket and the fuse. The power cord can be folded up into the

Bruce Roberts is a computer consultant who was formerly a technical editor for BYTE magazine. He can be reached at 84 Redfern Dr., Rochester, NY 14620.

recess behind that door. The other standard external connector (behind the left door) is the DB-25 connector for the parallel printer port. This is also where you find the connectors for the expansion boards.

You adjust the screen brightness with a slide control on the front of the machine. The power switch is conveniently located on the front panel and it's designed so you can't accidentally bump it.

The MBC-775 has retained IBM PC similarity to the point where the display flickers when you scroll, a common complaint due to the design of the IBM PC's color-display adapter. The glare from the screen can be overwhelming since the screen is not etched or treated to reduce reflections (I found myself darkening the room to read the screen easily).

The color-graphics capability of the MBC-775 is not immediately evident. When you first boot up the system there is no indication that the screen can display anything other than white characters on a black background.

The one BASIC demonstration program on the system disk only hints at the system's color capabilities and does not provide an introduction to the machine. It displays the Sanyo logo and the computer's name on a colored background then gives a few simple examples of characters, boxes, and line drawings in random colors. And Sanyo's minimal documentation contains no references to the demonstration program.

KEYBOARD

The keyboard layout mimics that of the IBM PC except for a few enhancements. All 10 function keys are there and the shift keys are still farther out to the sides than most touch-typists would like. The enhancements include LEDs (light-emitting diodes) in the Num Lock and Caps Lock keys. You will also find a second return key on the cursor/numeric keypad to make numeric data entry easier.

The keyboard is acceptable although the keys don't have high tactile resistance. The speaker produces an audible click each time you press a key. No option exists to turn off the sound.

Since the detached keyboard plugs into the front of the computer, you can use the entire length of the cord and not have to unplug it when you pack up the computer for travel. The legs that prop up the back of the keyboard also latch the keyboard closed against the computer (this mechanism doesn't feel sturdy).

PROCESSOR

The Sanyo MBC-775 uses an 8-MHz 8088-2 processor chip that runs at nearly twice the speed of the IBM PC's 4.77-MHz 8088 chip. Many of the newer IBM PC-compatible systems use this faster chip and allow you the option of the standard 4.77-MHz rate for more compatibility.

In the processor-intensive benchmarks such as the Sieve of Eratosthenes prime-number generator, the numeric calculations,

(continued)

Photo 1: *The Sanyo* MBC-775 *with built-in color monitor, keyboard, and two floppy-disk drives.*

and the spreadsheet recalculation, the Sanyo's speed advantage is clearly demonstrated. The MBC-775 runs almost twice as fast as the IBM PC on most of the benchmarks in the "At a Glance" section.

The system boots up quickly because it has no memory test. At least none is apparent on the screen or mentioned in the documentation.

The Sanyo MBC-775 uses a separate processor board that is plugged into a small motherboard. The processor board contains 256K bytes of RAM, the 8K-byte ROM (read-only memory), and the parallel port circuitry (the video and disk-drive controllers are on the motherboard).

The 8-MHz 8088-2 processor requires faster memory than the IBM PC, so if you upgrade the memory from the standard 256K bytes to the 640K bytes possible under MS-DOS, remember that Sanyo recommends 120-nanosecond chips in your add-on memory boards. RAM does not use a parity bit as the IBM PC does, so fewer memory chips are needed (eight instead of nine for 64K bytes). Note that you add all extra memory with third-party multifunction boards.

For faster number processing (if your software recognizes the presence of an 8087), you can add the 8087-2 numeric processing chip, which also runs at 8 MHz.

Photo 2: *The keyboard of the Sanyo* MBC-775. *Note the LEDs in the Caps Lock and Num Lock keys and the second return key below and to the right of the numeric keypad.*

Photo 3: *Sanyo* MBC-775 *color display of a world map using magenta and white on a black background.*

Expansion

You can open the top of the MBC-775 to get to the card cage by removing two screws inside the doors on the back. The top then hinges forward and lifts off. Loosen the eight screws on the metal card-cage cover and it will slide off. The speaker mounted in the cover will still be attached to the processor board and can be unplugged (the disk-drive assembly can also be easily removed at this point).

There are three slots on the motherboard but the processor board occupies one, so only two are left for expansion. These are full-length expansion slots, so you should be able to add just about any board you want.

Probably one of the first things you'll want to add to this system is a multifunction board with more memory and a serial port. The machine has a space on the processor board below the parallel port that looks like it should have had a serial connector, but none is provided.

The Centronics-type parallel port is configured just like that of the IBM PC, so you can use IBM-compatible cables.

The Sanyo has one annoying quirk: If you don't turn the parallel printer on before turning on the computer, the computer won't recognize the printer.

Disk Drives

I took some time getting used to the floppy-disk drives in the MBC-775 as they are recessed into the faceplate of the computer and have a squeeze-type latch for opening and closing the drive. You have to push your floppy disks into the bottom of the recess and squeeze the latch closed over

(continued)

AT A GLANCE

Name
Sanyo MBC-775

Manufacturer
Sanyo Business Systems Corp.
Computer Division
51 Joseph St.
Moonachie, NJ 07074
(201) 440-9300

Size
System unit: 20½ by 16¼ by 8½ inches
Keyboard: 19½ by 7¼ by 1¾ inches
Weight: 39 pounds and 13½ ounces

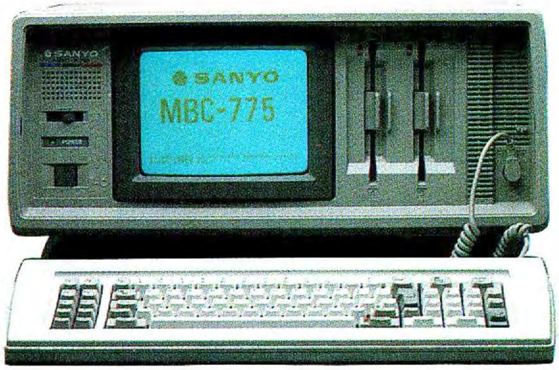
Components
Processor: 16-/8-bit 8088 at 8 MHz
Memory: 256K bytes expandable to 640K bytes
Display: 9-inch color monitor, 80 columns by 25 rows; 4-color 320- by 200-pixel medium-resolution graphics; 640- by 200-pixel high-resolution graphics in black and white only
Keyboard: Detached 84-key, IBM-style QWERTY with 10 function keys and numeric/cursor keypad; LED indicators in Caps Lock and Num Lock
Mass Storage: Two 360K-byte 5¼-inch floppy disks
Expansion: Two IBM PC-compatible slots
I/O interfaces: Parallel printer port, composite video, and RGB

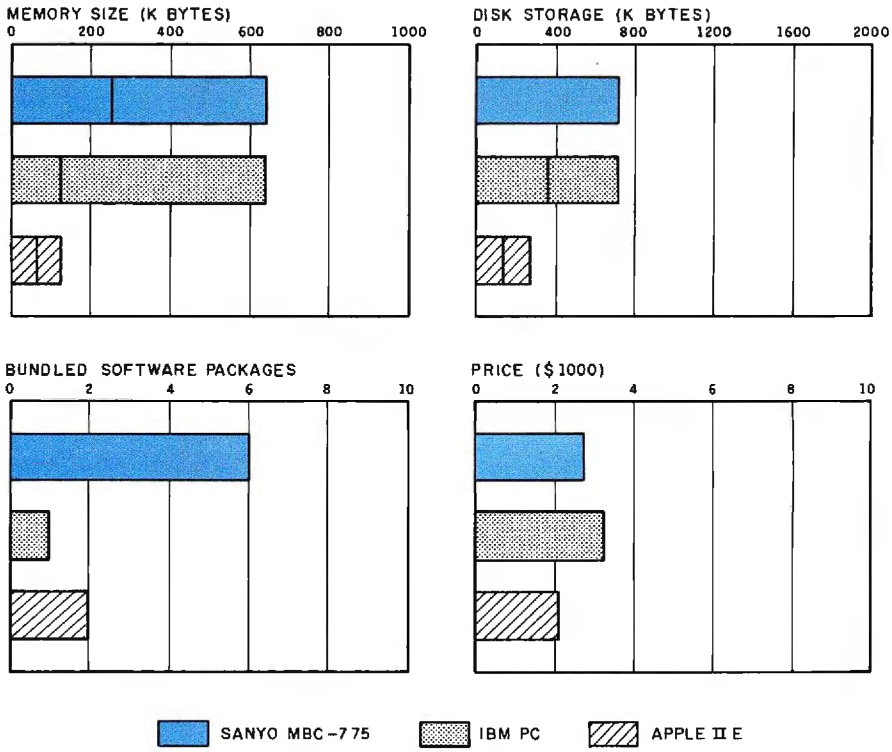
Software
MS-DOS 2.11, GW-BASIC 2.02, EasyWriter II, EasyMailer II, EasyFiler, EasyPlanner

Options
8087-2 (8-MHz) math coprocessor

Documentation
209-page operator's guide, 262-page EasyWriter/EasyMailer manual, 432-page EasyFiler manual, 223-page EasyPlanner manual

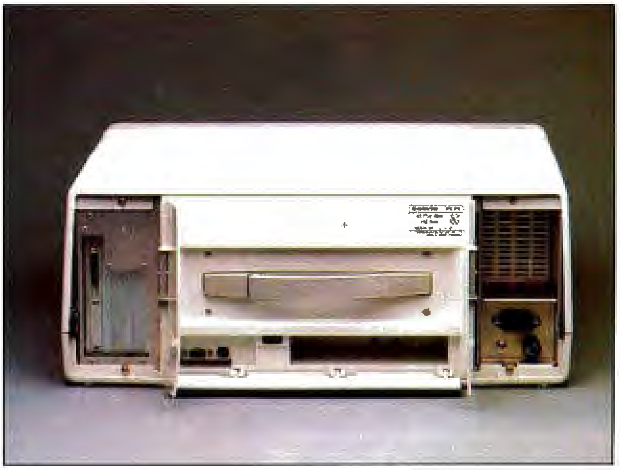
Price
$2599



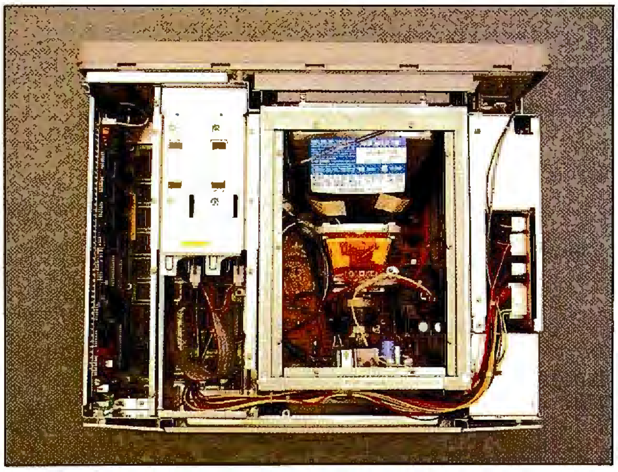


The Memory Size graph shows the standard and optional memory available for the three computers under comparison. The Disk Storage graph shows the capacity of the MBC-775 in comparison with each of the other computers. Note that the MBC-775 does not have a single-disk option. The Bundled Software Packages graph shows the number of software packages included with each system.

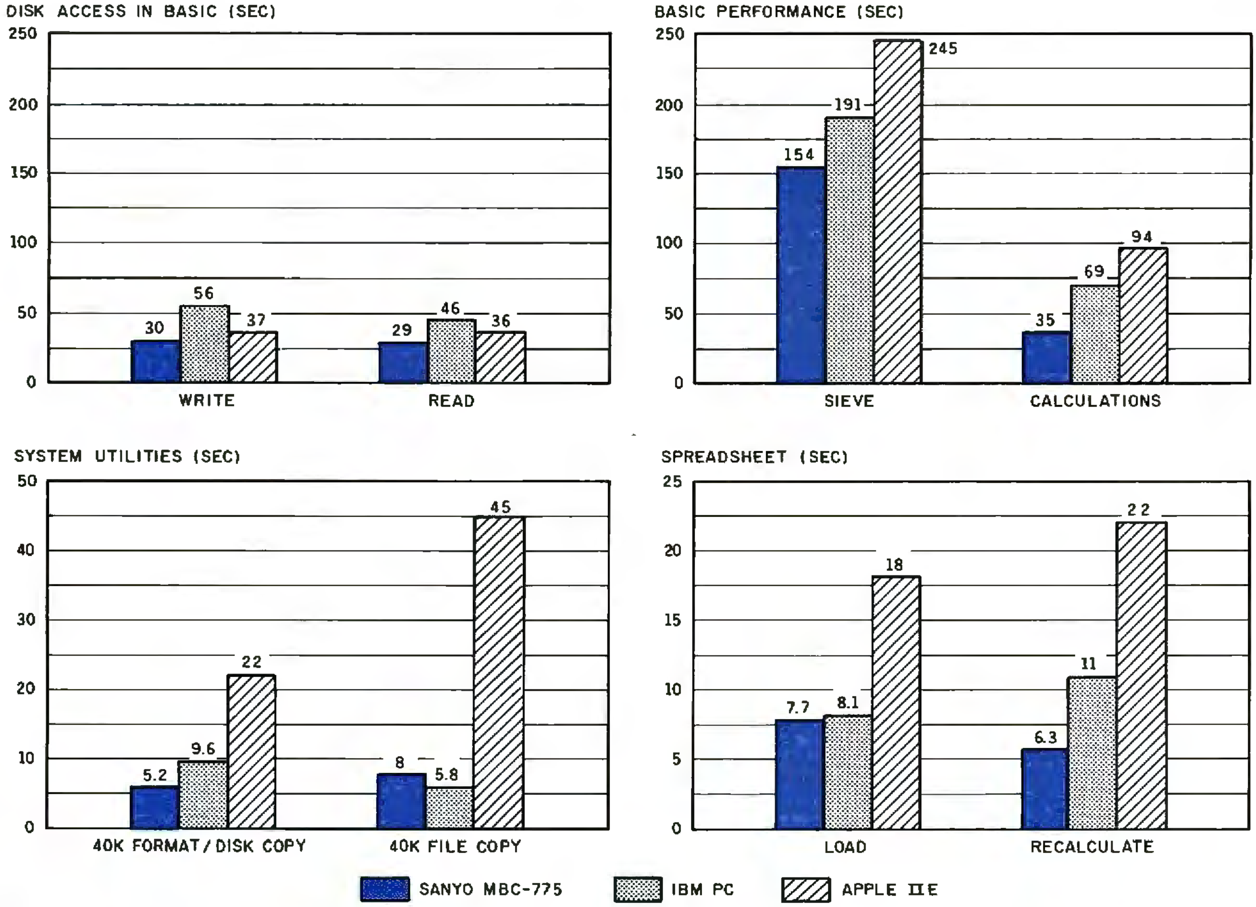
The Price graph shows the list price of each system with two high-capacity floppy-disk drives, a printer port and a serial port, 256K bytes of memory (64K bytes for 8-bit systems), and a monochrome monitor (the MBC-775 is color only; no optional monochrome monitor is available). Prices include the standard operating system and BASIC interpreter for each system.



The rear of the Sanyo MBC-775 portable computer with its three doors open.



The inside of the Sanyo MBC-775. From left to right are the processor board and two expansion slots, disk drives, color monitor, and power supply.



The graph for Disk Access in BASIC shows how long it takes to write and to read a 64K-byte sequential text file to a blank floppy disk. (For the program listings, see June 1984 BYTE, page 327, and October 1984, page 33.) In the BASIC Performance graph, the Sieve results show how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations column shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. The System Utilities graph shows how long it takes to format and copy a disk (adjusted for 40K bytes of disk data) and to transfer a 40K-byte file using the system utilities. The Spreadsheet graph shows how long it takes to load and recalculate a 25- by 25-cell Microsoft Multiplan spreadsheet where each cell equals 1.001 times the cell to its left. The tests for the MBC-775 used MS-DOS 2.11 and GW-BASIC 2.02. The tests for the Apple IIe were done with ProDOS. The IBM PC was tested with PC-DOS 2.0 and BASICA.

them. If you don't push your disk in far enough it will pop back out at you (at least you know the disk is seated properly before you can close the drive).

To open the drive, squeeze the latch again and the disk will pop out. It's a similar mechanism to some of the old 8-inch floppy-disk drives.

The drives are very quiet; you can't hear them over the cooling fan. I wish the fan were as quiet. It produces a loud humming noise that overshadows many of the machine's nicer features. I was tempted to disconnect the fan or try to replace it with a quieter one.

The MBC-775 has no room to install an internal hard-disk drive and Sanyo doesn't offer one. You can add external hard-disk drives by installing the hard-disk controller in one of the two expansion slots. [*Editor's note: Sanyo says that an enhanced version of the* MBC-775 *will be available in the near future. Enhancements will include a speed-select switch to change the clock from* 8 MHz *to* 4.77 MHz *for increased* IBM *compatibility (communications programs are particularly speed-sensitive) and an optional internal* 10*-megabyte hard disk.*]

SOFTWARE

Sanyo has included several software packages in the price of the computer, so you can start using it immediately without purchasing additional programs.

The software supplied includes the MS-DOS 2.11 operating system, the GW-BASIC 2.02 computer language, the EasyWriter II word-processing program with its companion EasyMailer II mail-merge program, the EasyFiler database, and the EasyPlanner spreadsheet program. Sanyo supplied WordStar and its affiliated programs with the MBC-550 dual-disk series machines and says this option will be available for the MBC-775 instead of the Easy packages, due to customer demand.

MS-DOS 2.11 is similar to IBM's PC-DOS 2.1. You can even boot up PC-DOS, but don't expect to run IBM PC BASIC; it requires the IBM PC BIOS (basic input/output system) in ROM in order to function.

Microsoft's GW-BASIC does an excellent job of replacing IBM PC BASIC and runs IBM's demonstration programs (complete with sound and color) and other common IBM PC BASIC programs. GW-BASIC supports both disk drives (unlike the old Sanyo BASIC) but doesn't have Sanyo BASIC's SYMBOL, WINDOW, and VIEW extended graphics commands.

The Sanyo MBC-775 exhibits a high degree of compatibility with the IBM PC. Many popular programs for the IBM PC (Lotus 1-2-3, Symphony, dBASE III, Framework, SideKick, Flight Simulator) work fine. However, programs written specifically for the IBM monochrome adapter card and copy-protected software that relies on the IBM PC's processor or disk-drive speed will cause problems.

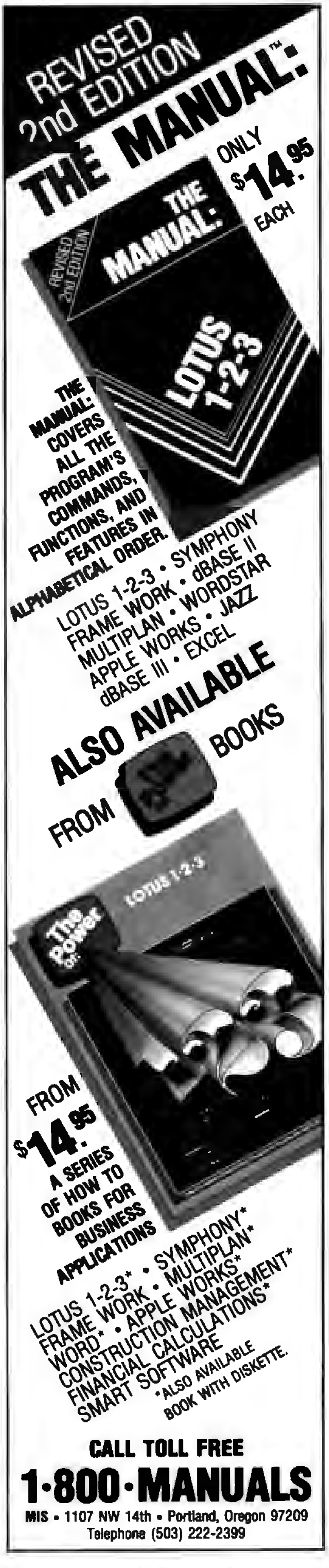
Maybe I'm too accustomed to other word-processing programs, but I found EasyWriter II awkward and not intuitively useful. The variety of modes (character, word, line, sentence, paragraph, block, and page) became overkill. You have to constantly switch between them and each responds differently.

I found myself using far more keystrokes to accomplish functions than I am accustomed to. The help facility is limited and usually didn't clarify problems; you end up going back to the manual for more information.

EasyWriter also has a file-folder/document/page approach that sounds nice for short letters but suffers when you deal with longer manuscripts. I found it especially annoying that EasyWriter does not list the available file folders it uses on the disk. Except for the default file folder you don't know what's on the disk and can't know unless you exit EasyWriter and get a directory. However, once you open a file folder, all its documents are displayed and you can select them easily.

EasyWriter's file folders are fixed-length random-access files that have a default size of about 20K bytes and use special coding so you can't type the DOS files out on the screen. The

(continued)



Sanyo has made some trade-offs on the MBC-775.

program doesn't have backup files (or an "undelete" function). As you switch from one page to another within a document, the last page is written to the file on the disk, saving your work. This slows you down in moving through the document, and dealing with text broken over page boundaries is cumbersome.

The fact that EasyWriter stores documents in its own format didn't bother me much since it lets you translate documents into ASCII (American Standard Code for Information Interchange) files and the reverse. However, this is an additional step when you need to share disks with other systems or send files via modem.

You can call EasyMailer from EasyWriter to merge mailing lists with form letters and include personalized information. You can use it as a simple database with sorting capabilities.

EasyPlanner didn't meet my expectations in many ways. It takes the row and column format too literally, such that it wants to work with whole rows and entire columns.

EasyFiler comes on four different disks for system, housekeeping, sample-data, and extract functions. It is complex to use, as is reflected in the size of its manual.

The nine disks that EasyPak comprises look like a substantial amount of software, but in the end it performed below my expectations.

DOCUMENTATION AND SUPPORT

Overall, I would rate Sanyo's documentation as poor. The system documentation is weak, with a brief introduction followed by lists of BASIC and MS-DOS commands. The skimpy technical reference section gives some pertinent I/O addresses, a memory map, interrupts, and BIOS calls.

There are no tutorials on disk to introduce you to the operating system, DOS commands, or BASIC. The documentation does not contain "read this first" sections or quick introductions. Sanyo's approach is to have you read everything before using the system or the software. This is neither realistic nor interesting.

The rest of the software manuals have been hastily adapted from existing MBC-550 series manuals, referring to different keyboards and disk-drive configurations. The manuals and disks provide good introductions but are not comprehensive.

The general consensus seems to be that this machine does not offer an outstanding price/performance ratio; few dealers are stocking it, even those who carry the MBC-550 series. You will see it advertised mostly by mail-order houses.

Sanyo lists a warranty for one year on the memory and processor board and 90 days on all parts and labor. If you are not a dealer, calls to Sanyo are answered with a tape that refers all inquiries to your local Sanyo dealer. It is not surprising to find that many users groups have formed to provide the support that Sanyo does not.

SUMMARY

The Sanyo MBC-775 faces planned obsolescence since IBM is supporting the faster 80286 processor as the next chip of choice. Also, the new IBM Enhanced Graphics Adapter represents the next generation of video-display controllers with its 16-color graphics in both the 320- by 200-pixel medium-resolution and 640- by 200-pixel high-resolution modes.

Sanyo established a reputation for low prices and good bundled software with the 550 series, but it has made trade-offs in designing the MBC-775. The MBC-775 relies on its 9-inch color screen, improved speed, possible price discounting, and portability to distinguish it from the mass of IBM PC-compatibles. It does better than the average personal computer but does not excel in any special characteristics. [*Editor's note: The Sanyo* MBC-775 *was supplied courtesy of Palmer T. Wolf of Richard Dean Associates Inc., Newburyport, Massachusetts.*] ■

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S·O·F·T·W·A·R·E R·E·V·I·E·W

Five C Compilers for the Macintosh

Aztec C

Hippo-C

Mac C

Megamax C

Softworks Macintosh C

BY TIM FIELD

Creating application programs for Apple's Macintosh is quite different from writing programs for more traditional microcomputers. This is due primarily to the fact that application programs have to be built up around the standard Macintosh user interface. This interface offers the mouse as the primary input device, using the keyboard only for text entry and "power user" command entry. Furthermore, full exploitation of such things as pull-down menus, multiple windows, dialog boxes, and icons are a must. Ironically, the effort required to shape an application program into the Macintosh user environment is often equal to or even greater than the development effort of the actual application solution itself.

Thanks to the rich complement of software tools available within the Mac's ROM (read-only memory) Toolbox, the Macintosh user interface can be efficiently supported by an applications programmer. It is very important that any Macintosh software-development system directly and completely support the facilities in the ROM Toolbox. What this means is that the portability of programs across a variety of machines (often an important topic to C programmers) becomes a virtual nonissue when compared with the need for complete support of the Macintosh ROM Toolbox.

You can think of each of the five compilers I review in this article as an entrant in a decathlon. My goal has been to put the compilers through a variety of tests, as well as objective and subjective evaluations, designed to spot strengths and weaknesses of each. My intent has been to judge them purely on merit and independently of how they may have performed in previous tests.

Let me note, however, that my evaluations and comments are intentionally biased in one respect. Rather than looking just for the best generic C compiler available for the Macintosh, I wanted to find the best development system for creating Macintosh application programs.

Some of the compilers come in two flavors, with one version for the "nonprofessional" C programmer and another more expensive and more capable version for the "professional" developer. Since my focus was on finding the best professional C-based development system for the Macintosh, I reviewed only the professional version of each compiler. In any case, I feel that the extra power offered by the professional versions more than justifies the extra cost, even for the nonprofessional C programmer.

THE COMPETITORS

The five compilers I compare are Aztec C from Manx Software Systems, Hippo-C from Hippopotamus Software, Mac C from Consulair, Megamax C from Megamax, and Softworks Macintosh C from Softworks Limited. Tables 1 and 2 summarize some of the characteristics of each compiler.

THE BENCHMARKS

Whenever I read a side-by-side comparison article such as this, I flip right to the benchmark test results. Let's go immediately to an overview of the benchmark process and the results, after which I will look at some of the individual properties of each compiler.

To test the raw performance characteristics of the five C compilers, I selected eight benchmark programs that I felt would offer opportunities for each compiler to show its stuff. I took some of these benchmark tests almost verbatim from the BYTE issue on the C language (August 1983). These test the standard facilities in each C compiler, such as how well it performs tight looping tasks or integer arithmetic. Another benchmark program was designed to test the efficiency of each compiler's interface to the Macintosh's ROM Toolbox.

All benchmarks were compiled and run on a 512K-byte Mac with two disk drives. While each of the compilers theoretically

(continued)

Tim Field (4321 Canyon Valley Rd., Diamond Springs, CA 95619) is an independent software developer/consultant working primarily with the IBM PC and the Apple Macintosh. He has an M.S. degree in computer science from Purdue University and a B.S. degree in electrical engineering/computer science from the University of California at Berkeley. His specialty is the low-level hardware/software interface.

Table 1: A *quick comparison of the five C compilers reviewed, highlighting important features.*

	Softworks C	Mac C	Aztec C	Hippo-C	Megamax C
Claims complete access to ROM	yes	yes	yes	yes	yes
Type of interface to MAC ROM	glue	direct	direct	glue	glue
Produces stand-alone Mac programs	yes	yes	yes	yes	yes
Direct support of desk accessories	no	yes	yes	no	yes
Source code for standard library	no	yes	yes	yes	no
Register variables	yes	no	yes	no	yes
Floating-point math	yes	no	yes	no	yes
Produces assembly code	yes	yes	yes	yes	no
In-line assembly	no	yes	yes	no	yes
Assembler included	no	no	yes	yes	no
Apple MDS assembler required	yes	yes	no	no	no
Form of user interface	Mac	Mac	UNIX-like shell	HOS (note 1)	Mac
Assembly-level debugging aids	yes	yes	yes	no	no
Library manager	no	no	yes	yes	yes
Intelligent linker	no	no	yes	no	yes
Copy-protected	no	yes (note 2)	yes	yes (note 2)	no

Notes:
1. See text for more information.
2. Unprotected version costs $25 extra.

Table 2: A *comparison of miscellaneous attributes of the C compilers reviewed.*

	Softworks C	Mac C	Aztec C	Hippo-C	Megamax C
Size of CHAR	8 bits	8 bits	8 bits	8 bits	8 bits
Size of SHORT	16 bits	8/16 bits	16 bits	16 bits	8 bits
Size of INT	32 bits	16/32 bits	16 bits	32 bits	16 bits
Size of LONG	32 bits	32 bits	32 bits	32 bits	32 bits
Size of FLOAT	32 bits	n.a.	32 bits	n.a.	32 bits
Size of DOUBLE	64 bits	n.a.	64 bits	n.a.	64 bits
Size of POINTER	32 bits	32 bits	32 bits	32 bits	32 bits
Bit fields	no *	no	no	yes	no
Enumerated types	no	no	no	no	no
Automatic variable initialization	yes	yes	yes	yes	yes
Structure passing	no	no	no	no	yes
Structure assignment	no	no	yes	yes	yes
Extra support function (with source)	no	yes	yes	yes	no

* Manufacturer claims it works, but the assembler would not assemble code output from the compiler.

can be used with single-drive 128K-byte Macintosh systems, to attempt such a feat would be a serious mistake. Realistically, two disk drives are an absolute must, and a 512K-byte Macintosh is highly recommended, even if the program you are developing will ultimately run on a 128K-byte Mac.

The benchmark programs timed themselves as they executed, using the Macintosh ROM TickCount() timer function to get their starting and ending times from the system clock. Thus, these times are accurate to within one-sixtieth of a second. Table 3 shows the results of the benchmark tests.

The C source code for the benchmarks is available for uploading from BYTEnet Listings at (617) 861-9764. However, let's look at a capsule summary of each benchmark test.

FRAME: Do an empty for loop that cycles 10,000 times. Since several of the other benchmark tests use such a loop, the results of FRAME can be used to factor out the time involved in simple looping.

FIB: Calculate the twenty-fourth value in the Fibonacci sequence, which is defined as the sequence of integers starting <0, 1, 1, 2, 3, 5, 8, 13, 21, . . . > such that the next number in the sequence is the sum of the two most recent numbers. Repeat this 10 times. The algorithm makes extensive use of recursion and tests the efficiency of function calling by each compiler.

FLOAT: Perform a number of multiplication and division operations on double-precision floating-point numbers. Repeat process 10,000 times. This tests the efficiency of floating-point support.

INTERFACE: Make repetitive calls to the Macintosh ROM GetNextEvent() operation. This tests the efficiency of C-to-ROM interface.

INTMATH: Perform a variety of integer math operations (+, −, *, /, <<). Repeat 10,000 times. This measures the efficiency of integer math operations.

QSORT: Create an array of 1000 random long integers and use the Quicksort algorithm to sort the array. Repeat the procedure 10 times. Like SIEVE, this benchmark is commonly found in general benchmark tests, so the results can be used to compare against other machines. QSORT uses recursion to a considerable depth, so it tests the efficiency of both function calling and parameter passing.

POINTER: Using a pointer, march through an array of 128 characters, setting each character to the blank character. Repeat this 10,000 times. This measures the efficiency of pointer use for array access.

SIEVE: Use the now legendary Sieve of Eratosthenes algorithm to determine all the prime numbers from 0 to 8190. Repeat 10 times. Although this does help measure array and integer math operations, it is included primarily for historical reasons and to allow for comparisons of the Macintosh with benchmarks run on other systems.

While the major portions of the benchmark tests remained unchanged from compiler to compiler, small deviations were required in

(continued)

Table 3: *The results of the benchmark tests and the sizes of the execution files produced.*

Execution Times
(in seconds)

	Softworks C	Mac C	Aztec C	Hippo-C	Megamax C
FRAME					
Normal	0.13	0.13	0.10	0.25	0.10
Register	0.08	n.a.	0.05	n.a.	0.05
POINTER					
Normal	24.33	26.60	25.50	33.23	30.02
Register	11.15	n.a.	13.15	n.a.	18.93
INTMATH					
Normal	30.05	5.10	5.03	15.93	5.05
Register	26.73	n.a.	2.70	n.a.	2.78
SIEVE					
Normal	8.83	7.98	6.20	12.65	6.20
Register	4.73	n.a.	3.88	n.a.	4.17
QSORT					
Normal	157.08	63.92	68.43	test failed	93.38
Register	93.72	n.a.	50.87	n.a.	70.80
FLOAT					
Normal	332.77	n.a.	268.22	n.a.	334.32
FIB					
Normal	28.60	31.67	24.72	47.22	25.97
INTERFACE					
Normal	59.18	71.40	56.22	78.47	72.00

File Sizes
(in bytes for "normal" [non-register] runs)

	Softworks C	Mac C	Aztec C	Hippo-C	Megamax C
FRAME	32,000	10,496	8537	20,992	6544
POINTER	32,000	10,496	8571	21,044	6586
INTMATH	32,512	11,008	9109	21,948	7128
SIEVE	40,448	10,752	16,897	21,318	6768
QSORT	36,608	11,008	13,113	test failed	7226
FLOAT	32,256	n.a.	9205	n.a.	7256
FIB	32,256	10,496	8751	21,304	6810
INTERFACE	32,256	10,496	8697	21,230	6700

AT A GLANCE

Name	Aztec C version 1.06C	Hippo-C Level 2	Mac C version 1.07 and Mac C Toolkit	Megamax C Compiler version 2.0	Softworks Macintosh C
Type	C compiler for the Mac	C compiler for the Mac	C compiler for the Mac	C compiler for the Mac	C compiler for the Mac
Manufacturer	Manx Software Systems Box 55 Shrewsbury, NJ 07701 (800) 221-0440 (201) 780-4004	Hippopotamus Software Inc. 1250 Oakmead Parkway, Suite 210 Sunnyvale, CA 94086 (408) 738-1200	Consulair Corp. 140 Campo Dr. Portola Valley, CA 94025 (415) 322-2757	Megamax Inc. POB 851521 Richardson, TX 75085-1521 (214) 987-4931	Softworks Limited 607 West Wellington Chicago, IL 60657 (312) 975-4030
Documentation	More than 600 pages in two binders, no index	Approximately 200 pages in 3-ring binder, index included	135-page manual, no index	More than 160 pages in 3-ring binder, index included	Stapled 5-page Mac-specific instructions plus 200-page generic Whitesmiths Ltd. C programmer's manual, no index
Price	$499	$399.95	$425 plus Apple MDS (purchased separately, Mac C is $295 and Mac C Toolkit is $175)	$299.95	$395 plus Apple MDS

order to accommodate the idiosyncrasies of individual compilers. For example, the global declaration INT DUMMY = 0 was added to the top of each program for the Softworks C compiler since it requires at least one initialized global variable in any program it compiles. I made such changes with great deal of care to ensure that the benchmark results were not affected to any significant degree.

Both Aztec C and Hippo-C can, at the programmer's option, create programs that run in either their unique program-development environments (discussed later) or as stand-alone programs that can be executed from the Macintosh Finder. The other three compilers always produce stand-alone programs. To be fair in the benchmark competition, I required each compiler to produce programs that could run as stand-alone Macintosh programs. While this did not affect the running times of the Aztec C or Hippo-C tests, it did increase the size of each of their programs.

Benchmark Results and Comments

As you can see in table 3, the overall winner of the speed portion of the tests was Aztec C. It placed first in almost every test and never finished worse than second. In the file-size portion of the benchmark contest, Megamax C placed first, with Aztec C and Mac C close behind.

I set up special versions of the FRAME, POINTER, INTMATH, SIEVE, and QSORT programs to test the efficiency of the register variables as offered by three of the compilers. Notice in table 3 the tremendous speedup of these versions of the programs as compared to the standard versions. Obviously, the omission of register variables in the Mac C and Hippo-C compilers is a real handicap for them. Mac C and Hippo-C also had to drop out of the FLOAT contest, as neither offers true floating-point support.

The only unexpected failure for any of the benchmark tests was the QSORT program when it was compiled and run using Hippo-C. The program ran out of stack space before it could finish, and Hippo-C offers no documented method of increasing its run-time stack.

A potentially controversial aspect of the benchmark testing procedure concerns the integer size used by the different compilers. The Aztec and Megamax compilers use 16-bit integers. The Softworks and Hippo compilers use 32-bit integers. Meanwhile, Consulair's Mac C allows the user to select between 16- and 32-bit integer sizes.

When setting up the benchmark tests, I had to decide whether to let each compiler use its native integer size (effectively favoring those with 16-bit integers for benchmark programs using a large proportion of integer operations) or force all the compilers to use 32-bit long integers (this time handicapping those with the 16-bit integers).

The natural pointer size for the Macintosh is determined by the 68000 microprocessor's hardware as 32 bits. However, 16-bit integers are usually sufficiently large to handle the vast majority of integer operations, and 16-bit integer operations can be accomplished two to four times as fast as 32-bit integer operations. And the availability of 32-bit long integers in C can handle the remainder of the integer operations that will not fit within the 16-bit range limitations.

Makers of Macintosh compilers face the dilemma of compromising the performance of integral operations in favor of supporting the widespread use of a poor programming style by many C programmers. Aztec C and Megamax C chose to support the better-performing 16-bit integers. Softworks C and Hippo-C went the route of 32-bit integers. Mac C wisely decided to sit on both sides of the fence and give the programmer the choice.

For the benchmark testing, I reasoned that since one of the primary goals of C programs is maximum performance, it was unfair to handicap the compilers that offer the faster 16-bit integer sizes by forcing them to use 32-bit integers. Thus, I ran all the tests for Mac C, Aztec C, and Megamax C with 16-bit integers. However, in the interest of fairness (and to satisfy my own curiosity), I subsequently reran all the benchmark programs through Aztec C using long integers; I found that Aztec C still handily beat Hippo-C in every test and lost to Softworks C only in the POINTER program (and then just barely).

Some of you may be wondering why I didn't even things out by running Softworks C and Hippo-C with their 16-bit short integers. This would not have helped since C specifies that all integral operations should, if possible, be carried out in the compiler's natural integer size. For example, if you add two short integer values together using Softworks C, Softworks converts the two 16-bit values to 32-bit values, performs a 32-bit addition, and then converts the result back to a 16-bit value if appropriate. Consequently, 16-bit short operations in Softworks C take as long or longer than similar 32-bit integer operations.

COMPILE TIMES

In order to time the compilation process for each of the compilers, I set up a trivial program composed of four separately compiled modules, each containing one function. I then timed how long it took the five compilers to compile and assemble each of the four modules, link them together, and begin program execution. For each system, I used the manufacturer's recommended setup on my 512K-byte Mac with its two drives and any tools (such as batch files) that accompanied the compilers.

Table 4 shows the results of the compile-time tests. With the exception of Aztec C running on its RAM (random-access read/write memory) disk, the Macintosh compilers performed abominably. (Only Aztec C came with a RAM disk.) With times ranging from more than 4 minutes to almost 8 minutes (this is for a very trivial program), the level of frustration becomes very high as you work through the cycle of implementing and debugging your programs. With a 128K-byte Mac or a single disk drive, you can expect even worse performances.

Table 4 also shows the time required to do the same process on a standard IBM Personal Computer using a

(continued)

Listing 1a: *The "startup" include file, used by all the other programs for timing.*

```
long time;
puts("Press any key to begin timed test: ");
getchar();
puts("\nStarting\n");
time = TickCount();
```

Listing 1b: *The "done" include file.*

```
time = TickCount() - time;
printf("ticks=%ld\n",time);
printf("Press any key to return to FINDER:  ");
getchar();
```

Listing 2: *The* FRAME *benchmark.*

```
/*        frame.c        */
#include  "stdio.h"
#define   COUNT 10000
main()
{
     int i;
#include  "startup"
     for (i = 0; i < COUNT; ++i) {
         ;
     }
#include  "done"
}
```

Listing 3: *The* FIB *benchmark.*

```
/* fib.c */
#include  "stdio.h"
#define NTIMES  10      /* number of times to complete fibonacci value */
#define NUMBER 24       /* biggest one we can compute with 16 bits */
main ()
     {
     int i;
     unsigned value, fib();
#include  "startup"
     for (i = 1; i< =NTIMES;  i+ +)
       value = fib(NUMBER);
#include  "done"
     printf(" \ nPerformed  fibonacci  series %d times \ n",NTIMES);
     printf("fibonacci(%d)     = %u. \ n",NUMBER,value);
     printf("Press any key to return to FINDER: ");
     getchar();
}
unsigned fib(x)            /* compute Fibonacci number recursively */
int x;
     {
     if (x > 2)
       return(fib(x - 1)      + fib(x - 2))
     else
       return(1);
     }
```

DeSmet C compiler. In this case, the DeSmet compiler finished in 1 minute and 20 seconds without using its RAM disk and needed only 18 seconds with its RAM disk. If you figure that a programmer will follow through the development cycle numerous times, you can see the great disadvantage of using a development system with a long cycle time.

I should note that the primary culprit here is the Macintosh disk drives. The drives were steadily grinding away throughout the compilation process for each of the compilers. As demonstrated by the difference in times of using Aztec C with and without its RAM disk, the compilation without the RAM drive spent about 83 percent of its time waiting on the disk drive.

AZTEC C

Aztec C from Manx Software Systems consists of a full C compiler, assembler, linker, and pair of text editors. Rather than follow the path of the Softworks, Consulair, and Megamax compilers, which exclusively use the Macintosh user interface (that is, support multiple windows, menus, icons, and mouse), Aztec C creates a more traditional programming environment based on the UNIX operating system. (See the "User Interface" section later in this article.)

The basis for Aztec's UNIX-like environment is its "shell." This essentially replaces the standard icon-based Macintosh Finder with a command-line-oriented operating-system interface. All commands are entered to the shell via the keyboard; there are no menus, no desk accessories, and the mouse doesn't do anything.

You might wonder how you could use such an environment to create stand-alone programs that take advantage of the Mac user interface. The secret is that the shell, acting as an operating system, can run any standard Macintosh program. While this program is running, it works in exactly the same manner as if it had been started by the Finder. The only dif-

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ference is that exiting the program returns you to the shell UNIX environment rather than to the Finder.

The programmer has three options for creating application programs using Aztec C: programs that run only under the Aztec shell (that is, they cannot be activated by the Finder); programs that run entirely on a standalone basis (can be started from the Finder or shell and use only standard Macintosh operations to receive input from the keyboard and send output to the display); and programs that stand alone but need to use a special Aztec C "console driver" to interact with the user.

To make the shell an appropriate development environment, the Aztec C package includes a vast array of tools, utilities, and programs that help in the C development process. Most of these are fashioned after corresponding tools found in UNIX. For example, the Aztec compiler, assembler, and linker are known as cc, as, and ln, respectively, and offer a fairly large subset of the options and features found in their UNIX counterparts.

The Aztec compiler supports floating-point data types and floating-point operations. It also supports up to six register variables, in-line assembly code, and a variety of compiler options. For example, one option is used to create an assembler source file in which the lines of C source are included as comments. This can simplify the task of associating your C source with the assembly code produced, making assembly-level debugging easier.

The assembler is a full macro assembler with options that allow you to perform peephole optimizations, create assembly listings, and so on. The Aztec linker is an intelligent linker: It recognizes the format of special libraries of functions and includes only those modules containing functions actually used by the program being linked. This results in consistently small run-time files. Aztec C's other resources and tools, most of which offer flexibility through a host of options, are:

Text editor (Z): A powerful full-screen text editor (quite similar to UNIX's vi) used to create and edit C and assembly source code (or, for that matter, any sort of pure text file). In addition to all normal text-editing functions are some specifically aimed at the C programmer, such as operations to find the next or preceding C function, to find matching parentheses, and so on. Z also offers macro commands as well as string-searching capabilities.

EDIT: The Apple MDS text editor (see the text box "Apple's Macintosh

68000 Development System" on page 286). You can use this editor instead of Z if you favor the standard Macintosh user environment for text editing.

RAMDISK: Allows users of 512K-byte Macs to set aside all but 128K bytes of RAM for use as a RAM-disk drive, offering astounding speed improvements.

LIBRARIAN: Lets you add functions to and delete functions from the Aztec C libraries.

ARCHIVER: An archive is a large storage depot for the source code of many C programs. Aztec C lets you group these sources together so that they don't clutter disks with extraneous filenames yet are still accessible later when you "de-archive" them.

EXECUTIVE: A batch-processing or executive capability that lets you create a file of text commands processed by the shell as if you were typing in the commands at the keyboard. This flexible facility will let you do variable substitutions using command-line arguments.

MAKE: Sophisticated program used to create and update any files created from other files. The standard application of MAKE is to have it look at each C and assembly source module that is required for creating a given application program, compile and assemble only those that have been changed since the last MAKE on this group, and then link everything, ready to run.

GREP: A powerful and flexible pattern-matching utility that searches through text files for occurrences (or lack thereof) of specified strings and patterns.

DIFF: Compares two source files.

RMAKER: Apple's MDS resource compiler.

Assorted debuggers: Various assembly-level MDS debuggers.

Included as part of the UNIX-like environment of the Aztec shell are many operations and features that make Aztec C a powerful development system. These include ls, which gets file directories; rm, cp, and mv to remove, copy, and rename disk files; cat, which looks at the contents of text files; redirection of standard input and output (for example, redirecting the output of cat from the display to the printer); full support of UNIX directories and subdirectories; and support of global * and ? characters when specifying filenames. You can even set up your own system prompt.

With all the features in Aztec C, good documentation is a must. Manx delivers. Aztec C comes with two binders containing more than 600

(continued)

pages of well-written documentation. Despite the lack of an index, I was able to find almost every piece of information I wanted.

Of great assistance to the Macintosh programmer are sections of the manuals devoted to Aztec C's specialized Macintosh functions (similar to the standard C library functions but supporting special characteristics of the Mac) and the Mac Toolbox routines. Also helpful is a section entitled "Tech Info," a technical discussion of important topics including the Mac's memory organization and what actually happens when the Finder shell starts up an application program. The documentation even looks at the issues involved in designing a Macintosh desk accessory using Aztec C. This discussion revolves around a real desk accessory that is included, source and all, with the system.

My one regret about Aztec C is that it's copy-protected. In fact, it is the only compiler of the group that does not come in a nonprotected version. Also, Manx chose to copy-protect the shell environment. The shell environment is so capable and well done that there are situations in which, were it not copy-protected, I would use it in place of the Macintosh Finder. In fact, I think Aztec C could successfully market its shell environment as a product by itself, providing a good alternative to the Finder.

Aztec C is the most comprehensive and professional package of the five compilers in our test group. It either

(continued)

Listing 4: The FLOAT benchmark.

```
/*          float.c           */
#include  "stdio"
#define CONST1   3.141597E0
#define CONST2   1.7839032E4
#define COUNT    10000
main()
{
      double a, b, c;
      int i;
#include  "startup"
      a = CONST1;
      b = CONST2;
      for (i = 0; i < COUNT; ++i) {
         c = a * b;
         c = c / a;
         c = a * b;
         c = c / a;
         c = a * b;
         c = c / a;
         c = a * b;
         c = c / a;
         c = a * b;
         c = c / a;
         c = a * b;
         c = c / a;
         c = a * b;
         c = c / a;
      }
#include  "done"
}
```


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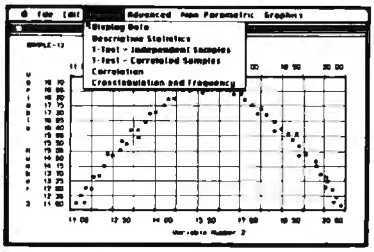

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Apple's Macintosh 68000 Development System

The Macintosh 68000 Development System (MDS) from Apple Computer provides a complete programming environment for assembly-language program development on the Macintosh. Since the Mac uses Motorola's MC68000 microprocessor, you can use any generic 68000 assembler for Macintosh assembly development. However, MDS is designed to help developers cope with the special difficulties involved in writing programs that conform to the user interface, such as the support of the mouse as an input device and appropriate use of icons, windows, menus, and desk accessories.

MDS is important to our C comparison article because four of the compilers reviewed currently make use of some or all parts of MDS. MDS consists of the following six components:

MDS is designed to help developers cope with writing programs conforming to the user interface.

EDIT: A disk-based text editor. By disk-based, I mean that EDIT can work with text files that are larger than the available internal memory of the Macintosh. Since EDIT is designed primarily for entering and editing the text source of programs, many of the formatting features of word-processing programs such as MacWrite are omitted. Instead, EDIT strives to satisfy some of the unique needs of the programmer, offering specialized functions and added speed in place of the missing word-processing features.

EDIT fully supports the Macintosh user interface. One of EDIT's most important features is its ability to open as many as four separate text files at once, with each file having its own fully functional window. This allows the user to cut and paste between files, simultaneously create and edit separate modules of a program, or just refer to the contents of one file while working with another. The second star attraction of EDIT is its speed. For example, EDIT is significantly faster than MacWrite in text search/replace operations.

Other features of EDIT include a choice of type font and size (although you cannot mix different fonts or sizes within a file), optional auto-indentation (very handy for creating easy-to-read source code), and full access to desk accessories, cut/copy/paste, and search/replace activities.

EDIT's combination of raw speed and support of the Mac user environment makes for a friendly and powerful programmer's tool. In fact, it is often quicker and easier to use EDIT instead of MacWrite for simple nonprogramming-related text-entry and editing tasks.

ASM: A macro assembler that translates assembly-language source files, such as those created by EDIT, into relocatable object modules ready to be linked into application programs that can be run. ASM supports all the MC68000 instructions and addressing modes, following the guidelines and syntax laid down in Motorola's 68000 reference manual.

ASM offers such features as macro expansion (in two variations), complex constant expression evaluation, constant string handling, and conditional assembly, as well as many other support operations. It also supports Macintosh source specifications.

RMAKER: In the Macintosh, a "resource" is a special grouping of data or code that defines some specific entity used by a program. For example, menus, fonts, and icons are common data resources, consisting of special "descriptions" of the particular items. In the case of a menu resource, the description includes such things as the text for each item on the menu and which, if any, command-key shortcut can be used to invoke that item. When the program begins executions, it simply tells the ROM Toolbox's Menu Manager about this resource. The routines within the Menu Manager can then be used to create and display the menu title on the screen, handle the task of pulling down the menu, and report to the program any items selected by the user.

In effect, a Mac resource is a specially defined data structure used to formally group information in such a way that it can be shared easily by different parts of the program and ROM Toolbox managers. Being a data structure, it is possible to define resources within the assembly source of a program. In fact, ASM directly supports this. However, anyone who has sweated the details of making sure each element of numerous complex data structures is set up properly knows that this is a time-consuming job.

To ease the task of defining and using resources, RMAKER is included in MDS. RMAKER is a "resource compiler." It takes a text file (created by the user with EDIT) that describes a program's resources and converts the text into the appropriate data structures.

LINK: Binds together one or more object modules that were created by ASM or RMAKER to produce an executable application program file. LINK supports the Macintosh notions of program segmentation and separate data and code "forks." LINK also offers traditional linking options, such as the ability to create a "map" of the resulting program.

LINK is not an intelligent linker. It blindly assumes that the user wants every last byte of every module included within the program. This is fine and dandy unless a programmer wants to use only a few of the functions offered by a file that contains many commonly needed functions needed by the program.

EXEC: A primitive executive or batch-file processor. The task of creating an assembly program involves a cycle that begins with the use of EDIT to create and edit the assembly source, moves to ASM for assembly of one or more modules, heads on to LINK for the linking procedure, takes the program out for a test run, and then heads back to EDIT to make any corrections or changes necessary. EXEC offers a way to mechanize this development cycle, albeit in a very limited manner.

To use EXEC, you work with EDIT to create a special "job" file that specifies each step of the assembly cycle. For each step, you can include a string to be passed to the application (such as the name of a file to be assembled or linked), the application to be called if no error is found in the current step (usually EXEC, so the processing of the current job file will continue), and the application to be called when an error is found (usually EDIT, so you can fix the problem and start the loop again). EXEC then takes this file and moves you through the specified cycle.

Assorted Debuggers: MDS has several useful assembly-level debuggers, including one for a 128K-byte Mac, one for a 512K-byte Mac, and others for use with external stations, such as another Mac, a Mac XL, or a simple terminal attached via one of the Mac's serial ports. The capabilities of these debuggers vary, but all are helpful, giving the user the ability to display and change both memory and register values as a program executes, disassemble selected parts of memory, single-step or trace through a program, set breakpoints, selectively step over or trace into system ROM traps, and keep tabs on the size of the system and application heaps.

The debuggers are designed to keep out of the way of the application program being debugged. For example, if you use the version for the 512K-byte Mac, you can easily switch back and forth between seeing what your program is displaying on the screen and seeing the information offered by the debugger.

All in all, MDS is a capable assembly-language development system. Some or all of the components of MDS can be found in four of the C compilers reviewed. The most extensive use is by Softworks C and Mac C, both of which require that you purchase MDS separately. They both expect the programmer to use EDIT to create the C source-code files; then they convert the source code into assembly source code that is assembled and linked using ASM and LINK. This makes it very simple to mix C and assembly modules.

The Aztec C and Megamax C compilers use their own assemblers and linkers, but both packages currently contain EDIT and RMAKER for text editing and resource compilation. Since both also offer their own text editors, users of these two systems can select the editor of their preference. Aztec C also includes the various MDS debuggers for assembly-level debugging.

A final note: At the time of this writing, MDS is months overdue for release to the general public as a stand-alone product. However, Apple has allowed some companies to license and include all or part of MDS with their products. This is a big break for all purchasers of either Softworks C or Mac C since they get MDS for free with the purchase of the compiler. However, Apple reportedly plans to eliminate these licensing rights at the time that MDS is finally released for sale. Unless things change, new buyers of Softworks C or Mac C will then have to bear the cost of MDS.

dominated, tied, or came close to first in virtually every test and comparison. Furthermore, Aztec C offers numerous features and advantages that the others cannot begin to touch.

HIPPO-C LEVEL 2

Hippo-C Level 2 from Hippopotamus Software creates its own programming environment that uses a command line. It comes with a two-pass C compiler, a 68000 assembler, a linker, and an editor. The Hippo-C programmer can create programs that run only within the Hippo-C environment or, with minor changes, programs that run in both the standard Macintosh environment under the Finder and the Hippo-C environment.

The programming environment created by Hippo-C, called the Hippo Operating System (or HOS), is somewhat reminiscent of the command-line orientations of UNIX or MS-DOS but without the flexibility of either. I found it lacking in several areas, hampering my programming efforts more frequently than assisting them. One small example: I could not find any way to eject a disk and insert another one while using Hippo-C. This limited me to working only with the data and program files on the disks in my two drives when I started HOS. If I needed other files, I had to exit HOS back to the Finder, copy the files onto the mounted disks, and restart HOS.

Anyone who has used UNIX will find HOS confusing and frustrating. Many UNIX utilities such as ls, cp, mv, make, and grep are present in name but work differently than their UNIX namesakes. For example, make is just an ultra-simple batch-file mechanism without the ability to do variable substitution, much less handle the sophisticated operational inferences of the UNIX command of the same name.

The HOS utilities are not implemented very efficiently. For example, the cp file-copy command requires more than 20 disk accesses of both the source and the destination files to copy just a small file from one disk to another on a 512K-byte Mac. Even worse, the mv file-rename utility does

(continued)

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Listing 5: *The* INTERFACE *benchmark.*

```
/*        interface.c        */
#include  "stdio.h"
#include  "Events.h"
#define COUNT 10000
main ()
{
     int i, eMask1, eMaskd2, bool1, bool2;
     EventRecord eRcrd1, eRcrd2;
#include  "startup"
     eMask1 = eMask2 = -1;
     for (1 = 0; i < COUNT: + +i) {
       bool1 = GetNextEvent(eMask1,    &eRcrd1);
       bool2 = GetNextEvent(eMask2,    &eRcrd2);
       bool1 = GetNextEvent(eMask1,    &eRcrd1);
       bool2 = GetNextEvent(eMask2,    &eRcrd2);
       bool1 = GetNextEvent(eMask1,    &eRcrd1);
       bool2 = GetNextEvent(eMask2,    &eRcrd2);
       bool1 = GetNextEvent(eMask1,    &eRcrd1);
       bool2 = GetNextEvent(eMask2,    &eRcrd2);
     }
#include  "done"
}
```

not actually rename a file. Rather, it first copies the file from the old filename to the new and then removes the old file. Thus, due to the inefficiencies of cp, the simple task of renaming a file becomes time-consuming. To make matters worse, all the HOS utilities are disk-based and require multiple disk accesses for even the most trivial task. Given the Macintosh's terribly slow disk-drive interface, this results in the slow performance of HOS.

HOS does support the UNIX global replacement character * (but not its companion ?) for use with certain operations that need filenames, but it doesn't support it consistently and logically. Redirection of input and output is possible using the > and < characters, but output concatenation (> >) and use of standard Macintosh devices as the source or destination of such redirection is not allowed. HOS does not support hierarchical structure, such as UNIX directories or the Macintosh Finder's folders, so there is no way for you to organize disk files. Using ls, the directory-listing command, results in a display of the entire contents of every mounted disk. This is a serious handicap for anyone using a hard disk with HOS.

HOS does have some nice features. For example, it always looks to both disks for any program that you request to be executed. This frees you from having to specify disks and search paths, although the ability to specify search paths is sometimes very useful. HOS also has a special MAKEMAKE command that helps automate the process of compiling, assembling, and linking one or more C modules into a program that can run.

The Hippo-C text editor bears a strong resemblance to Apple's MDS editor. It uses the normal Macintosh environment and allows up to eight separate text files to be opened at one time. It has a really helpful feature for tracking down compile-time errors. If you run the Hippo-C compiler and receive a list of errors, you can open the editor with an option specifying that you want the error messages placed into the C program immediately following the portion of the pro-

(continued)

gram that caused each error. You can then easily work through the program, finding and fixing each error, after which you can ask the editor to remove the error messages from the file. Save the revised code file and you are ready to try to compile again.

The C compiler uses two passes to produce assembly code. If you are using a 128K-byte Mac, the compiler can use the 20K bytes of RAM set aside for the screen display as part of its work space. This allows you to create larger C programs on a 128K-byte Mac than would be possible otherwise. The compiler itself is absolutely inflexible, offering no compile-time options. This is quite unfortunate, as demonstrated by Hippo-C's inability to run the QSORT benchmark program because of a shortage of stack space. Additionally, the compiler does not allow for in-line assembly code within C programs.

The assembler, like the compiler, is most noteworthy in its lack of flexibility. It has no assembly-time options. It allows very limited constant expressions (only addition and subtraction of numbers to labels) and has no macro-processing capabilities. The linker is adequate, but it is also limited in its features and offers no options. A simple librarian function works in conjunction with the linker, but the programs produced by Hippo-C are nonetheless excessively large.

Hippo-C's manual is almost, but not quite, adequate. The highlight is its index. The documentation is readable but provides little help in terms of creating stand-alone Macintosh applications. For example, the manual does not address the differences between the string formats of C programs and the Pascal-type strings expected by the Macintosh ROM routines.

The manual discusses how Apple's MDS RMAKER (resource maker) program can be used to add resources to a program made by Hippo-C, but RMAKER is nowhere to be found. The user is simply advised that RMAKER is available from Apple. Combine this with the inability of Hippo-C's assembler to directly support resources and Macintosh application developers are left high and dry as far as including resources in their programs.

Although Hippo-C does not directly support C floating-point operations, Hippopotamus devotes a chapter in its manual to describing how to take advantage of the Macintosh's built-in floating-point support. Using the techniques described in this chapter, the C programmer can do a fair number of floating-point operations (such as +, −, *, /, sin, cosine, etc.). In addition, a definition file provided on the Hippo-C disk can be included in C programs to set up typedefs for C floating-point types. Although the

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Listing 6: *The* INTMATH *benchmark.*

```
/*          intmath.c          */
#include  "stdio.h"
#defint COUNT 10000
main()
{
      int i, j, k;
#include  "startup"
      for (i = 0; i < COUNT; ++i) {
         j = 240; k = 15;
         /* test byte-byte combinations */
         j = (k * ( j / k ));
         j = (k * ( j / k ));
         j = ( k+k+k+k+ k+k+k+k+ k+k+k+k+ k+k+k+k+k );
         k = (j -k-k-k-k -k-k-k-k -k-k-k-k -k-k-k-k );
         /* test byte-word combinations */
         j = (j << 4); = (k << 4);
         j = (k * ( j / k ));
         j = (k * ( j / k ));
         j = ( k+k+k+k+ k+k+k+k+ k+k+k+k+ k+k+k+k+k );
         k = (j -k-k-k-k -k-k-k-k -k-k-k-k -k-k-k-k );
         /* test word-word combinations */
         j = (j << 4); k = (k << 4);
         j = (k * ( j / k ));
         j = (k * ( j / k ));
         j = ( k+k+k+k+ k+k+k+k+ k+k+k+k+ k+k+k+k+k );
         k = (j -k-k-k-k -k-k-k-k -k-k-k-k -k-k-k-k );
      }
#include  "done"
}
```

Listing 7: *The* QSORT *benchmark.*

```
/* QSort.c  */
/* sorting benchmark—calls random the number of times specified by MAXNUM to
   create an array of long integers, then does a quicksort on the array of longs.
   The program does this for the number of times specified by COUNT.
*/
#include  "stdio.h"
#define MAXNUM 1000
#define COUNT 10
#define MODULUS ((long) 0x20000)
#define C 13849L
#define A 25173L
long seed = 7L;
long rrandom();
long buffer [MAXNUM] = {0};
main()
     {
     int i,j;
     long temp;
```

(continued)


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```
#include  "startup"
     printf("Filling array and sorting %d times\n",COUNT);
     for (i=0; i<COUNT; ++i)
       {
       for (j=0; j<MAXNUM; ++j)
         {
         temp = rrandom(MODULUS);
         if (temp < 0L)
           temp = (-temp);
         buffer[j]=temp;
         }
     printf("Buffer full, iteration %d\n",i);
     quick(0,MAXNUM,buffer);
     }
#include  "done"
     }
quick(lo,hi,base)
     int lo, hi;
     long base[];
     {
       int i,j;
       long pivot, temp;
       if (lo<hi)
         {
         for (i=lo,j=hi,pivot=base[hi];     i<j; )
           {
           while (i<j && base[i]<pivot)
             ++i;
           while (j<i && base[j]>pivot)
             --j;
           if (i<j)
             {
             temp=base[i];
             base[i]=base[hi];
             base[hi]=temp;
             quick(lo,  i-1, base);
             quick(i+1,  hi, base);
             }
     }
long rrandom(size)
     long size;
     {
     seed = seed * A + C;
     return(seed  % size);
     }
```

steps involved are tedious, this does give you a degree of floating-point functionality.

In my short time spent working with Hippo-C, I found several significant bugs and glitches that hampered my work. One example: When I interrupted the execution of a make batch file, I lost a great deal of the Macintosh's available memory. I suspect this is due to the memory not being released to the Macintosh's memory manager as it should have been. Subsequent attempts to use the compiler often failed, informing me that not enough memory was available (even using my 512K-byte Mac) to compile the program. I had to perform a full system reset to correct the situation.

The bugs in Hippo-C can probably be explained by the fact that the version I received was one of the first production models.

The operative word for Hippo-C is

(continued)

limited. Despite some nice touches, the HOS working environment lacks the power needed for true professional software development. The compiler, assembler, and linker are all inflexible. The sum of the parts does not add up to a professional development system for the Macintosh.

MAC C

The Mac C compiler from Consulair is designed to be integrated into the Apple Macintosh 68000 Development System. The MDS text editor is used to create C source files from which Mac C produces assembly code. You then assemble and link this into an execution file with the MDS package. The combination of Mac C and MDS gives you a fully integrated C compiler/assembler/linker/debugger system that supports most of the standard C language and provides useful Macintosh-specific enhancements.

Optionally available from Consulair is Mac C Toolkit, a support library that would be useful to any serious Mac C user (either a Macintosh software developer or just an intensive C programmer). Also available is Mac C Examples, a disk of C source code demonstrating a variety of Macintosh interfacing techniques. This is a must for anyone starting down the difficult path of learning how to develop software for the Mac.

If you like Apple's MDS, you should enjoy Mac C. This friendly C compiler was created by Bill Duvall, who wrote MDS. It becomes apparent very quickly that the same philosophies are at work in these two products. The advantage to this is that the separate systems intertwine quite comfortably.

The documentation for Mac C comes in the form of a programmer's guide consisting of 135 pages, 52 of which are appendixes. The manual is concise yet very informative. Despite an abundance of distracting spelling errors, I like the Mac C manual. It tells you what you need to know to use the compiler without extraneous information.

Consulair's Mac C Toolkit offers an array of tools fashioned especially for use in developing Macintosh applications. The Toolkit is a disk of some 120 routines and C functions. Best of all, the C source code is included for all the Toolkit operations, making it a breeze to modify them for your particular needs or learn how to work with the Mac more effectively.

The Toolkit offers high-level functions for support of the Macintosh environment and user interface (including input/output [I/O] operations such as disk-file or serial-port interaction, string-manipulation facilities, and memory-management features), as

(continued)

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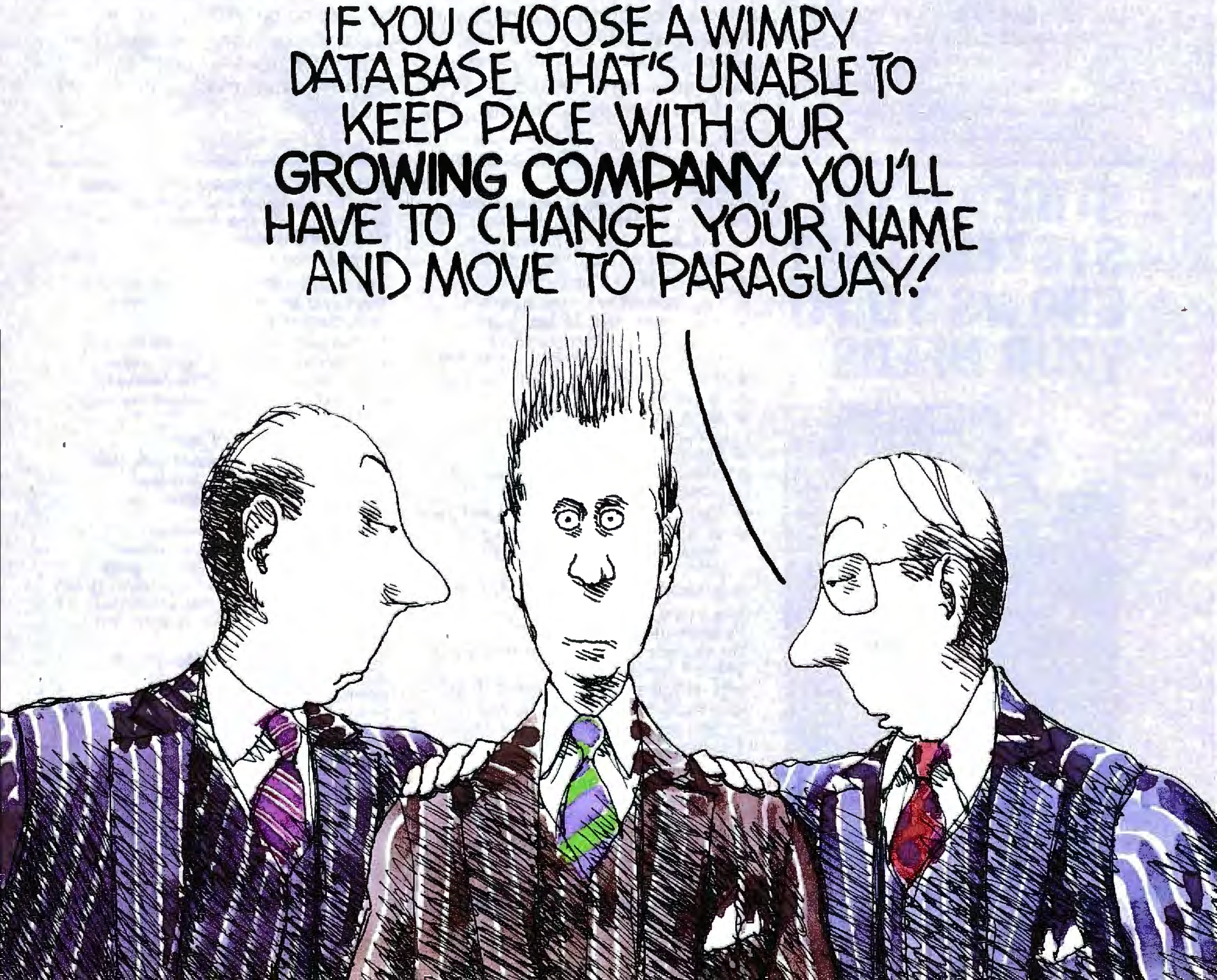

A revealing comparison between R:base 5000, dBASE III and Revelation

	Revelation	R:base 5000	dBASE III
Maximum Characters/Record	65000	1530	4000
Maximum Fields/Record	65000	400	128
Relational Operators	9	6	6
Data Dictionary	Yes	Yes	No
Procedural Language	Yes	Yes	Yes
Variable-Length Fields	Yes	No	No
Report Writing Features:			
A) Access to Date/Time	Yes	Yes	No
B) Row or Column Formats	Yes	Yes	No
C) Accessible Tables	6000	40	10
Password Security	Yes	Yes	No
Definable Data Entry Rules	Yes	Yes	No
Pre-Defined Macros	Yes	Yes	Yes
Application Generator	Yes	Yes	No
Application Compiler (1)	Yes	Yes	No
Run-Time Module	Yes	Yes (2)	Yes (2)
Natural Language	Yes	Yes (3)	No
Network Version	Yes	No (4)	No

1) From original manufacturer; 2) Available soon; 3) Extra cost option; 4) Announced for late 1985. dBASE III is a trademark of Ashton-Tate. R:Base 5000 is a trademark of MicroRIM, Inc. MS is a trademark of Microsoft. IBM is a registered trademark of International Business Machines Corporation. NetWare is a trademark of Novell, Inc.

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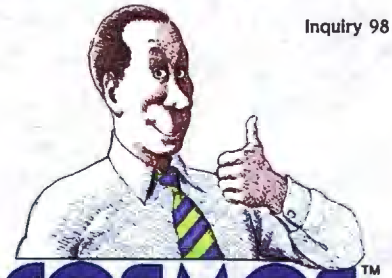

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well as low-level I/O functions that provide such things as "Teletype simulation windows" (to handle the Macintosh window creation and manipulation chores for programs that need simple text windows) and easy access to the Mac keyboard, serial ports, mouse, and disk files.

For accessing the Macintosh ROM Toolbox routines, Mac C offers a direct interface without the use of any "glue code." The compiler recognizes ROM function calls and emits the proper code to set up parameters as required by the ROM routines. However, strings must be converted back and forth between C and Pascal string types as appropriate. (Mac C supplies efficient functions that do these conversions.)

Unlike most compilers, which use the system stack to pass parameters to functions, Mac C uses the microprocessor's internal registers to hold the first seven parameters, while the stack gets any extras. Since most C functions have fewer than seven parameters, the stack is not often used for parameter passing. I suppose the idea is that passing parameters through registers results in faster execution time since less stack activity is required. In practice, this may not always work out since any function that wishes to make a number of other function calls itself needs to save its registers on the stack anyway. However, the QSORT benchmark function, which tests the efficiency of function calling and parameter passing, was Mac C's only first-place score. The negative side of the use of registers for parameter passing is that it precludes implementation of the register variable feature. Thus, even though Mac C won the standard QSORT benchmark, it was left in the dust when Aztec C kicked into high gear with the use of its register variables.

Mac C supports in-line assembly code. Additionally, the assembler programmer can use the full capabilities of the Apple MDS assembler and easily link pure assembly modules with modules generated by Mac C. In fact, since Mac C itself emits assembly source code that is subsequently assembled using the MDS assembler, it is possible for the programmer to directly modify the assembly file produced by Mac C.

The Mac C Examples disk is a real bargain at $25. This disk includes source code for a variety of C programs that demonstrate different Macintosh program-development techniques. It covers creating desk accessories in C, using dialog boxes, icons, events, windows, ports, and even working with the sound-generating capability of the Mac. You will have to work a little at making the most of these tools since they are self-

(continued)

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When I learned to fly I considered it the ultimate challenge. That was before I tried to get my first IBM PC up and running, configured like I wanted.

I had decided that I wanted my PC to be 100% IBM. I soon found that though there were many IBM PCs advertised in the magazines at very attractive prices, the only thing about them that said IBM was the mother board, case and a poorly laid out keyboard. The other parts were made by third party vendors. In some cases these add on boards were by recognized companies and in other cases they were offshore knockoffs of inferior quality.

I chose instead to buy a bare bones IBM PC, put in the exact cards I wanted and possibly save some money. I compared features and prices of all the cards advertised in the major computer magazines, decided on my best buy and called in several orders. A week or so later the parts started to arrive. I opened up the case of my IBM and went to work. It was not a pretty sight. Three months and a hundred very frustrating hours later I had the system I wanted. It contained a 10 meg hard disk, maximum memory, modem, ports, a Key Tronic keyboard and a good video board. The computer ran alright and I was fairly happy with it.

Total time spent working on the PC, calling the board manufacturers for missing information and installing batch files and patches to use the new features? About as much time as I spent training to fly high performance aircraft. How much extra money? It's probably cheaper learning to fly.

It was with those seemingly endless hardware loops still fresh in my mind that I started PS Computers. Taking into consideration all the good and bad points of the IBM PC/XT we went out into the marketplace and purchased in volume the finest PC components at the best prices. We picked out a faster mother board, a more versatile multifunction card, a heavier duty power supply, a VLSI hard disk controller, the latest video board, and nice quiet drives.

Very carefully and with great attention to detail we install these proven components in a case identical in appearance to the IBM PC. We call this computer the Turbo 640.

COMPATIBILITY

If a program runs on the IBM PC, it will run on the Turbo 640. I use Dbase III, Lotus and Microsoft Word daily on my PS Turbo 640. In the turbo mode (selected with three keystrokes) the increase in program execution speed is immediately evident. Peter Norton's System Information program assigns the PS Turbo 640 a processing speed factor of 1.4 in comparison to an IBM PC. That's 40% faster

VIDEO

The video card and monitor decide what you will and will not see when you turn on your PC. Basically, the options are monochrome text, high resolution graphics and color graphics. Generally speaking, if a PC type computer has graphics capabilities the text will be displayed as fuzzy pixel generated characters.

The PS Turbo 640 is an exception. The 640 uses the hottest display card on the market - Paradise Systems' MGC II. The MGC II displays crisp monochrome text, high resolution graphics and color graphics on the 640's 12" TTL amber monitor. Color graphics (like Flight Simulator) are converted to 16 shades of amber by the MGC II; therefore, they appear sharper than when viewed on a color monitor. Though the MGC II is standard with every Turbo 640 you may never realize it's there. You don't have to set any switches and there are no software drivers to load. If you ever need to use a color monitor with the Turbo 640, you're in luck - the MGC II gives great color on any RGB monitor.

MEMORY

One of the most common PC upgrades is additional memory. It's purchased as little black ICs that are pushed into sockets on a circuit board. The maximum contiguous memory that a PC type computer can use is 640K - exactly the amount that comes already installed right on the Turbo 640 mother board. This means you'll never have to find out for yourself how easily the little leads of those chips bend over backwards and break off.

IO

The PS Turbo 640 system includes a multifunction card that will handle four disk drives, has two serial ports, a parallel port, a game port and a battery backed up clock. Two front panel LEDs indicate power on and high speed processor mode.

KEYBOARD

The Turbo 640 comes with a 5151 style keyboard. The dedicated arrow keys, numeric keypad and caps lock all have LED status indicators. Unlike the stock IBM PC keyboard, you don't need fingers like E.T. to effectively reach the return key.

MONITOR

The 640's monitor is a high resolution, TTL, nonglare amber display. The power cord plugs into the back of the computer allowing the entire system to be powered by one wall outlet and to be turned on with the computer's power switch. The swivel base provides effortless adjustment of the monitor for best viewing angle.

TECH STUFF

The PS Turbo 640 uses the 8088-2 processor running at a keyboard selectable 4.77 or 7.50 MHZ. The mother board is an extremely well constructed product of Japan. There are 2 buss extension points and 8 expansion slots (the floppy based system has two slots taken; the hard disk version has three taken). A socket is provided for the 8087-2 coprocessor chip. The 135 watt power supply is standard on all Turbo 640s, providing ample power for specialty add on cards.

The 5.25" floppy drives are manufactured by TEAC and the hard disk drives are from Seagate. Both are quiet and very reliable.

SOFTWARE

We want to be sure you can use your new computer the moment you take it out of the box, so the Turbo 640 system includes software.

RAM disk and printer spooling programs are provided as well as the PopUp Deskset from Bellsoft. PopUps are utility programs that provide you with memory resident functions like a calculator, notebook, clipboard, alarm clock, calendar and DOS commands. When you need any of these facilities, no matter how deep into your spreadsheet, database or document you might be, two keystrokes pop any of them up on your screen. When you're finished just hit the escape key; your program never knew you were gone.

IBM PC DOS 2.10 and the full DOS manual are included. The Turbo 640 runs Basic just fine, however Basic and Basica on the PC DOS disks are proprietary to IBM. PC DOS Basic will run only if your system contains IBM ROM Basic. We've chosen not to provide these extra ROMs with the Turbo 640 package. ROM Basic is available and can be installed in existing sockets on the 640's mother board.

Having three different Basics running around inside your computer at the same time borders on being an unnatural act. To save you the headache of figuring out which Basic to use when and for what; Turbo Pascal 3.0 from Borland International is packaged with every Turbo 640 system.

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Listing 8: *The* POINTER *benchmark.*

```
/*        pointer.c        */
#include  "stdio.h"
#define COUNT      10000
#define ALLOTTED   128
main()
{
    char workarea[ALLOTTED],    *ptr;
    int i;
#include  "startup"
    for (i=0; i < COUNT; ++i)  {
      ptr = workarea;
      while (ptr < (workarea + ALLOTTED))  {
        *ptr = ' ';
        ++ptr;
      }
    }
#include  "done"
}
```

Listing 9: *The* SIEVE *benchmark.*

```
/*        sieve.c        */
#include  "stdio.h"
#define TRUE    1
#define FALSE   0
#define SIZE    8190
char flags[SIZE+1] = {0};
main()
{
    int i,prime,k,count,iter;
#include  "startup"
    for (iter=1; iter <= 10; iter++)  {
      count=0;
      for (i=0; i<=SIZE; i++)
        flags[i] = TRUE;
      for (i=0, i<=SIZE; i++)  {
        if (flags[i])  {
          prime = i+i+3;
          for (k=i+prime; k<=SIZE; k+=prime)
            flags[k] = FALSE;
          count++;
        }
      }
    }
#include  "done"
    printf("\n%d  primes.", count);
    getchar();
}
```

documenting (that is, the only way to figure out what is going on is to read through the comments in the source code itself), but there are some useful things here.

Mac C's major omission is support of floating-point numeric operations. It is possible for a skilled and determined programmer to set up typedefs

(continued)

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to support float variable types and use the floating-point package supported within the Macintosh Toolbox; however, this is not a trivial task and is not documented or supported by Mac C.

Unfortunately, the things that have the greatest negative effect on Mac C are due to three elements over which it has no direct control: the dreadfully slow Macintosh disk drives, the inherent disadvantages of the Macintosh interface as a development environment, and limitations of the MDS linker. Since Mac C is not the only compiler to suffer from these problems, I will not discuss them until later.

There is a lot to like about Mac C. It has a good manual, useful Toolkit routines, excellent interface to the ROM Toolbox, and copious amounts of documented source code. The system works as a unit to provide a willing and friendly assistant in the development process. However, Mac C has enough negative aspects to hamper the efforts of a serious application developer.

[Editor's note: Just prior to press time, Consulair announced a number of updates for its Mac C package. These include floating-point math, structure assignment, passing structures by value, enumerated types, improved code optimization, and others. The upgrade with floating-point math is $50; the upgrade without is $5. Contact Consulair for further information.]

MEGAMAX C

Megamax C from Megamax Inc. is a one-pass C compiler with an optional "code improver" (optimizer), intelligent linker, librarian, and disassembler. Megamax lets you select from two text editors. The first is Apple's MDS EDIT. The second is an editor that works much like Apple's EDIT but is missing a few of its features and requires about one-third as much disk space. In addition, Megamax has licensed and included RMAKER.

The Megamax C compiler converts C source directly to object code that is ready for linking. There is no separate assembler available. However, in-line assembly is supported, allowing you to mix assembly and C code. In fact, the support of the C #define within in-line assembly modules effectively gives you assembly macro support. However, the lack of a separate assembler needlessly inhibits the developer from fully exploiting the limits of the Mac's potential. There are times when I want pure C code, other times when I want to mix C and assembly, and still other times when I want pure assembly-coded programs or modules.

Curiously, even though no assembler is provided, Megamax does include a disassembler. This would be even nicer if an assembly-level debugger were in the package. You are left

(continued)

Table 4: *Results of the compile-time test. The Frustration Factor is a subjective item that tries to indicate the amount of user interaction required for each compilation run; for example, can you start the compilation and go do something else or do you have to nursemaid the computer the entire time?*

	Time Required (in minutes)	Frustration Factor
Softworks C	7:27	high
Mac C	7:47	high
Aztec C	4:07	
With RAM disk	0:40	low
Hippo-C	5:20	medium
Megamax C	4:16	medium
DeSmet C on IBM PC	1:20	low
With RAM disk	0:18	

to fend for yourself as you try to determine why your programs seem to be zapping the Mac as they execute. If Megamax can license Apple's editor and resource maker, why not also license and include MDS's fine assortment of debuggers?

Megamax's intelligent linker is very good, adding to a program only those standard C library functions actually used. This compiler consistently generated the smallest program files of the bunch. A good librarian further enhances the efforts of the linker and permits easy additions, extractions, and deletions from the library file.

Megamax C gives you two options for improving the execution times of a program. First, you can use up to four register variables. Second, you can use an optional optimizing pass just after compiling a program module. This is a traditional peephole optimizer that in the case of the benchmark tests seemed to offer speed improvements from 0 percent to 5 percent and code-size reduction of no more than one-half of 1 percent. Making this pass optional is a nice touch since it permits the programmer to skip the optimization in order to speed up the development cycle of a program as it is being debugged. All the Megamax C benchmark programs used this optimizing pass.

(continued)


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Megamax C uses glue routines to interface a C program to the Macintosh ROM Toolbox routines. These routines provide fully automatic interfacing to the ROM Toolbox, including setting function parameters in the proper order and converting between C- and Pascal-style strings as needed.

The manual for Megamax C is good and has a real index that covers all chapters and appendixes. After spending what seemed like forever scanning and rescanning the other compilers' manuals for information, it was a relief to find quick access to any topic I needed.

Megamax C offers numerous functions from the standard C library. Unfortunately, no source code is available for these. Furthermore, there are few additional support functions.

The outstanding features of Megamax C are its linker that produces very small run-time files (at least as compared with the other compilers in our group), its completely automated interface to the Macintosh ROM Toolbox, and its support of register variables and floating-point operations. Negative aspects of Megamax C are its lack of either an assembler or assembly-level debugger, its scarcity of special Macintosh-oriented support functions, and its lack of source code for any of its standard C functions.

Listing 10: *Register version of the* FRAME *benchmark.*

```
/*          frame.c          */
#include  "stdio.h"
#define   COUNT 10000
main()
{
     register int i;
#include  "startup"
     for (i = 0; i < COUNT; ++i) {
          ;
     }
#include  "done"
}
```

SOFTWORKS MACINTOSH C

Softworks Macintosh C from Softworks Limited is a three-pass optimizing compiler designed to be integrated into Apple's Macintosh Development System. The result is a tightly knit unit that uses the MDS editor to create the C source code and launch the Softworks C compiler. The Softworks compiler produces assembly-language source code to be assembled and linked by MDS into an executable file that can be run. The integration of Softworks C with Apple's MDS is seamless.

At the core of Softworks C is a generic Whitesmiths Ltd. 68000-

(continued)

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Listing 11: *Register version of the* INTMATH *benchmark.*

```
/*        intmath.c        */
#include  "stdio.h"
#define COUNT 10000
main ()
{
     int i;
     register int j, k;
#include  "startup"
     for (i = 0; i < COUNT; ++i) {
        j = 240; k = 15;
        /* test byte-byte combinations */
        j = (k * ( j / k ));
        j = (k * ( j / k ));
        j = ( k+k+k+k+ k+k+k+k+ k+k+k+k+ k+k+k+k );
        k = (j -k-k-k-k -k-k-k-k -k-k-k-k -k-k-k );
        /* test byte-word combinations */
        j = (j << 4); = (k << 4);
        j = (k * ( j / k ));
        j = (k * ( j / k ));
        j = ( k+k+k+k+ k+k+k+k+ k+k+k+k+ k+k+k+k );
        k = (j -k-k-k-k -k-k-k-k -k-k-k-k -k-k-k );
        /* test word-word combinations */
        j = (j << 4); k = (k << 4);
        j = (k * ( j / k ));
        j = (k * ( j / k ));
        j = ( k+k+k+k+ k+k+k+k+ k+k+k+k+ k+k+k+k );
        k = (j -k-k-k-k -k-k-k-k -k-k-k-k -k-k-k );
     }
#include  "done"
}
```

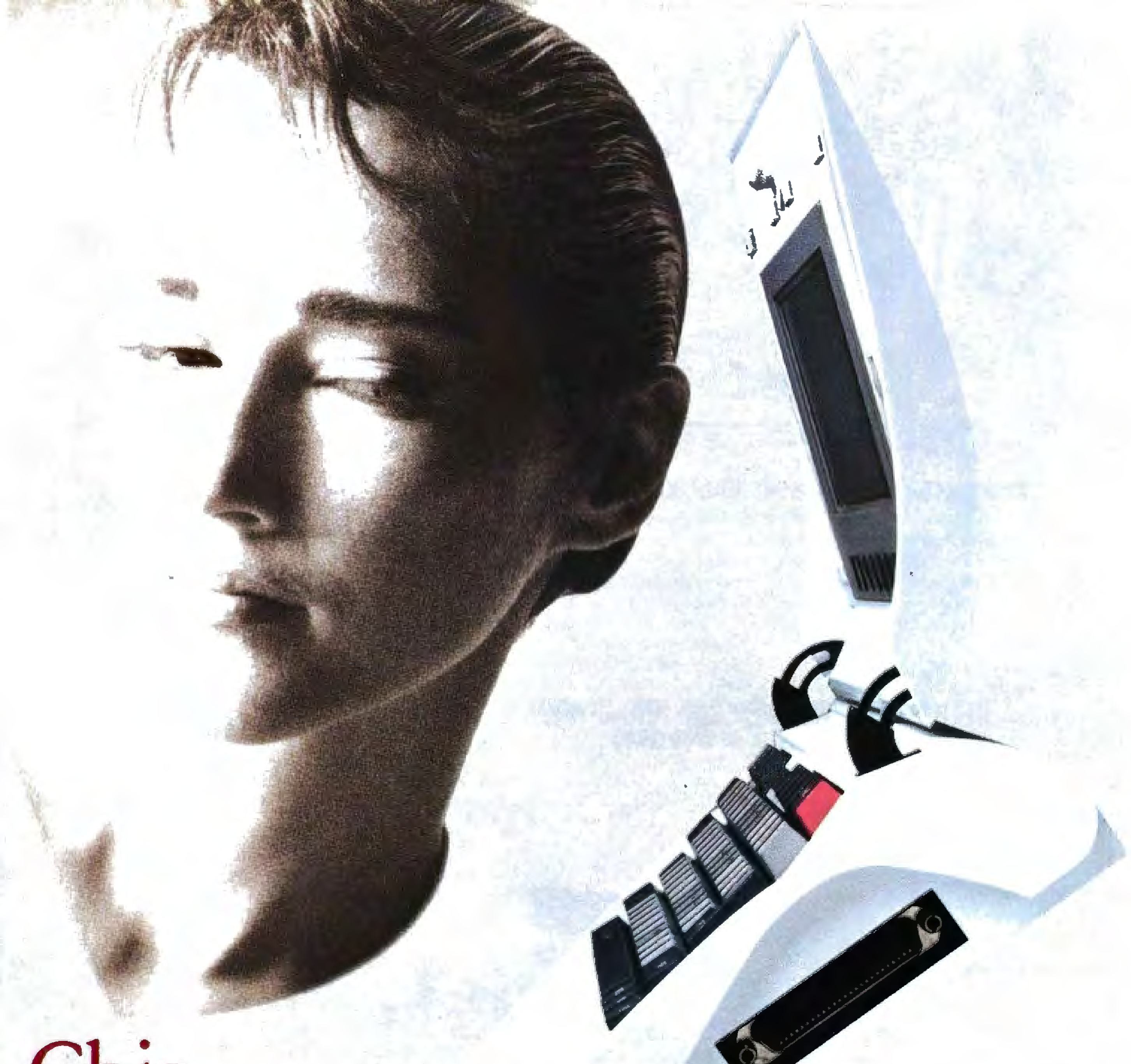
based C compiler. Draped around this inner core is a Macintosh user interface and some mechanisms that let you access the Macintosh ROM Toolbox. Whitesmiths compilers have been available for a variety of machines for some time. Using such an established and mature compiler as its nucleus should theoretically help to give the Softworks C user a well-designed, time-tested compiler without the "infant" bugs that often plague new software. However, theory and reality often do not converge. Such is the case with Softworks C.

Actually, the "documentation" for Softworks C is the major source of difficulty. This supposed documentation consists of 5 stapled pages of notes entitled "Instructions for Softworks Macintosh C" and a 220-page generic Whitesmiths C programmer's manual. While the Whitesmiths manual is fairly comprehensive, the differences between the system it describes and the Softworks compiler are vast. More than half of the Whitesmiths manual does not relate at all to the facilities found in Softworks C.

"Instructions for Softworks Macintosh C" would be almost laughable if its shortcomings were not so serious. It is virtually useless, spending three of its five pages discussing implementation restrictions and known bugs without a good discussion of anything. For example, the important topic of interfacing C code with the Macintosh ROM Toolbox routines consists of seven sentences. Woefully inadequate.

If you turn to the Whitesmiths manual and scan the descriptions of C functions, you might well begin to get excited about the range and power of the compiler. However, when you turn back to "Instructions

(continued)



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WORK SPACE COMPUTER INC. U.S. REPRESENTATIVE OFFICE. 3848 Carson St. Suite 301 Torrance, California 90503, U.S.A. *Phone:* 213-540-1553. *Telex:* 322800 WORK SPACE for Softworks Macintosh C," your hopes are dashed as you read: "The UNIX-style library mentioned in Whitesmiths manual is included in this release, but not all of Whitesmiths functions are included." You are instructed to use only those UNIX functions mentioned in pages 22 to 24 of chapter 2, ignoring those described in pages 26 to 143. The reader is cheerfully told that "explanations of the UNIX-style calls are available in most C tutorials." No complete list of what functions are implemented is to be found.

Well, things are grim but not all is lost. Most of the functions commonly found in standard C libraries are in fact included in the Softworks compiler. These functions work well and efficiently. However, the lack of adequate and organized documentation is a continual aggravation. You are never quite sure which C functions are available and which ones are not. There are 10 separate library modules on the Softworks C disk but no clue as to which library contains which functions.

It may be that Softworks is in the process of bringing its documentation up to par. On one enclosed disk entitled "Documentation Under Construction," I found a number of MacWrite document files that describe the interface to each of the Macintosh ROM Toolbox routines. They included a brief synopsis of what each routine does, what parameters it expects, and where in Apple's *Inside Macintosh* manual you can find more information.

The Softworks C compiler itself is not bad, with some things working in its favor and others against it. It supports float operations, register variables, and most standard C system-interface and library functions. However, the source code for these library functions is nowhere to be found, and there are no additional support functions beyond the standard C libraries, such as those found in Mac C and Aztec C to help in specific areas of Macintosh program development.

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(continued)

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	Video Camera	User	•	•	—
RECOM-MENDED	Pointing Device	•	•	•	1/2 Slot
	ScreenMaster	•	•	•	1/2 Slot
	Camera Accessory Kit	User	•	•	—
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Inquiry 60

Listing 12: *Register version of the* QSORT *benchmark.*

```
/* QSort.c  */
/* sorting benchmark—calls random the number of times specified by MAXNUM to
   create an array of long integers, then does a quicksort on the array of longs.
   The program does this for the number of times specified by COUNT.
*/
#include  "stdio.h"
#define MAXNUM 1000
#define COUNT 10
#define MODULUS ((long) 0x20000)
#define C 13849L
#define A 25173L
long seed = 7L;
long rrandom();
long buffer [MAXNUM] = {0};
main()
    {
    int i,j;
    long temp;
#include  "startup"
    printf("Filling array and sorting %d times \ n",COUNT)"
    for (i=0; i<COUNT; ++i)
      {
      for (j=0; j<MAXNUM; ++j)
        {
        temp = rrandom(MODULUS);
        if (temp < OL)
          temp = (-temp);
        buffer[j]=temp;
        }
    printf("Buffer full, iteration %d \ n",i);
    quick(0,MAXNUM,buffer);
    }
#include  "done"
    }
quick(lo,hi,base)
    int lo, hi;
    long base[];
    {
```

piler, the Softworks compiler had me anticipating some pretty spectacular run times for the standard C benchmark tests. But there was really nothing that distinguished it from the middle of the pack.

I found some peculiarities about Softworks C somewhat disturbing. For example, every program *must* include at least one initialized global variable. If you neglect this, your program will compile and assemble just fine. But when you try to link the program, you will receive a number of unexplained "undefined external" error messages. The first few times this happens, you are sure to waste a significant amount of time trying to determine the cause of these errors.

I also discovered an incompatibility between the Softworks compiler and the MDS assembler when I tried to use the feature for structuring bit fields. The compiler had no problem emitting code to handle my bit fields, but the assembler choked when it tried to assemble the code produced by the compiler. After witnessing this, I would not be surprised to find other instances of incompatibility between the compiler and the assembler.

Softworks C is the only compiler of the bunch that does not have provisions for automatically opening and manipulating text windows for displaying standard printf operations. If you compile and run a standard C program using Softworks C, be prepared to see all text placed direct-

(continued)

 Inquiry 31

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```
          register int i,j;
          long pivot, temp;
          if (lo<hi)
            {
            for (j=lo,j=hi,pivot=base[hi];      i<j; )
              {
              while (i<j && base[i]<pivot)
                 ++i;
              while (j<i && base[j]>pivot)
                 --j;
              if (i<j)
                {
                temp=base[i];
                base[i]=base[hi];
                base[hi]=temp;
                quick(lo,  i-1, base);
                quick(i+1,  hi, base);
                }
        }
long rrandom(size)
        long size;
        {
        seed = seed * A + C;
        return(seed  % size);
        }
```

ly onto the standard gray Mac background, making it very difficult to read.

Softworks C error messages have a couple of shortcomings. Whenever an error is found during compilation, an error message is displayed. However, before you have a chance to read it, the message is covered up by a dialog box announcing that an error has been found. You are prompted to point the mouse and click on a dialog button to acknowledge that you are aware an error has occurred, but when you do, you still are not shown the covered error message. After a delay of many seconds, you are taken back to the MDS editor, where the C source file is opened in one window and, finally, a window opens to display the error message. However, all error messages are linked to the source files only by line numbers, so you have to count down lines from the top of the file. There is no excuse for a computer program forcing you to do such mundane tasks.

Aside from its documentation, the most significant shortcomings of Softworks C result from limitations of the Macintosh user interface and the MDS linker.

My feelings about Softworks C can be summarized in one word: disappointing. This compiler has a lot of potential. It is a complete implementation of C with decent power, but a number of areas must be cleaned up before it can be considered a professional development system.

PROBLEMS WITH MDS LINKER

As I have mentioned, Mac C and Softworks C use the MDS linker to combine or link one or more object files into a single executable application program. Unfortunately, some nega-

(continued)

Listing 13: *Register version of the* POINTER *benchmark.*

```
/*        pointer.c        */
#include  "stdio.h"
#define COUNT        10000
#define ALLOTTED     128
main()
{
     char workarea[ALLOTTED];
     register char ptr;
     register int i;
#include  "startup"
     for (i=0; i < COUNT; ++i)  {
        ptr = workarea;
        while (ptr < (workarea + ALLOTTED))  {
           *ptr = ' ';
           ++ptr;
        }
     }
#include  "done"
printf("ALLOTTED=%d\n",ptr-workarea-1);
}
```

tive aspects of the MDS linker dramatically affect the ease of use and the efficiency of both Mac C and Softworks C as professional software-development systems. The root of the problem is the fact that the MDS linker has no notion of a library.

In the software-development world, a library is a special file that contains the object code for a number of operations commonly used by many programs. For example, a library might store the code for all the standard C functions. A linker that knows about such libraries can use them to selectively pull into the final executable file only those functions actually needed by the program being linked.

Linkers (such as the one used by MDS) that do not have the facilities to handle libraries must instead be supplied object-file modules contain-

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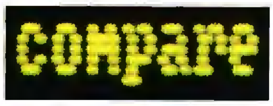

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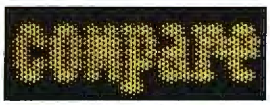

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Listing 14: *Register version of the* SIEVE *benchmark.*

```
/*          sieve.c          */
#include  "stdio.h"
#define TRUE   1
#define FALSE  0
#define SIZE   8190
char flags[SIZE+1] = {0};
main()
{
    int iter, count, prime;
    register int i,k;
#include  "startup"
    for (iter=1; iter <= 10; iter++)  {
      count=0;
      for (i=0; i<=SIZE; i++)
        flags[i] = TRUE;
      for (i=0, i<=SIZE; i++)  {
        if (flags[i])  {
          prime = i+i+3;
          for (k=i+prime; k<=SIZE; k+=prime)
            flags[k] = FALSE;
          count++;
        }
      }
    }
#include  "done"
    printf("\n%d  primes.", count);
    getchar();
}
```

ing all the functions needed by the program. But such a linker cannot select which portions of a given module are needed and which are not. Rather, the entire object file must be included in the executable program, thus needlessly increasing the program size.

In addition to causing larger program sizes, the omission of library facilities in a linker usually complicates life for the programmer in another way. Linkers that know about libraries are usually smart enough to know about one or more standard libraries. For example, such a linker may know the name of a library containing all the standard C functions. Anytime a C program uses one of these functions, the linker automatically goes to that library to find the code that performs the requested function.

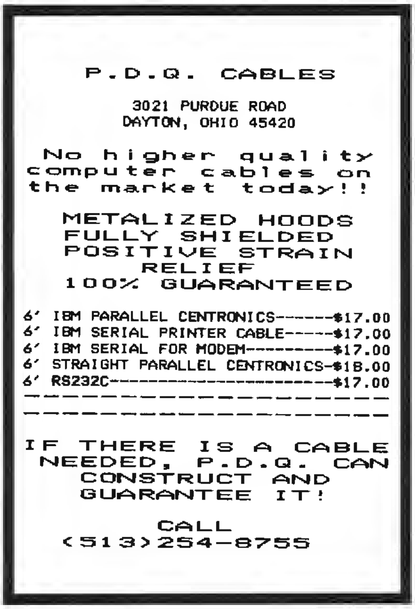
Since the MDS linker knows nothing about standard libraries of functions, it becomes the programmer's responsibility to tell the linker which object file (or files) contains them. This creates a dilemma. If all the standard functions are grouped into a single object file, life is easier for the programmer, but the resulting program size quickly balloons. If the standard functions are broken into multiple object files, the final program size can be reduced, but the programmer must then be concerned with which of these object files to include or leave out. On top of this, when little or no documentation is included to tell the programmer which modules contain which functions, the result is a good deal of frustration.

USER INTERFACE

The makers of our Macintosh C compilers have taken two fundamentally different approaches in the area of the user interface, the way in which the programmer and the development system interact. On the one

(continued)

Inquiry 169



Inquiry 297

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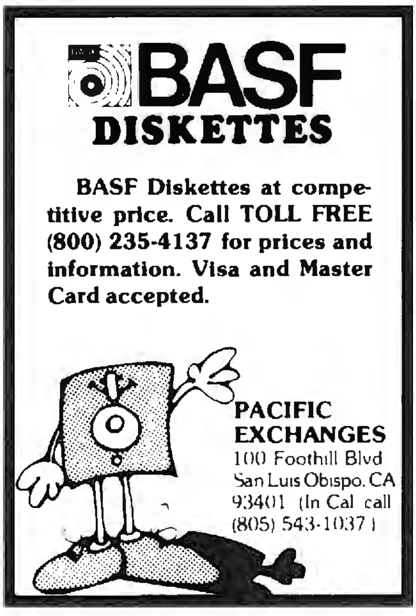

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hand, we find Mac C, Megamax C, and Softworks C offering the Macintosh's visually oriented user interface. On the other hand, Aztec C and Hippo-C create a more traditional programming environment oriented almost exclusively to receiving commands via the keyboard and responding with text on the display.

I am in general a strong supporter of the Mac's user interface. It can create a friendly and intuitive environment for users to interact with application programs. This greatly reduces the time required to learn new applications and reduces the difficulties of moving from one application to another.

For both practical and philosophical reasons, however, I contend that certain computer applications do not lend themselves well to the Mac user interface. Although time and space do not permit me to fully support this, it is my conviction that software development is just such an application. As long as the traditional command-line environment gives the developer full access to create applications that support the Macintosh environment, it is a potentially more powerful development environment as compared to the Macintosh environment. (Note: I say "potentially" because the quality of a given implementation of a command-line environment may be quite poor. This is demonstrated by Hippo-C's HOS environment.)

The UNIX-like environment of Aztec C gives it an edge over the three compilers based on the Mac environment. Those C compilers using the Macintosh environment are less flexible and more frustrating in the development cycle than Aztec C's more traditional UNIX-like command-line environment. A few examples of the features that greatly assist the programmer in Aztec C's command-line environment but which do not fit readily into the Mac icon-oriented environment include cat, which lets you quickly scan the contents of a text file without entering a text editor; use of global * and ? characters (to do such things as selectively get directory listings of

(continued)

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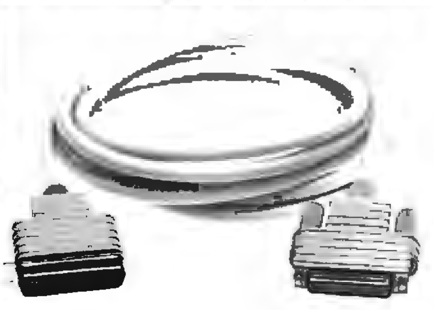

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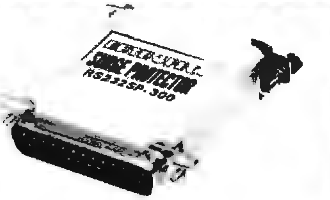

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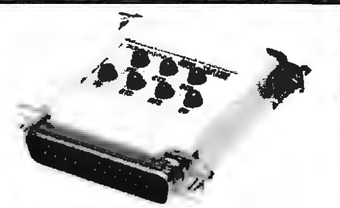

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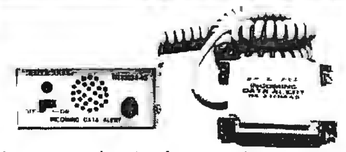

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certain categories of files); redirection of standard input and output; use of files or devices as the source or destination of such redirection; and specification of compile-time, assembly-time, or link-time options when such an operation is invoked.

MACINTOSH PROGRAMMING ISSUES

Any development system designed to create Macintosh applications must address many Mac-specific issues. Unfortunately, space does not permit me to look at either the range or the detail of all these issues for each of our five compilers. However, I'll briefly cover a few of these issues as they relate to the compilers in our group.

Interface to ROM Toolbox: The real power in the Macintosh is due more to the hundreds of functions embedded within its ROM Toolbox than to any other single attribute. Thus, the scope and method of access into this Toolbox provided for by a compiler is of utmost interest to Macintosh programmers.

The ROM Toolbox was designed to be accessed directly by Apple's Lisa-based Pascal compiler. This creates a couple of problems for a standard C compiler. However, due to differences between C and Pascal, any C compiler must provide some mechanism for assisting the C programmer in using the ROM Toolbox.

Our five compilers take two different strategies to provide a smooth interface to the ROM Toolbox. One method is to have the compiler produce standard C programs and then set up special glue routines to tie the C programs into the ROM Toolbox. One glue routine is set up for each Toolbox function. When the compiler spots a Toolbox function call in the C source, it sets up a call to the glue routine associated with that Toolbox function. The glue routine is responsible for coping with any differences between the C calling program and the ROM Toolbox function. An alternative solution to this problem is to embed in the C compiler the knowledge of what the ROM Toolbox needs for each routine. Rather than use a special glue routine, the compiler can issue code that directly calls the ROM routines in the required manner. Direct interfacing maximizes the performance of C programs that use the ROM Toolbox, while glue routines can seriously impair the execution speed of such programs. However, glue routines are easier for a compiler creator to implement, and they keep the compiler "pure" by not making it do anything not C-like.

Parameter Passing: One difference between the way C and Pascal programs

(continued)

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But that's just the weeding out process. We then take each drive that we've put through our tester and test it again with the controller you've requested. We call this a "tested pair."

DOS Doesn't Do It

In case you're thinking that all this is an unnecessary duplication of what DOS does for you, let me explain the disk facts of life.

If DOS did what you may think it is supposed to do when you format the disk, DOS would map around these bad areas. Unfortunately, DOS doesn't do this.

DOS 2.0 and 2.1 can't enter the bad tracks. DOS 3.0 can, but only on the IBM AT. Unfortunately, as the press has so well documentated, the AT's hard disk develops bad tracks later on.

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We believe the problem is so bad, we use a software program that performs a powerful test of your disk drive on all of the IBM or IBM compatible computers—PCs, XTs, and ATs. Our format takes hours to analyze the disk. But when we finish, you know that the bad tracks are really mapped out so you won't write good data that will disappear into a black hole. We even send you a printed statement of our test results.

Our software allows you to type in the bad track locations from the list supplied by the manufacturers, so you'll never write good data to them—even if DOS didn't identify them as bad. The software even lets you save the location of these bad sections to a file, so that you can reformat your disk without spending hours retesting.

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As you might suspect, some hard disks are faster than others in their ability to move from one track of data to another. The time it takes the hard disk to move one-half way between the beginning of the disk to the end is called the "average access time."

The first generation of 10 megabyte hard disks had average access times of 80-85 milliseconds (msec). But computer users love speed, and guess what—the average access time for the new 20 megabyte hard disk in the IBM AT is only 40 msec. (We sell an AT equivalent with only 30 msec access time!)

There are some legitimate reasons for the shorter access time. It's particularly helpful when there are multiple users on the same hard disk. It's also important when running a compiler. But remember, before you get too wrapped up in the access speed, there's always that ST 506 interface which won't let data transfer from the hard disk to the computer any faster than 5 megabits/second. We've bypassed that choke hole, too. If you want the functional equivalent of a Ferrari with a turbocharger, order our 10 Mbit per second 100 megabyte hard disk with 18 msec of average access speed.

Compatibility

To be sure that your hard disk is 100 percent compatible with the IBM XT you don't need to buy the same hard disk that's in the XT. You can't even be sure what brand hard disk it is because IBM, like Express Systems, goes into the marketplace and buys hard disks from several vendors. However, they buy their XT hard disk controller from only one vendor—the same one we do.

You can buy the IBM XT controller from IBM for $495 or you can buy from us, the functional equivalent, manufactured by the same company that makes it for IBM for only $195. Is it the exactly identical IBM XT controller? No, it's better. First, it takes less power, and secondly, it can control from 5 to 32 megabytes—the IBM controller can work with only 10 megabytes. It is 100 percent IBM XT compatible, and 100 percent is 100 percent. If you want to save a slot, we carry a version that lets you operate two hard disks and two floppy disk drives.

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You can operate with more than 32 megabytes (the limit of DOS) through the use of "device drivers." Express Systems can supply you with device drivers for our hard disks for over 32 megabytes formatted. But, if you don't have individual files, or databases that are large, you might want to consider one of our controllers that can divide our 65 megabyate (formatted) hard disk into two equal volumes of 32 megabytes each.

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We offer you a choice between iron oxide and plated media—the stuff that covers the hard disk and gives it its magnetic properties. Iron oxide is,—well, it's rust. If you inadvertently joust your disk, you may cause the low flying head to dig out some iron oxide. A little rust flake can ruin your whole day. Plated media is more resistant to damage, and if it happens, less data is lost.

We offer both types of hard disks. The iron oxide is older





Complete Hard Disk Kits

Formatted MB	Height	Plated Media	Average Access	Transfer Rate	PC or PC/XT	AT
10	½	no	85 msec	5 Mbits/s	$ 395	$ N/A
10	½	yes	85 msec	5 Mbits/s	$ 495	$ N/A
21	½	yes	85 msec	5 Mbits/s	$ 795	$ 595
21	Full	no	30 msec	5 Mbits/s	$ 1,535	$ 1,340
32	½	yes	85 msec	5 Mbits/s	$ 995	$ 795
32	Full	no	30 msec	5 Mbits/s	$ 1,775	$ 1,575
65	Full	no	30 msec	5 Mbits/s	$ 2,295	$ 2,070
100	Full	yes	18 msec	10 Mbits/s	$ 4,995	$ 4,995

Removable Hard Disk

10	½	no	90 msec	5 Mbits/s	$ 1,095	N/A

Tape Systems and Subsystems

Formatted Storage Capacity	Height	Data Transfer Rate (k/sec)	PC or PC/XT	AT
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60 Mbytes Subsystem		88	$ 1,295	$ 1,295
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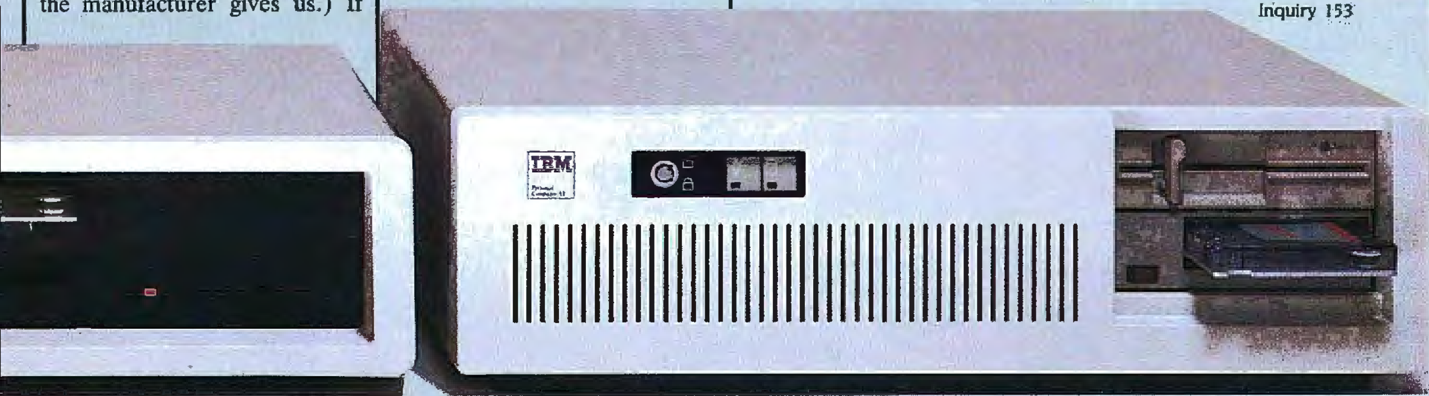

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The ROM Toolbox routines using character strings expect the strings to be in Pascal format.

do things is in the order in which they pass parameters to procedures or functions. While both C and Pascal generally use the system stack to pass such parameters (except for Mac C, which passes parameters via registers), Pascal usually pushes the parameters onto the stack in order from left to right. C works through its list of parameters from right to left. For functions that have either no parameters or only a single parameter, this does not create a problem. However, for multiparameter routines, the list of parameters for C is in reverse order when compared to its Pascal equivalent.

Consequently, when a C program calls a ROM Toolbox function that expects multiple parameters in Pascal order, something must be done. The compilers that use glue routines, including Softworks C, Hippo-C, and Megamax C, rely on these glue routines to actually alter the order of the parameters on the stack as a program executes. Aztec C and Mac C, which offer direct interfaces to the Toolbox, change the output of the compiler so that the parameters for Toolbox function calls are initially placed on the stack in the appropriate order.

Strings: Another difference between C functions and the Pascal-oriented ROM Toolbox procedures and functions has to do with how Pascal and C define text strings. Pascal expects a string of characters to begin with a single byte that contains a count of the number of characters within the string, followed by the characters of the string itself. Consequently, a Pascal string is limited to 255 characters.

A C string is a string of characters followed by a zero (null) byte. This means that there cannot be a character represented by the value 0, but it does not limit the ultimate size of the string. Since the Mac ROM routines were written for use by Pascal, any of these routines that work with character strings expect the strings to be in normal Pascal format.

The situation requires that any C string be converted to its Pascal equivalent before being used as a parameter to a ROM Toolbox routine. Likewise, any string converted to Pascal form or created by one of the Toolbox routines must be changed back into a C string before being used by a standard C function.

Hippo-C and Megamax C glue routines provide for completely automatic string conversions. This eliminates the problem of a programmer neglecting to do the necessary string conversions. However, it does mean that such conversions will occur every time Toolbox routines that use strings are invoked.

On the other hand, Aztec C, Mac C, and Softworks C give the programmer the responsibility of doing conversions. This allows the programmer to determine when the conversions are absolutely necessary. For example, there may be many times when a string can initially be converted from C to Pascal form, left in Pascal form for use by Toolbox calls, and be converted back to a C string only when the resulting string is to be printed out with a standard C function. The compilers that take this route provide efficient string-conversion routines that the programmer can use when needed.

I prefer having the opportunity to make my programs as efficient as possible, so I will gladly take the added burden of deciding when string conversions are necessary rather than have my compiler do this for me. The thing I like most about C as compared with Pascal is the way C offers added flexibility at the cost of providing less "dummy protection" against my potential mistakes.

(continued)

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Segmentation: The maximum program block size that the Macintosh can work with is 32K bytes. However, through a group of ROM Toolbox routines collectively known as the Segment Loader, a programmer can divide large programs (those larger than 32K bytes) into multiple segments. The Segment Loader routines then can be used to bring appropriate program segments into whatever memory space is available as the segments are needed. This allows for very large and complex programs to run even when RAM space is limited.

Obviously, segmentation is important to Mac applications developers, so the support of segmentation by serious software-development systems is required. Of the five compilers in our group, Hippo-C is the only one that does not offer direct support of Macintosh segmentation. The use of the Mac's Segment Loader is quite straightforward in the other four systems.

CONCLUSIONS

Which compiler is best? Of the five compilers in the group, I am most impressed with Aztec C. It won or tied for first in almost every test or comparison. Among other things, I like its flexible UNIX-like shell environment, its extensive documentation, and its numerous and powerful development tools. My only significant criticism of Aztec C is that it's copy-protected. The only people to whom I would recommend any of the other compilers over Aztec C are those allergic to the UNIX environment.

Mac C and Megamax C tie for second place. Each has many strengths and some weaknesses. The interesting thing is how much these two compilers complement each other. One's strength is the other's weakness and vice versa. Megamax's support of floating-point operations and register variables, combined with its easy-to-use intelligent linker and its comparatively low price, just offsets Mac C's abundance of extra support functions and sample programs, source code, support of a full-fledged assembler, and inclusion of assembly-level debuggers.

Softworks C comes in fourth place. It offers a full C development system with a lot of potential, despite the documentation's determination to hide it. The weak link of the MDS linker hurts Softworks C. I do hold out some hope for this compiler. If its creators will come out with real and useful documentation and fix up the loose ends in the system, Softworks C will be up there fighting with Mac C and Megamax C.

Hippo-C pulls up the rear. The severely limited Hippo Operating System creates an unfriendly environment for professional software development. The compiler, assembler, and linker are inherently inflexible. The assembler is outclassed by the full-featured assemblers in Aztec C and the Apple MDS used by Mac C and Softworks C. All in all, Hippo-C just does not offer the sort of power required by professional software developers, nor does it provide for the needs of nonprofessional C programmers.

It is important to note that the compilers I've reviewed are surely not the last word in C development systems for the Macintosh. All the manufacturers of these compilers are working at improving their systems to better provide for the needs of their users. While I was working on this article, updates came through on every one of the five compilers. Many of the changes found in these updates were impressive, forcing me to step back and remove criticisms I had leveled against the earlier versions.

By the time this article is printed, entirely new compilers are bound to be offered. The exciting part is that the ultimate winners will be those of us who want to create C programs with and for the Macintosh. ■

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By Joseph Sugarman, President

The letter-quality printer you see above has a suggested retail price of $1795. It prints bidirectionally at 40 characters per second using a daisy wheel print element, comes with a parallel interface and prints a 13.6 inch line.

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JS&A bought out an entire warehouse full of these printers, promised that we would not display the name on the unit, in our photo, mention the name in our ad nor reveal the name over the phone to avoid embarrassing the manufacturer or his dealers.

I'm so convinced that this is one of the greatest values I've ever offered, I am making a bet and a commitment. First, the commitment. I'm giving you 30 days to test it out. If it's not the best printer value in the country, return it for a full refund including your $25 postage.

Finally, I'll bet that you'll immediately recognize the name of the billion dollar company whose name is on the product or you don't deserve to own a computer. The company is a successful computer company whose products you may even now own. They'll back the product with service through its 90-day limited warranty and for years to come with hundreds of national factory service centers throughout the United States.

EXCEPTIONAL VALUE

The printer is not an outdated model with old technology but a brand new unit with the latest electronics and the most advanced technology. For example, there's an automatic print pressure control which automatically varies the printing pressure according to the shape of the character. This single feature produces an incredibly clean impression while prolonging the life of the daisy wheel. But there's more.

An aluminum diecast integral-constructed frame gives the printer a solid home for its advanced electronics. And with a weight of 30 pounds, you know there's built-in commercial-quality construction. The controls include: 'line feed' which advances the carriage by one line, 'page advance' which advances the document to the next page when using continuous form paper and a 'set page' button that tells the printer where the start of the form is located. A lighted condition panel tells you the printer status with red and green LEDs. You can use single sheets or continuous form fan-fold paper and with the 'paper out sensor' the printer detects the last sheet of the fan fold paper and automatically stops. And the printer has a 2K buffer memory.

There are also features that give you enormous printing flexibility. You can underscore words, double print each character which creates a bold look or you can use shadow print which moves the print head 1/120th of an inch between strikes. With the proper daisy wheel you can also set the printer for proportional printing which gives your documents a professional—almost printed look.

SELF-TEST MODE

There's a self-test mode which lets you print out all the characters on your daisy wheel continually until you stop. And the system uses standard Diablo daisy wheels and ribbons which you can get from JS&A or any computer store.

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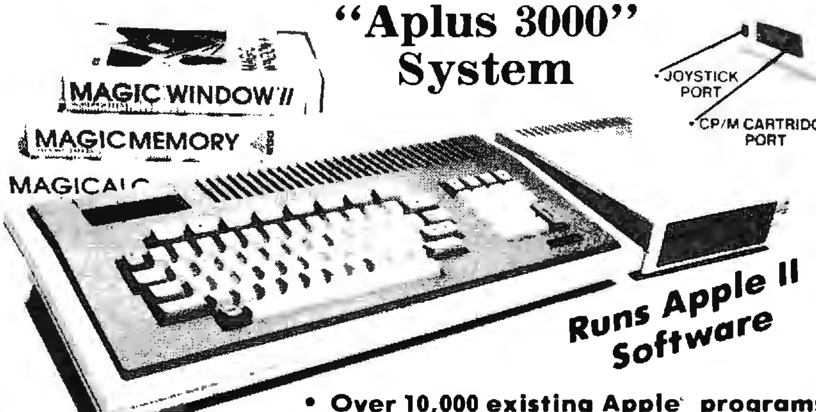

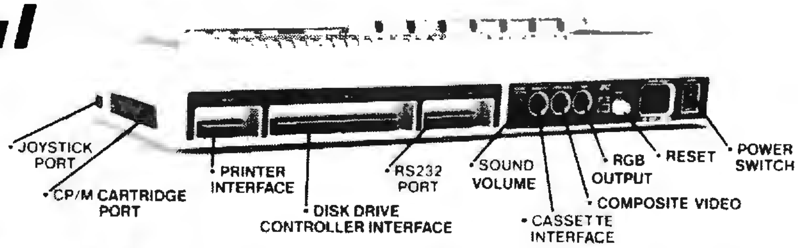

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Features	Aplus 3000	Apple IIe	Commodore 128
RAM	**192K**	64K	128K
Runs Apple II Software	**Yes**	Yes	No
Function Keys	**24**	None	16
4 Voice, 6 Octave Sound	**Yes**	No	Yes
Composite Video	**Yes**	Yes	Yes
Disk Drive	**included**	Extra Cost	Extra Cost
Numeric Keypad	**included**	Extra Cost	Included
Video Cable	**included**	Extra Cost	Extra Cost
RGB Color Card	**included**	Extra Cost	Included
80 Column Card	**included**	Extra Cost	Included
Centronics Printer Interface	**included**	Extra Cost	Extra Cost
Drive Controller	**included**	Extra Cost	Included
$150 Wordprocessor (Magic Window)	**included**	Extra Cost	Extra Cost
$150 Spreadsheet (MagiCalc)	**included**	Extra Cost	Extra Cost
$60 Database prg. (Magic Memory)	**included**	Extra Cost	Extra Cost
Your Cost	**$499.00**	$1745.00	$1117.90

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ACCESSORIES	LIST	SALE
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RGB cable (RGB Monitor hookup)	$ 24.95	$ 19.95
Centronics cable (for Centronics printer)	$ 34.95	$ 24.95
Technical reference manual	$ 29.95	$ 19.95
Comstar 10x 120-140 CPS dot matrix printer	$399.00	$189.00
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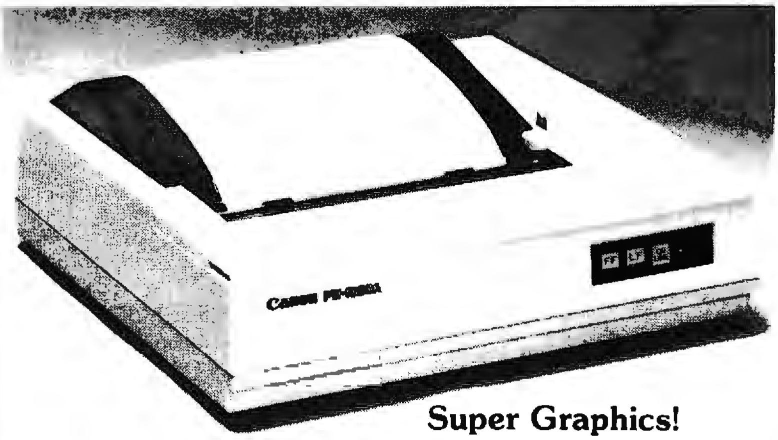

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(IBM - Commodore) **SPECIFICATIONS** (Apple - Atari - Etc.)

Printing Method
Impact dot matrix

Printing Speed
160 CPS at standard character printing
27 CPS at NLQ character printing

Printing Direction
Text Mode — Bi-directional
Graphic Mode — Unidirectional

Print Head Life
100 million characters

Printing Characters
Standard 11 x 9 dot matrix
NLQ 23 x 18 dot matrix
Character size: 2 x 2.42 mm (standard)
Character set: Full ASCII character set (96), 32 special European characters

Down Loading
11 x 9 dot matrix; NLQ 23 x 18 dot matrix optional

Print Buffer
2K-byte utility buffer

Image Printing
Image Data: Vertical 8, 9 and/or 16 dot
Resolution: Horizontal 60 dots/inch
Horizontal 120 dots/inch (double density)
Horizontal 240 dots/inch (quadruple density)

Interface
8-bit parallel interface (Centronics type)

Paper
Plain paper, Roll paper, Single sheet, Fanfold, Multipart paper: max. 3 sheets (original plus 2)

Ink Ribbon Cartridge
Ribbon Life: 3 million characters/cartridge

Maximum Number of Characters

Standard:	10 cpi	80 cpl
Enlarged:	5 cpi	40 cpl
Condensed:	17.1 cpi	136 cpl
Condensed enlarged:	8.5 cpi	68 cpl
Elite:	12 cpi	96 cpl
Elite enlarged:	6 cpi	48 cpl
NLQ pica:	10 cpi	80 cpl
NLQ pica enlarged:	5 cpi	40 cpl

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S·O·F·T·W·A·R·E R·E·V·I·E·W

Magic/L

This descendant of FORTH is a complete environment for program development

BY MICHAEL W. GILBERT AND ALBERT S. WOODHULL

Michael W. Gilbert is a composer and videographer, and a consultant in collaboration with Albert S. Woodhull. Albert S. Woodhull is an associate professor at Hampshire College. He is a biologist turned computer scientist who enjoys using FORTH *and assembly language for real-world access. Both can be reached at Woodhull and Gilbert, 73 Spaulding St., Amherst, MA 01002.*

Loki Engineering Inc. of Cambridge, Massachusetts, developed Magic/L (pronounced "magical"), a descendant of FORTH, for Data General and Digital Equipment Corporation minicomputers, but it has now adapted the language for 8-bit microcomputers running CP/M. All the versions share most of the same features; we are reviewing the CP/M product. This version does have several unique utilities and most CP/M system calls as primitives.

The new language takes advantage of the fact that hardware constraints are much less serious now than when its ancestors were developed. FORTH uses reverse Polish notation, requiring somewhat more effort on the part of programmers but permitting compact coding of program sequences. At the expense of more memory, Magic/L uses conventional infix notation. A Magic/L definition appears like a program written in Pascal or C, and programmers who know another conventional language might find Magic/L easier to learn than FORTH.

Both FORTH and Magic/L are more than languages; they are also complete environments for program development. They are extensible in that you add definitions (declarations, subroutines, functions, or procedures) to the resident core of the language system. Therefore, you can access variables and invoke executable program segments from definitions or directly from the console. As a result, although Magic/L's FORTH ancestry provides for compilation and speedy execution of the compiled program, you still can have an interactive programming environment in which to assess immediately the effects of changes and additions to a program without first recompiling it. To enhance the programming and development environment, Magic/L includes both line and block editors, capability for immediate interpretation of console input, a compiler, an assembler, and an I/O (input/output) package. Users with very small systems should note that extensibility has its price; the smallest Magic/L version (executable .COM file) that can be generated requires well over 30K bytes of disk space, the size of the unextended language.

THE USER'S VIEW

When you access Magic/L from CP/M, you will see a copyright notice, a version number, the amount of free memory, and the Magic/L prompt: mgl>. The Magic/L compilation process is incremental—compilation takes place as you enter the source statements from the console at the prompt or from a text file. For example,

```
mgl> INTEGER P Q R ( 10 )
```

compiles (allocates storage associated with a name) the simple integer variables P and Q, and R, a 10-element array of integers. The statement

```
mgl> P := 1
```

executes immediately, assigning a value to variable P. To verify, you can immediately execute the PRINT statement:

```
mgl> PRINT P
1
```

Of course, if you have not entered all the needed information, you cannot compile or execute statements immediately after you enter a line. FORTH users are familiar with the error message "Compilation only, use in definition." In this situation, Magic/L has a better approach—the software defers compilation until you complete the statement. At the prompt, a multiple > indicates that the statement requires further input and a – identifies an unfinished definition. Therefore, you can enter and test a conditional statement at the console:

```
mgl> IF ( P == 1 )
mgl>> PRINT "*True*"
mgl>> ELSE
mgl>> PRINT "*False*"
mgl>> ENDIF
*True*
```

(continued)

AT A GLANCE

Name
Magic/L

Type
Language with interactive development environment

Manufacturer
Loki Engineering
55 Wheeler St.
Cambridge, MA 02138
(617) 576-0666

Format/Computer
CP/M-80 version reviewed, available for other mini- and microcomputer operating systems

Documentation
200-page reference manual with examples, and separate 88-page CP/M supplement (other versions have own documentation)

Price

Magic/L CP/M-80	$295
Magic/L MS-DOS	$495
Magic/L RT-11	$500
Magic/L UNIX	$750

And you can also enter multiline definitions:

```
mgl> DEFINE MAXI
mgl-> PRINT MAX ( a b )
mgl->> END
mgl>
```

The Interactive Environment and Compilation

Magic/L compilation involves only one pass over the input text. Thus, overall analysis and code optimization are not provided. The compiler does not produce native machine code, either. However, the process goes well beyond the replacement of strings by compact tokens. The Magic/L documentation is short on internal details, but we suspect that Magic/L "compilation" generates dictionary entries that consist of lists of addresses of more primitive entries, in a manner similar to FORTH. The run-time process is most properly described as interpretation of an intermediate language, although the efficiency of this process is high in terms of memory space and speed of execution.

Since Magic/L compiles and links new definitions into the language as you enter them, the environment acts as a debugger. You can try out new functions, subroutines, and commands directly from the keyboard, without the usual compile-and-link cycle that other languages require. For example, you could enter a function, test it with dummy data, and modify and retest it, all directly at the keyboard. You are encouraged to test your code frequently and to adopt a structured, modular approach. Magic/L doesn't entirely eliminate the traditional edit, compile, run, crash, and repeat cycles, but it can drastically shorten the time from discovery of a bug to testing a new version.

A block-editing facility lets you save the definitions you enter at the console on disk as text files. You can also use the Magic/L line editor or any other text editor to write routines and definitions as source files. The EXT (extend) command compiles definitions from a disk file into the Magic/L dictionary so you can save different disk images of Magic/L under different names for specific applications. For example, you could create turnkey applications with a customized prompt and automatic execution of a predetermined definition.

Although compiling new definitions is very efficient in terms of memory usage, creation of turnkey versions will be most attractive for large applications, since the minimum size of the image stored on the disk is always large—the entire language is the run-time package. An alternative used extensively in the CP/M implementation of Magic/L is the use of relocatable precompiled modules. These require little disk space and load very quickly.

Magic/L Syntax

A Magic/L statement contains a series of strings that can include words (previously defined tokens maintained as an ordered list, the dictionary), literals, or undefined tokens as in a definition. The Magic/L dictionary initially contains about 500 words, which you can combine to form new words that you then add to the dictionary. You can make words to be variables and arrays, subroutines and functions, control structures, operators, definers (used to create new words), punctuation, assembler mnemonics, system calls, and immediate commands.

You delimit the tokens in a Magic/L statement with blanks or with the end of a line. You can have word names up to 15 characters long, although Magic/L retains only the first 5 characters and the length of the string. In the current version you can use virtually all the ASCII (American Standard Code for Information Interchange) characters to name a word, but the documentation suggests, in the interests of compatibility with future versions, that you limit names to alphanumeric and a few other special characters.

The dictionary can contain words that themselves contain old definitions of the same word. If you reuse the word NAME, the new definition will link to the old one and Magic/L will return the message: Redefined:

(continued)

NAME. Newer words named NAME will link to the new definition. As in FORTH, you can use the FORGET command to cut definitions from the dictionary.

DATA TYPES, OPERATORS, AND CONTROL STRUCTURES

Table 1 shows the intrinsic data types, the full set of operators, and the control structures built into Magic/L. You can create records to contain variables of any data type, including other records; record structures are similar to those available with C's struct feature. Magic/L has no intrinsic operators that act on record variables, although you can implement them. You can also define and create data types, although we did not attempt this.

All data types are defining words. You can use them to declare variables and enter them into the dictionary. For example:

mgl> INTEGER A B C ;; LONG D E

(continued)

Table 1: *Data types, operators, and control structures in Magic/L. All literals can be in decimal, octal, or hexadecimal, and the default radix can be set to any value. You can apply the assignment operator := and all the logical operators to strings. The* DO *and* ITER LOOP *constructs can access their index variables as an undefined variable* I. *In nested loops, you can refer to indices of outer loops as undeclared variables* J *and* K. *This is similar to* FORTH. I', J', *and* K', *which are also predefined, count down as* I, J, *and* K *count up. They are convenient when you require a loop that runs backward.*

Data Types

CHAR	8-bit unsigned integer values
INTEGER	16-bit signed integer values
LONG	32-bit signed integer values
ADDRESS	16-bit signed integer values containing addresses
REAL	32-bit single-precision floating-point values
PARAMETER	named 16-bit integer constants

Operators

Arithmetic operators:	+ − * /
Bitwise operators:	NOT AND OR XOR
Logical operators:	== <> > >= < <= ==0 <>0 >0 >=0 <0 <=0
Assignment operators:	:= += −= INCREMENT DECREMENT CLEAR SET

Control Structures

```
IF ( <condition> ) ... ENDIF
IF ( <condition> ) ... ELSE ... ENDIF
BEGIN ... UNTIL ( <condition> )
BEGIN ... IF ( <condition> ) ... REPEAT
BEGIN ... FOREVER
WHILE ( <condition> ) ... REPEAT
CASE ( <function number> ) function0 , function1 , ... ENDIF
DO <low value> , <high value> ... LOOP [( <increment> )]
ITER <count> ... LOOP [( <increment> )]
```

Listing 1: *An example of a* DEFINE. . . END *sequence.*

```
DEFINE SQUAREIT INTEGER            ;DEFINE <routine name> <type>
INTEGER NUMBER                     ;<input argument declarations>
SQUAREIT := NUMBER * NUMBER        ;<executable code>
END                                ;END
```

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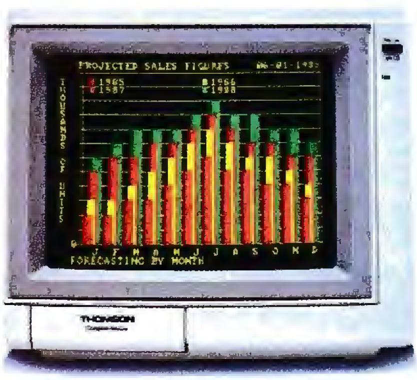

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THOMSON

You do not explicitly declare string variables. You store string data in subscripted CHAR arrays:

```
mgl> CHAR CLIENT ( 10 )
```

Having declared the variables A and CLIENT, you can now assign values to them:

```
mgl> A := 327 ;; CLIENT :=
"Michael"
```

Loki has kept Magic/L trim by eliminating certain types of error checking. FORTH users will understand the philosophy; a lot of checking can slow down run-time performance. However, beginning users will have to be very careful. In the current version of Magic/L, you could assign a string longer than the length for which you defined the CHAR array. As a result, you might overwrite memory and cause an erroneous value or a crashed system. It is also possible to assign an integer value to a CHAR variable; in this case, you would obtain erroneous results but no apparent damage to the system.

We would prefer to have the check on string lengths. The errors are hard to avoid and, in a completed application, you are likely to include string input as part of the user interface; checks protect the system from damage. We can't complain too much because, if you wish, you can personally implement checks—one of the benefits of an extensible language.

Definition Types and Structure

You can define functions, subroutines, commands, and parsed commands in a DEFINE . . . END sequence. Functions can be of types INTEGER, LONG, and REAL. An annotated example of a function definition appears in listing 1. You could call the function with:

```
mgl> INTEGER A
mgl> A := SQUAREIT ( 8 )
mgl> PRINT A
  64
```

You define subroutines in a manner similar to functions, but subroutines do not return values. A command is a special form of subroutine that avoids the use of parentheses in the calling syntax, counts the number of input arguments, and can then iterate through them. Parsed commands are commands that take string arguments only, without quotation marks. They are useful in creating routines that use

(continued)

Table 2: *The CP/M command interface is entirely written in Magic/L. CP/M users will feel comfortable here, although the position of source and destination filenames is reversed relative to the CP/M standard.*

Command	Description
BINCOM <file1> <file2>	a binary comparison of two files
COPY <sourcefile> <destfile>	equivalent of PIP <dest> = <source>
DIR <filespec>	directory, same as CP/M CCP
DISK	displays space on current disk
DUMP <filespec>	dumps file to console in hexadecimal
ERA <filespec>	erase, same as CP/M CCP
GET <file>	equivalent of PIP currentdr:file = file
MOVE <file>	equivalent of PIP file = current dr:file
REN <oldname> <newname>	equivalent of REN <new> = <old>
TY <file>	type, same as CP/M CCP
DEV	displays current I/O byte assignments and possibilities
LST, PUN, RDR, CON	used with argument to set I/O bytes
RESET	equivalent of warm boot or Control-C
A:, B:, C:, D:	used to select disk/drive
$SELECT	used to create new drive selection commands (e.g., MAKE "E:" $SELECT 5 ; for a fifth drive)

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Magic/L comes with a basic dictionary that includes many functions, subroutines, system variables, and other words already defined.

Magic/L's CP/M command interface (see table 2). Within a definition, you can make local declarations to create local variables.

LIBRARY ROUTINES

Magic/L comes with a basic dictionary that includes many functions, subroutines, system variables, and other words already defined. All the language's features (including those mentioned in this review) are words delivered in the dictionary. Magic/L includes a full range of block moves; shifting, bit, maximum/minimum, and pack/unpack functions; type conversion routines; peeks and pokes; floating point; trigonometric functions; system variables accessible to the user; and buffers. We find the language to be complete and refer potential users to the manual.

A formatted print feature allows runtime specification of field width, radix, padding character, and tabbing, with all defined data types formatted appropriately. You can redirect text to an I/O channel, including out to a disk file or memory buffer. Input features include ASCII input of numeric or string data from the keyboard or from an I/O channel, which could be a disk file.

Magic/L uses a channel-based I/O system, with the mapping of a channel to a filename that you create with the OPEN function. The I/O system is rather basic and straightforward to keep it transportable. Magic/L supports random-access, block, sequential, and text I/O. You can create modular enhancements if needed.

The CP/M version includes a sophisticated module facility and a library of precompiled relocatable modules that you can include during initial configuration or access during use. Designed to overcome CP/M 2.x's limited address space, this feature lets the user load precompiled relocatable binary files of code into free memory space. The delivered version includes ED (editor), ASM (assembler), BINCOM (binary comparison), CCP (console command processor), and others as modules that you call in as needed. You can create additional modules, but we have not tested this feature.

SYSTEM-DEPENDENT FEATURES

The CP/M implementation contains many features, especially the direct emulation of many CP/M features and commands, that will make regular CP/M users feel at home. The CP/M command interface emulates a standard CCP with integrated PIP and STAT functions. It is entirely written in Magic/L so you can use all CP/M interface words in your programs and definitions. You can also write your own CCP commands and custom command-line interpreters. You can redefine all standard CP/M system calls (0 through 40) as Magic/L words. Almost half of them are already implemented, and it is not hard to generate the remaining ones.

To allow for complete user customization, Loki's latest release (version 2.50) supplies source code for the CCP module. Moreover, the new version enhances several of the CCP commands. The DIR routine alphabetically sorts its listing but does not display SYS files. (A separate DIRS routine displays the SYS files.) You can display and change the current USER, the RO, and SYS attributes. The BINCOM and DUMP routines also let you specify a starting location.

You can create complex words to perform automatic backups, peripheral changes and routing, and so on. You could also create a one-word command to back up all data and index files on drive C to drive D, rename them, and then print the space remaining on the disk.

(continued)

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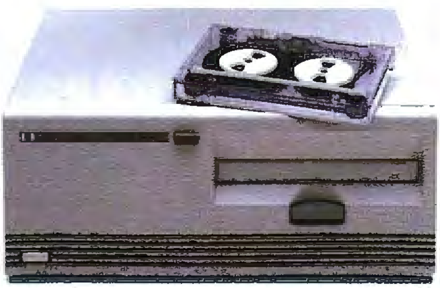

HEWLETT PACKARD

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Magic/L has a good line-editing facility, reconfigurable for different terminals. You can use the block editor for editing control structures that are longer than one line and compound or block statements, including definitions. You can invoke the block editor at any time; as a convenience for debugging, it edits the contents of a buffer that contains the last-entered multiline definition. If you wish, you can write the edited block to disk. The feature encourages the development of complex definitions in a "let's try it" interactive fashion. The text editor uses the same commands as CP/M's ED.COM with very few differences. ED is not everyone's favorite text editor, but we appreciate Loki's deci-

(continued)

Listing 2: *The Sieve of Eratosthenes in Magic/L.*

```
; Sieve of Eratosthenes, translated from Pascal version by
; Gilbreath

parameter flagsize := 8190
char flags ( flagsize + 1 )
integer prime kth count

define sieve
print "1 iteration"
caoff                              ; turn off console status check
        count := 0
        iter flagsize
              flags ( i ) := -1
        loop
        iter flagsize
              if ( flags ( i ) )
                    prime := i + i + 3
                    kth := i + prime
                    while ( kth <= flagsize )
                           flags ( kth ) := 0
                           kth := kth + prime
                    repeat
                    count := count + 1
;                   print prime
              endif
        loop
print count , " primes"
end
```

Table 3: *Timing the Sieve of Eratosthenes. (See listing 2 for the Magic/L code. For the FORTH and BASIC code, see "A High-Level Language Benchmark" by Jim Gilbreath, September 1981 BYTE, page 180.) We performed the first tests using CP/M 2.2 with a Microsoft Softcard (a 2-MHz Z80) in an Apple. When we obtained our review copy of Magic/L, Loki Engineering informed us that it had not tested Magic/L in the CP/M Plus environment. Nonetheless, we repeated the benchmark with the CP/M Card's 6-MHz Z80 with the results in the second column. We had no qualitative problems using Magic/L with the Advanced Logic Systems CP/M Card and CP/M Plus in the Apple.*

	2-MHz Z80	6-MHz Z80
FIG-FORTH	16.4 seconds	6.6 seconds
Magic/L	22.7 seconds	9.2 seconds
MBASIC	6 minutes 5.2 seconds	3 minutes 31.9 seconds

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EUROPEAN DISTRIBUTORS **TDI Pinnacle Ltd** 29 Alma Vale Road. Bristol BS8 2HL England. Tel (0272) 742796 Telex 449273 sion to implement its editor in a way that minimizes the relearning required to use the tool. However, the text editor does not let you return to interactive program testing while editing, as do the line editors in many FORTH versions. In sum, the Magic/L ED works quite well for small jobs, and we choose to use our usual editors for larger ones.

Programmers need a way to invoke assembly-language code for serious program development. You can link assembly-coded routines with high-level Magic/L code, including variable, value, and argument passing, and the CP/M implementation includes an assembler supporting 8080 syntax. Use of the Magic/L assembler is somewhat different from conventional assembly-language programming, and perhaps a little easier to learn, because assembly is interactive under Magic/L. This is a one-pass assembler and experienced assembly-language programmers will notice the restrictions on forward references. However, our experience in using assembly language in FORTH will apply to Magic/L as well: Assembly code segments are almost always very short because only very limited time-dependent or hardware-specific routines require assembly language. A fairly simple assembler will almost always be adequate.

PERFORMANCE

We ran one iteration of the Sieve of Eratosthenes in Magic/L (see listing 2), FIG-FORTH, and standard CP/M Microsoft BASIC. The results are in table 3. Magic/L does pay a price in performance, relative to FORTH, for its much more convenient syntax, but the penalty is small. For many users the comparison with interpreted BASIC will be more important.

The command caoff in the SIEVE.MG program turns off Magic/L's normal checking for a console key press. Originally we wrote the program without this; the CP/M 2.2 version was slower by about 50 percent. The console checking had a much more serious effect under CP/M Plus, slowing the program by a factor of 6. This seems to be a problem of the console status-check routine in the Advanced Logic Systems CP/M Plus

(continued)

MAGIC/L UPDATE

We have spent many months with Magic/L version 2.40 for CP/M. After we finished the initial review, Loki supplied us with the updated version 2.50, which features several improvements.

First, a command retrieval function stores the most recently entered Magic/L command lines in a 512-character circular buffer. You can recall, edit, and reexecute them.

A cross-reference capability lets you generate a complete listing of all symbols used by a program.

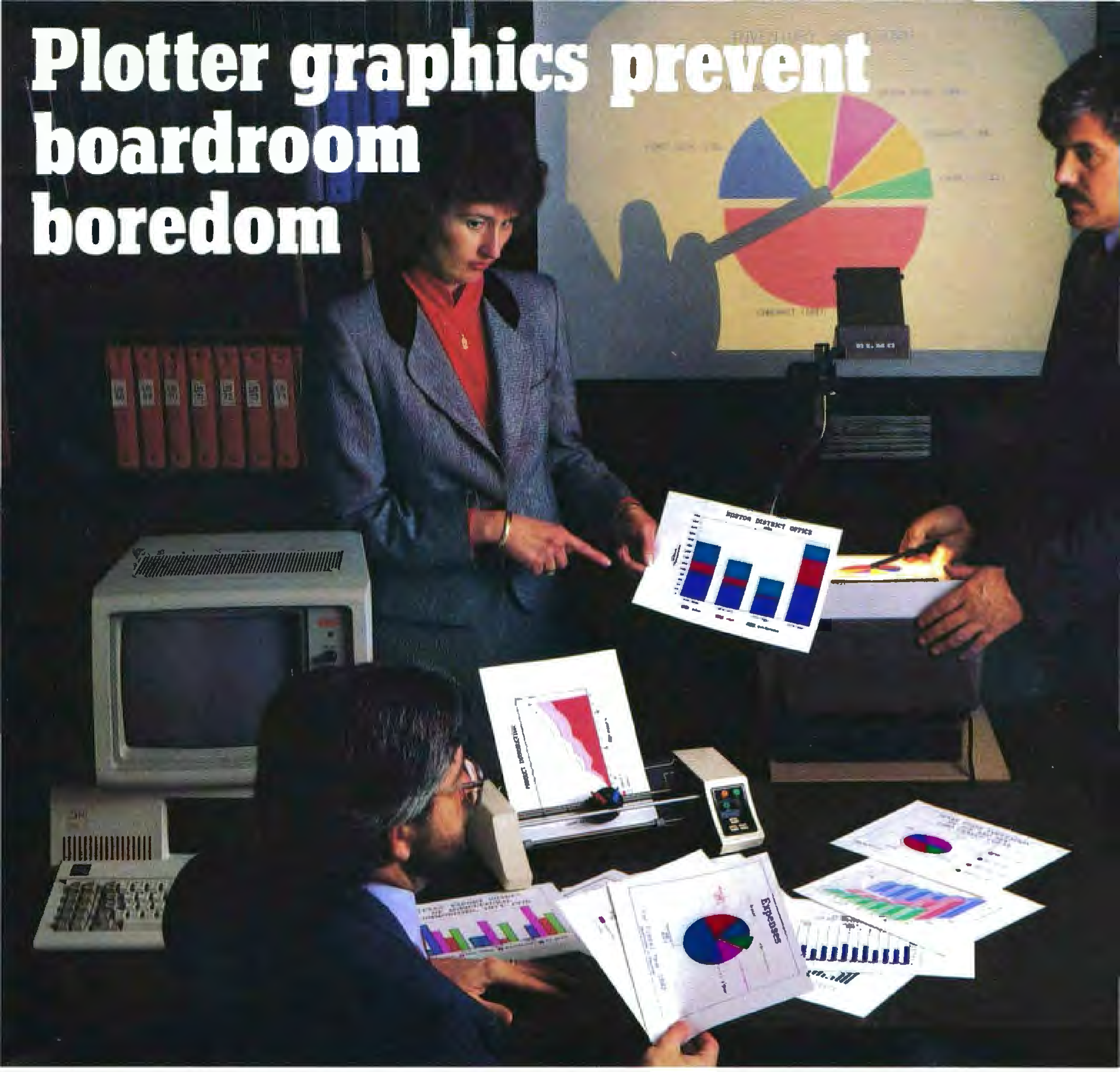
A dictionary editing utility lets you compress, edit, or eliminate the symbol table from a saved Magic/L program. This saves memory and, when used on a turnkey program, can eliminate the requirement for Magic/L runtime sublicensing.

Control-C no longer aborts to the CP/M prompt. You have the choice of returning to CP/M or to the mgl> prompt.

Improved floating-point support further speeds optimization and now conforms internally to the IEEE standard, making it compatible with the 8087 (this is of interest to MS-DOS–version users).

This release also includes several new source files. Loki has indicated that future releases might include the information necessary to recompile a smaller kernel of the language for target applications, as is possible with many versions of FORTH.

Plotter graphics prevent boardroom boredom



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> *Magic/L is designed more for the serious software developer than for the novice.*

BIOS (basic input/output system) rather than a problem with Magic/L.

DOCUMENTATION, BUGS, AND SUPPORT

The documentation is fairly good and contains quite a bit of information. It has discussions of advanced applications and features, good hints on debugging code, and an interesting discussion on speed efficiency versus space efficiency. We would have liked a glossary that was more detailed than an index but more concise than a reference manual. It would also be nice to have a single comprehensive index to the terms defined in the user's manual and the Magic/L CP/M supplement.

Some words expect argument values in octal, and the documentation occasionally refers to octal. The use of octal is a carryover from implementations on minicomputers. Most micro users would prefer to specify character codes and other arguments in hexadecimal. We also wished for some familiar FORTH tools, like the VLIST command that displays all defined words with the most recently defined first. The Magic/L equivalent lists the most recent words last, an annoyance when you just want to see how you named a variable.

REAL operations did not function properly in the version 2.40 (see the text box "Magic/L Update," page 348, for the features of the latest version) that we originally received. A call to Loki resulted in a quick fix:

```
C>type realfix.mg

; REAL FIX FOR MG/L
;
DEFINE FIXREAL
if ( dup ( rliteral ( $tbuf ) ) )
exec ( rlval 2315x )
endif
END
poke ( base fixreal , 33fex )
```

The fix, which Loki dictated over the phone, shows the ease with which you can make changes in Magic/L.

The error-message facility requires that you have the error-message text file on the system. Magic/L lets you specify the drive on which the message file exists. We would have preferred to have the messages as a module. Most, but not all, error situations are documented. The error checking in general is simpler and sparser than in most high-level languages, and it is sometimes easy to crash the system with an error (a stack underflow, for example). We did this a few times when we were starting, but we no longer have this problem.

CONCLUSION

Overall, we have found Magic/L to be a well-conceived, well-implemented, and useful language combining the finer features of various other languages. The ability to create and use modules to be imported to and exported from the Magic/L system is especially powerful, since you can customize any or all the parts of Magic/L for individualized applications. And those already used to a structured programming language like Pascal or C should be able to write useful programs quickly because of the ease of translation.

In addition to the features we have discussed, Magic/L has other interesting aspects. For example, the language permits vocabulary branching, has the ability to divide the symbol table into subvocabularies, and lets you directly access Magic/L internal compiler routines.

Obviously, Magic/L is not a panacea for all programming problems. Magic/L, like FORTH, is designed more for the serious software developer than for the novice. Once mastered, however, it offers an environment in which development seems to flow very naturally. Magic/L is easily maintained and modified and can be as powerful as a user's ability to extend it. ■

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IBM's Professional Graphics System

For what you get, it's less expensive than it seems

BY RIK JADRNICEK

With CAD (computer-aided design) software rapidly becoming an economical and professional reality on desktop microcomputers, the search is on for the hardware to keep pace with it. The 320- by 200-pixel four-color graphics cards available for the IBM Personal Computer are just not equal to the detailed drafting, painting, and surface-shading tasks required in a professional environment.

The IBM Professional Graphics System (PGS) consists of a high-resolution color monitor matched to a graphics-controller board; it provides flickerless 640- by 480-pixel graphics images in 256—out of a possible 4096—simultaneously displayed colors. To better understand the difference between PGS and the average microcomputer CAD offering, let's take a brief look at the graphics capability currently available for IBM PCs.

Many personal computers come from the factory equipped with high-resolution graphics capability, including the NEC APC and the Victor 9000. IBM PCs offer "expansion slots"; third-party vendors fill these slots with a wide variety of graphics-enhancement controller boards that provide tremendous flexibility when configuring a system for graphics work.

Many of these graphics-enhancement boards for the IBM PC serve a dual purpose. They emulate the standard 320- by 200-pixel IBM color-graphics card, making the PC compatible with much of the business-graphics software currently available. In addition, they provide a variety of high-resolution graphics options ranging from monochrome to 1024- by 1024-pixel color resolution. A quality graphics software package attempting to do professional CAD work will use the higher-resolution products.

The Tecmar Graphics Master board ($695) is a popular choice because it emulates standard IBM color graphics and provides a 640- by 480-pixel high-resolution color option that lets you display 16 different colors simultaneously on a graphics monitor. It uses a standard TTL (transistor-transistor logic) nine-pin connector and provides character generation for displaying text. Since the board puts out an interlaced signal, a standard graphics monitor flickers when it displays the higher-resolution image. Many users have found out the hard way that you need a special long-persistence phosphor monitor (costing between $695 and $1500) for an acceptable display. This configuration is limited to applications requiring only 16 colors.

Some graphics boards, like Conographic's Cono-Color 40, require a special monitor (starting at $1600) with a higher nonstandard horizontal-scan rate and analog inputs. The Artist 1 from Control Systems ($2250) provides 1024- by 1024-pixel resolution with 256 simultaneous colors displayable out of a palette of 16 million. However, it doesn't have 6845 emulation for text generation, so you need a dual-monitor system to do nongraphics work. Also, you need a 19-inch monitor with a nonstandard horizontal-scan rate and long-persistence phosphors (starting at $2400). To complicate matters, different software packages may have drivers for different graphics cards. You can end up with a lot of gear that may soon be obsolete.

What do you do if you want to create fine line drawings requiring no more than 16 simultaneous colors with your IBM PC? At the same time you want to paint and create surface shading requiring at least 256 simultaneous colors with that same system. In addition, you want to display text and run business-graphics software for financial analysis. Well, you are well on your way to $5000 worth of gear and a two-monitor system.

THE PROFESSIONAL GRAPHICS SYSTEM

The IBM PGS consists of a matched high-resolution color monitor and graphics-

(continued)

Rik Jadrnicek, a BYTE contributing editor, is president of Microflow (POB 1147, Mill Valley, CA 94942) and a CAD consultant combining knowledge of systems integration, software design, and programming. Rik also enjoys sailing, music, and video.

AT A GLANCE

Name
IBM Professional Graphics System

Manufacturer
International Business Machines
1000 NW 51st St.
Boca Raton, FL 33432

Components
Professional Graphics 12-inch display (CRT), Professional Graphics controller card

Software
Demo disks, diagnostics disk, Graphical Kernel System (six disks), Professional Graphics Series device drivers, Graphics Development Toolkit (includes language libraries and supplemental programs)

Features
640- by 480-pixel resolution,
256 simultaneous colors

Documentation
Installation guide, booklet covering display-device driver, GKS programmer's guide, two volumes covering GKS language bindings, and reference booklets for FORTRAN, BASIC, Pascal, and Macro Assembler

Price

Professional Graphics display	$1295
Professional Graphics controller card	$2995

controller card. The system emulates the 6845 for text generation and the standard IBM color-graphics card to run business-graphics software, it provides graphics with 640- by 480-pixel resolution displayed in 256 simultaneous colors, and it is an integrated system. When you consider the costs of a good graphics board and compatible monitor, PGS's $4290 price tag doesn't seem so expensive.

The PGS board occupies two slots in the IBM PC. A TTL nine-pin connector carries the noninterlaced signals to a special high-resolution color monitor that looks much like the standard IBM color monitor. PGS will not drive a standard color monitor.

I used the AutoCAD program from Autodesk Inc. (Sausalito, California) and the AE/CADD Master Template architectural software from Archsoft Corporation (San Francisco) to evaluate the graphics system. These products make extensive use of color and drawing primitives to create professional drawings on the display. I was unable to find any painting or three-dimensional software that currently supports PGS.

Comparisons of color palettes and fine line representations are shown for the standard IBM color-graphics card (see photos 1 and 4), the Tecmar Graphics Master card (see photos 2 and 5), and the IBM PGS (see photos 3 and 6). PGS provides the ability to represent subtle shades of color because it is capable of displaying 256 simultaneous colors.

With the Graphics Master, the image tends to flicker despite the use of a long-persistence phosphor monitor due to the interlaced signal generated by the board. It can be quite distracting during prolonged use in a production environment. PGS did not flicker at all while displaying the same images. This is reason enough to consider the product for professional work.

When I was using PGS as a single-monitor system, the 6845 emulation for text generation seemed to be quite slow compared to both the IBM color-graphics card and the Tecmar board. During text editing and directory scrolling, PGS was sluggish to an extent that could interfere with production work. Keep in mind that you can use PGS in a dual-monitor configuration with the text displayed on a monochrome monitor.

In my work I use the IBM AT for writing, drafting, data extraction from drawings for report generation and spreadsheet analysis, three-dimensional manipulation of two-dimensional images, and renderings using images created in the drafting and three-dimensional stage. I am constantly putting different graphics boards into my system and using two monitors. In general, professional drafting software tends to support the 16-color boards, while professional three-dimensional and painting software requires and supports the 256-simultaneous-color boards. If these packages begin to support graphics systems like PGS, the days of swapping graphics boards and monitors may soon be over.

The PGS package includes ample documentation if you want to develop drivers for existing software or entirely new applications. It comes with a three-disk Graphics Development Toolkit that contains a set of linkable libraries for graphics and text functions. The Virtual Device Interface Controller and a set of device drivers for display units, printers, and plotters are also included.

Reference booklets contain the specific language syntax for each function. I saw booklets for FORTRAN, BASIC, Pascal, and Macro Assembler. The Toolkit provides the means for writing device-independent graphics software so you can direct program output to any supported workstation or input/output device without having to modify your application.

The three-volume Graphical Kernel System (GKS) includes six disks, a programmer's guide, and two volumes of language bindings. GKS is designed for use by BASIC, C, or FORTRAN programmers. You do not need expertise in graphics programming, but GKS does assume you have a certain

(continued)

Photo 1: *A palette of 256 colors created with Autodesk's AutoCAD program and displayed using the standard IBM color-graphics card.*

Photo 4: *An architectural drawing using Archsoft's AE/CADD Master Template displayed using the standard IBM graphics card with 4 simultaneous colors at 320- by 200-pixel resolution.*

Photo 2: *The same palette of 256 colors displayed using the Tecmar Graphics Master.*

Photo 5: *The same architectural drawing displayed using the Tecmar Graphics Master board with 16 simultaneous colors at 640- by 480-pixel resolution.*

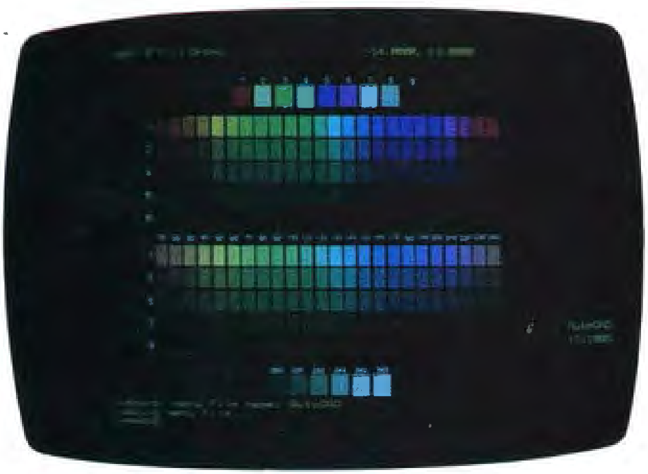


Photo 3: *The same palette of 256 colors displayed using the IBM Professional Graphics System.*

Photo 6: *The same architectural drawing displayed using the IBM Professional Graphics System with 256 simultaneous colors at 640- by 480-pixel resolution.*

A Systems Programmer's Experience with IBM's Professional Graphics Controller

BY RODRIGO SILVEIRA

I recently set out to write a display driver to be used by Autodesk's AutoCAD program to drive the IBM Professional Graphics Controller (PGC). Two design assumptions tailored my effort. First, the AutoCAD program won't allow any software between itself and any graphics boards. This means that all communications between AutoCAD and the graphics board must be handled by the AutoCAD software itself. The Graphical Kernel System (GKS) and Graphics Development Toolkit accompanying the PGC were therefore of no use in this particular application. Second, AutoCAD's core code expects a series of well-defined subroutines to exist at the driver level. Anytime a display operation is needed, AutoCAD calls one of these subroutines.

In the driver design there are three layers of subroutines: well-defined AutoCAD subroutines, PGC primitive subroutines, and AutoCAD/PGC communication subroutines.

Since the documentation accompanying PGC pertains to GKS and to the Toolkit, I had to get the Professional Graphics Controller technical reference manual from IBM.

There was no documentation on how to use the cold-restart flag, the warm-restart flag, and the error-enable flag, addressed C600:0306, C600:0307, and C600:0308, respectively (all hexadecimal). I called IBM for help and was told to set each of them to a nonzero value to correct the problem. This was the first in a series of satisfactory results obtained by calling IBM technical personnel.

During the first development phase, I ran into a problem testing the AREA subroutine. I wrote a series of small programs designed to execute the primitives in listing A. After execution I expected the ellipse to be filled with the color 24 (red), the current default color. Instead, the ellipse was not filled, but part of the viewport was. If I changed the current color to a color other than 24 before executing the AREA command, then the ellipse was filled properly. I never did resolve this situation because I didn't need this feature.

I ran into several instances where the PGC "lost control" in the communication area. This happened when AutoCAD drove the controller very fast. For example, when a VIEWPORT was followed by a series of drawing commands, the board would draw using the previous VIEWPORT instead of the current one. In order to circumvent the problem, I inserted timing delays between the VIEWPORT command and AutoCAD. However, since the driver was initially developed on a PC XT, the problem recurred when I tried to run it on a PC AT.

Further investigation led me to change the algorithm used to write commands to the communication area. Initially, I wrote bytes to the communication queue as long as there was at least 1 byte free. The algorithm read the WRITE and READ pointers, determined the number of bytes available, and wrote either the whole command or as many bytes as were available. Once the entire command was written, control returned to the driver. I

Listing A: *The primitive commands that should have filled the ellipse with red.*

```
HX                    —Communications are in hex
RESETF                —Reset program parameters
WINDOW 0,639,0,479    —Define the viewport coordinates
LUTINT 0              —Initialize the lookup table
COLOR 24              —Set the current color
MOVE 320,240          —Set the current point
ELLIPSE 200,100       —Draw an ellipse
AREA                  —Random area fill
```

familiarity with graphics concepts. Unless you are simply using PGS with existing applications software, GKS is an integral part of it. The manual covers installation and start-up procedures, GKS concepts, programming with GKS, and GKS routines. The volumes of language bindings discuss how to adapt GKS to specific programming languages. Binding conventions, argument conventions, and GKS error handling are discussed along with installing and linking your programs to the GKS libraries.

SUMMARY

The IBM Professional Graphics System has something to offer for both the end user and the program developer. Since the card is likely to be widely supported, you may find all the software you need supported by one hardware system. PGS is a good candidate for the CAD/CAM (computer-aided manufacturing) field since you can display drafting drawings that require only a few colors along with changed the algorithm to write to the communication queue only after determining that there were 256 bytes available. This circumvented the problem for both the XT and the AT.

A refinement of this algorithm was later developed at the suggestion of my colleague Greg Lutz. He proposed that I write to the output queue only after determining that the number of bytes available equaled or exceeded the number of bytes used by the command to be executed by the PGC. This new algorithm did not work, and it exhibited the same symptoms as the ones I'd experimented with before.

A simple change did the trick. By writing to the output queue only after determining that the number of bytes available exceeded the number used by the command, I got the PGC to work satisfactorily.

While creating the display driver, I loaded my own RGB (red-green-blue) values into the lookup table (LUT). Later, when I used the RESETF command, the default palette 0 was not loaded. I tried the LUTINT 0 command but it didn't work either. In order to reset the default palette to 0, I had to turn the power off and then on again. Since this doesn't create a significant problem in the functioning of the driver, I decided to live with it.

In general, interfacing software to the IBM PGC is straightforward compared to other cards I've used. You send commands to the PGC board via high-level commands. The board comes with primitives that are easy to use. For example, if you want to construct a circle, you simply execute a single primitive instead of manipulating a variety of mathematical constructs. This eliminates the need for assembly-language programming and makes driver creation faster, easier, and simpler to debug. And the driver will be simpler to maintain in the future because the code is easy to understand.

As a graphics controller, the IBM Professional Graphics System has good color capability at 640- by 480-pixel flickerless resolution of up to 256 simultaneous colors. However, some improvements are definitely possible. The resolution should be 1024 by 1024 pixels for the price. Also, when you are using the system with a single monitor for graphics and text, the 6845 emulation for character generation is quite slow. Other than that, the IBM Professional Graphics System seems equal to most of the graphics tasks you might face.

Rodrigo Silveira (521 MacArthur Ave., Redwood City, CA 94063) is a systems programmer and technical manager for Autodesk Inc. He spent five years as a Sperry Univac 1100 systems programmer and has been in the CAD/CAM/CAE industry for the past three. Rodrigo's other interests include chess and volleyball.

painted and three-dimensional surface-shaded images that require a wide variety of simultaneous colors.

Don't let the price tag discourage you. The cost of putting together a graphics system that compares with PGS using the graphics cards and monitors currently available exceeds the PGS price of $4290. As a bonus, the PGS 6845 emulation for text generation lets you do it all on a single-monitor system, saving the cost of a monochrome card and monitor. Looking at PGS, I get the feeling that things are going in the right direction. I only wish the display had a resolution of 1024 by 1024 pixels. Maybe next year. ■

Juki's 6300 Daisy-Wheel Printer

Letter-quality output and Diablo compatibility

BY WAYNE RASH JR.

Juki's 6300 printer, a Diablo 630 clone, is the company's top-of-the-line offering to people looking for low- and medium-priced printers. Juki brought dot-matrix-printer prices to the letter-quality-printer field when it introduced its 6100 nearly two years ago. That printer was characterized by solid construction and the best manual in the printer industry. The 6300 follows in that tradition.

Fortunately, the 6300 has departed from its older sibling's footsteps in several important ways. You do not, for example, have to disassemble the printer to set the configuration switches. The linear induction motor that drives the carriage for the 6100's print head is gone as well, replaced by a cogged belt that may be low tech but is more accurate in positioning the print head.

The Juki 6300 is a better clone of the Diablo than its predecessor is. Where the 6100 is merely plug-compatible with a Diablo printer, the 6300 also accepts Diablo ribbons and print wheels. This makes buying supplies a lot more convenient since Juki daisy wheels are rarely stocked by any but Juki retailers. The 6300 uses regular Diablo HyType II ribbon cartridges but will not accept the ¼-inch taller HyType II High Capacity cartridges. I must admit that Diablo ribbon cartridges are not as easily obtainable nor as inexpensive as the IBM Selectric typewriter ribbons used by the 6100.

The printer software supports every print mode of the Diablo 630 with the exception of the alternate ribbon color. In addition, you can select shadow printing that is similar in appearance to bold printing. When you install the printer driver for your word processor, all you have to do is select the menu choice for the Diablo 630. Juki does give you instructions for installing the shadow-printing feature into WordStar.

The 6300 also supports graphics just as a Diablo does. Regrettably, very few commercial software packages support the excellent graphics produced by this printer. For this reason, I was unable to test this feature myself; however, I have seen graphics produced by it, and I have used the Juki 6100 for graphics.

The ease of setting the configuration switches for the serial interface and for the various print options is improved significantly over the earlier Juki printer. With the 6100, you had to strip the printer down to its frame to set the serial interface. Now, all the DIP (dual in-line package) switches are located on the rear of the printer or underneath the front cover.

USING THE 6300

Even an inexperienced user should have an easy time with the Juki 6300. The setup instructions in the manual are excellent, and the DIP switches are preset with the settings you are most likely to need.

The optional tractor feed takes only a moment to install. The mechanism snaps on top of the printer, and the paper alarm plugs into the rear. This is a well-constructed bidirectional tractor feed that works well once the paper is in place. Getting the paper started is inconvenient: You must lift the rear of the feed mechanism and flip the platen pressure control to make the paper feed properly. Once the paper is started, you flip this control to its original position and lower the rear of the feed mechanism.

The Juki 6300 seems to be quieter and less obtrusive than the Diablo 630 it emulates. It is much smaller and lighter and seems to impart less vibration to the printer stand. The noise shield included with the printer works with the tractor feed in place.

In general, the Juki 6300 is equally capable of working with WordStar or printing program listings. Only WordStar 2000 upset the calm by somehow defeating bidirectional printing, but it does this with all the printers I've tried.

THE BENCHMARKS

Juki claims that the 6300 generates text at the rate of 40 characters per second (cps)

(continued)

Wayne Rash Jr. is a member of the professional staff of American Management Systems Inc. (1777 North Kent St., Arlington, VA 22209), where he consults with the federal government on microcomputers.

AT A GLANCE

Name
Juki 6300

Type
Daisy-wheel printer

Manufacturer
Juki Office Machine Corp.
299 Market St.
Saddle Brook, NJ 07662
(201) 368-3666

23844 Hawthorne Blvd.
Suite 101
Torrance, CA 90503
(213) 320-4860

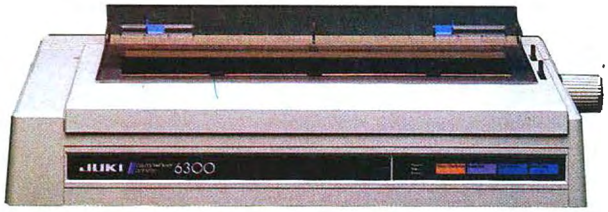
Size
23.6 by 15.7 by 4.9 inches;
32 pounds

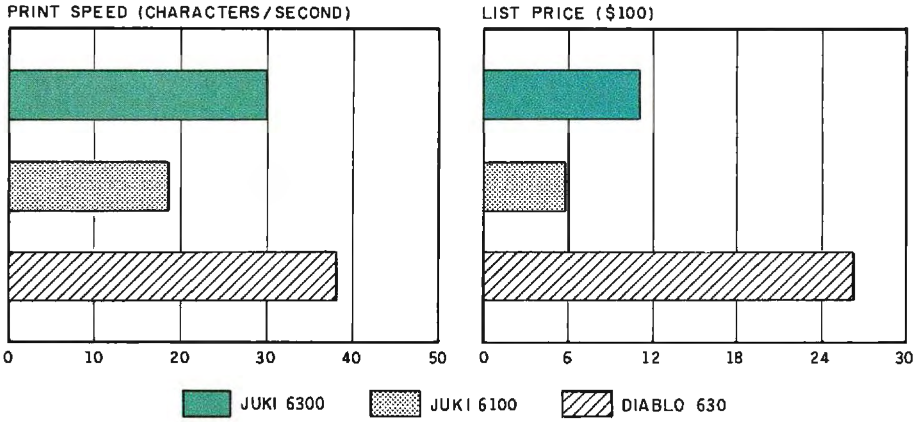
Features
32-cps Shannon test at 12 pitch; 3K memory expandable to 15K; friction feed; accepts Diablo print wheels and ribbons; software-compatible with Diablo 630; supports Diablo graphics; supports 10-, 12-, and 15-pitch settings and proportional spacing

Options
Tractor feed; memory expansion to 15K

Documentation
User's manual, spiral-bound, 215 pages

Price
$995





This is the Juki 6300 daisy wheel printer

This is the Juki 6100 This is the Juki 6100

This is the Diablo 630 printer.

The Juki 6300 printer (using a Courier 72 daisy wheel) is compared with the Juki 6100 (using a Courier 10 daisy wheel) and the Diablo 630 (using a Courier Legal 10 daisy wheel). The pitch for all printers is 10 characters per inch.

Print speeds were determined by timing how long it took the printers to print the Shannon test (573 characters; see the February 1984 BYTE, page 193). The prices are list prices, including tractor-feed mechanism.

and prints the Shannon test at 32 cps. While the printer performs as promised, you should not expect to turn out characters at this rate. To see why requires a few words about performance tests for daisy-wheel printers.

The primary factors in determining the speed of a daisy-wheel printer are the time required for the print mechanism to move from one letter position to the next and the time required for the daisy wheel to spin into position to print the required character. As a result, the speed of the printer is affected by both the pitch and the nature of the text being printed.

The effect of the pitch is fairly obvious. If you are printing 12 characters per inch, it takes less time to move between characters than it does if you are printing 10 characters per inch. Printing at 12 pitch is faster, and this is the pitch used by Juki for determining its speed specifications.

The effect of the nature of the text on printing speed is a much more complex issue. Sergio Mello-Grand treated this issue very thoroughly in his article "The Art of Benchmarking Printers" (February 1984 BYTE, page 193). He also presented a number of benchmarks for dot-matrix and daisy-wheel printers, some of which I used

(continued)

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Juki excels in documentation; the manual is well written and easy to read.

to determine the printing speed of the Juki 6300.

Two of the benchmarks used at BYTE for dot-matrix printers were listed by Mello-Grand as Bench 6 and Bench 7. Bench 6 consists of printing 50 lines, each containing 80 *A*s. Bench 7 consists of 10 spaces followed by 60 *A*s. The latter tends to favor printers that look ahead far enough to skip past spaces. Neither of these tests gives you an approximation of a daisy-wheel printer's actual printing speed, although they will show you how fast the print mechanism moves. In this case, the test results of 39.18 cps came very close to the Juki's maximum rated speed of 40 cps using Bench 6. Bench 7 showed a slightly slower 37.93 cps. The difference was most likely due to the higher proportion of carriage returns per character. Both benchmarks were printed at 12 pitch. At 10 pitch, the speeds slowed to 30.53 cps and 30.30 cps, respectively.

A more accurate approximation of a daisy-wheel printer's capabilities can be shown using benchmarks designed specifically for this type of printer. The most common of these benchmarks is the Shannon test (Mello-Grand presented two versions in his article). An even more accurate benchmark is Mello-Grand's first-order approximation using on-line UNIX manuals.

The two Shannon tests are distinguished by having different line lengths. The shorter line requires more carriage returns, and this can affect the overall speed. I ran both tests at 10 pitch and at 12 pitch. The 12-pitch tests support Juki's claim of 32 cps, since the 80-column Shannon test resulted in a speed of 33.12 cps and the 60-column test resulted in 32.56 cps. At 10 pitch, the speeds fell to 30.16 cps for either test.

The first-order approximation puts daisy-wheel printers through a tougher test, and the resulting speeds demonstrate that fact. At 12 pitch, the Juki 6300 was able to print at 27.62 cps, while at 10 pitch the speed fell to 26.32 cps. According to Mello-Grand, this last benchmark most closely approximates the speed at which the printer will actually operate when printing normal English text. You should remember when you read these benchmarks that most printers are set at 10 pitch for normal printing. In any case, the Juki 6300 was somewhat slower than the Diablo 630 in these tests.

DOCUMENTATION

If there is an area where Juki excels, it is documentation. As far as I remember, this is the best printer manual I've ever seen. The 6300's 215-page manual is surprisingly complete, well written, and easy to read. There is a complete, detailed table of contents and a complete index as well.

The manual has specific instructions for connecting the printer to the most popular computers, including the IBM PC, the Apple II, and Kaypro computers. There are also generic instructions in case your computer doesn't resemble any of these. I connected the printer to a Zenith Z-100 using the instructions for the IBM PC parallel printer.

CONCLUSION

Juki's 6300 is an excellent medium-speed printer. It appears to be entirely adequate for office use, yet it is priced low enough for many home users. The printer works with nearly any word-processing program due to its nearly complete emulation of the Diablo 630.

While there are a few compromises that reflect the 6300's lower price, they are very few. The speed is a little slower, and you don't get to change ribbon colors. But on the other hand, the Juki is smaller and quieter than the Diablo 630. And on top of everything else, there's that excellent manual. ■

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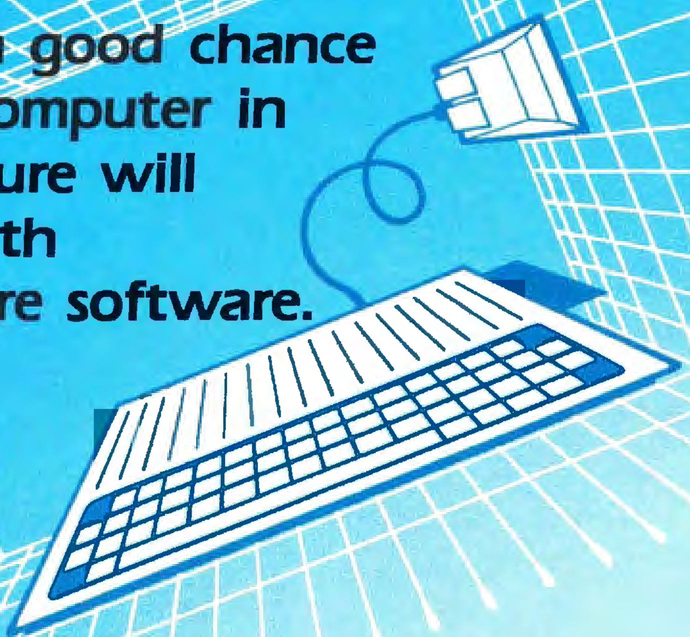

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THE TANDY 1000

The $999 Tandy 1000 is not at all IBM PC-compatible and is undoubtedly the worst-supported computer in its price class (see "The Tandy 1000" by Rich Malloy, August, page 266).

The 128K-byte version of the 1000 does a pretty good job of emulating the Sanyo MBC-550, which no one should find very exciting. Only by adding the overpriced 256K-byte memory-expansion board, which comes with 128K bytes in spite of its name, can you make the 1000 run most, but not all, IBM software. That board includes the DMA controller that is part of the IBM motherboard. So much for compatibility.

The Tandy 1000 is not even compatible with its own documentation. It is advertised as providing four times as many colors as the IBM, and its reference guide specifies that screen mode six provides 16 colors. It actually provides 4 colors, including black and white. That discrepancy is explained away as being a misprint in the manual.

I purchased the 1000 in November 1984 on the dealer's verbal representation that the technical reference manual and fixes for the BASIC language bugs would be available early in 1985. There has been no sign of either of these necessities as of July 1985, and Radio Shack in Fort Worth will not answer my correspondence.

KEN BARBIER
Covina, CA

I tested several IBM PC programs on the Model 1000, both with and without the extra memory/DMA board. All of them ran without problems.

Like the IBM PCjr, the Tandy 1000 provides 16 colors in medium resolution (320 by 200 pixels). This is four times the number that the IBM PC Color Graphics Adapter provides at the same resolution. This is evidenced by a color photo in my review that shows over 12 colors on the screen at one time. Tandy's BASIC manual does not make it very clear, however, that to access these extra colors from BASIC you have to first use a CLEAR ,,,32768 *command.*

Unfortunately, early versions of computers are often subject to more problems than later versions. Check with your dealer for updates.

—RICH MALLOY
Senior Technical Editor

THE JUKI 6100

I was interested in David Lewiston's letter about the Juki 6100 printer (August, page 286). I have not had the ribbon problem to which Mr. Lewiston refers. When the printer refuses to print because it is out of ribbon, the reel *is* out of ribbon. I have not had a problem with ribbon starts.

I have had problems with an irregular form feed caused by the fact that the gears needed grease. Once I greased the gears, I had no problems with the form-feed mechanism. Another minor mechanical problem is that the small metal flanges used to keep the ribbon in place have come loose, but all that keeps me from repairing that is a couple of small screws and my own laziness.

Having used the Juki 6100 for a year and a half under fairly rigorous conditions, I am pretty pleased with it. I can only conclude that Mr. Lewiston received a defective machine and that he should have had it replaced with a good one.

GEORGE G. JUMPER
Canoga Park, CA

LETTER BUG

My letter on Microsoft BASIC (July, page 299) should have read "I wish that Microsoft provided an Install program. . . ."

ALAN T. CHATTAWAY
Vancouver, British Columbia, Canada

PRINTER CRITERIA

I want to suggest a couple of additions to your checklist of features to look for when you review printers. I own four different brands of printers and it astonishes me how poorly they meet my needs. New machines don't seem to be any better.

First, I'd like to see you check for whether the printer makes labels. This seems silly considering how much software has been written for this application, but of all my printers only the IDS Prism printers will do the job. If you have a printer with a cylindrical platen, the labels peel off the carrier, particularly if it's hot and humid and your office is not air-conditioned. If the climate is controlled in your office, a simple test is to put the labels in the printer at quitting time and try to run the printer the next morning. You'd have to send my Diablo out for service because the labels come off in completely inaccessible places.

Second, you should see whether you can print an address on an envelope. This too seems elementary, but the Diablo is the only machine I have that will pass the test. The Prism can't grip an envelope at all. My Mannesmann Tally printers smudge the envelope and require special control codes to disable the "paper out" feature.

This reminds me of a third glitch. The Mannesmann Tally 180L "paper out" sensor is not in the paper path if you use bottom feed. In that case, you always have to disable it via control codes from the computer—a real inconvenience.

FARRELL CHOWN
Arnprior, Ontario, Canada

We certainly appreciate your concerns. However, we presently feel that application-specific tests would be of less general utility for our readers. We will keep your suggestions in mind if we ever decide to change our criteria.

—GLENN HARTWIG
Technical Editor, Reviews

PCJR COMMUNICATIONS

I'd like to reply to P. M. Moretti's problem with PCjr communications programs (July, page 299). Two versions of PC-Talk III in the public domain have been modified for the PCjr: one for the internal modem and one for an external modem.

These might not be available on your local bulletin board or, if they are, you might not be able to download them. They are both available from Public Brand Software, POB 51477, Indianapolis, IN 46251. The company also has a complete catalog of IBM PC-/MS-DOS software.

BOB OSTRANDER
Indianapolis, IN ■

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This month's Computing at Chaos Manor finds Jerry falling behind on his computer research. He does provide some legitimate reasons for this happening but admits that the real reason is that he got hooked on BYTE's new computer-conferencing system called BIX. This leads Jerry to a discussion of both ARPANET and BIX. There are also sections on the computers he uses most often and on this year's NCC in Chicago.

Bruce Webster wrote his column on a Macintosh for the first time. The reason he did this is because his product of the month is the Monster Mac upgrade from Levco. It is Bruce's opinion that this 2-megabyte upgrade goes a long way toward turning the Mac into a high-powered, high-speed machine. He also looks at Apple's plans for the Mac, discusses proper balance in computer systems, and gives his view of NCC.

In BYTE U.K., Dick reviews an early beta-release version of Living C-Personal this month. It's a new software product that features an editor, interpreter, animator, and tracer/debugger, all rolled into one menu-driven windowing environment. Dick found the maintenance of existing programs the most interesting application and claims that, at $99, Living C-Personal is one of the software bargains of our time.

In this month's Mathematical Recreations, Bob Kurosaka explores the properties of repeating decimals, those nonterminating decimals with a cycle that repeats endlessly. He also includes a program to calculate the cycle and discusses how to handle repeating decimals.

In BYTE Japan, Bill describes his latest computer purchase: the Fujitsu FM-16β. He bought the HD model, which has a 5¼-inch 10-megabyte hard-disk drive that replaces the topmost floppy-disk drive. The hard-disk interface occupies one of the four expansion slots but also leaves open the possibility of connecting an additional hard-disk drive.

C·O·M·P·U·T·I·N·G
A·T C·H·A·O·S M·A·N·O·R

Old Favorites and New Ones

ARPANET
BIX
Zeke
SideKick
SuperKey
Kaypro 286i
NCC
Fastback
Janus Ada
Seastalker

BY JERRY POURNELLE

Jerry Pournelle holds a doctorate in psychology and is a science-fiction writer who also earns a comfortable living writing about computers present and future.

I really meant to be organized this month. Alas, it didn't work. First there was a book-signing tour with Larry Niven to promote our novel *Footfall*. Seven cities in five days. These tours are a lot of fun, but they can be grueling; in the trade we call them the author's death march. It was great, though, especially in Silicon Valley, where not only were there long lines of people waiting to have books signed, but they had *my* books rather than Larry's. . .

I hadn't long returned from that when I headed to Chicago for the National Computer Conference (NCC). I just got back from that, and I leave for Europe in five days. I've got the best travel agent in the business, and Mrs. Pournelle is both temperamentally well-organized and highly skilled at taking care of details; even so, I have to do some things myself.

I know the cheapest commodity in the world is a good excuse, but I have *very* good reasons for falling behind. However, we must be truthful. The *real* reason I got so little research done this month is that I got hooked on BIX.

THE OLD ARPANET

To explain the fascination of BIX, I'll have to give a bit of history.

Computer-assisted communications have some similarities to telephone networks and more similarities to magazine and pamphlet publishing; but in truth they're a radical break with the past, something new and different and exciting. Except for science-fiction writers, few even suspect their implications. (Vernor Vinge's *True Names* and William Gibson's *Neuromancer* are two SF works that try to look at the electronic future. They describe a future more bizarre than I foresee, but they're well worth reading.)

I was fortunate enough to get on a large computer network almost as soon as I had a microcomputer. The U.S. Department of Defense Advanced Research Projects Agency (originally called ARPA, now called DARPA for reasons I never heard) maintains a fairly extensive communications system to assist DOD-sponsored research. DARPA supports computer facilities at several hundred universities and companies. There are ways to call local numbers and be connected, through the network, to all parts of it, including some very distant places.

The ARPANET was constructed to aid official research projects. Because it's paid for by the taxpayers, it is supposed to be restricted to "official business." Finding the limits of "official business" isn't simple. Example: a visiting scholar is coming to work on a DARPA project. A network message requesting housing is certainly "official." Suppose, though, that the scholar is coming to work on a nonofficial project, but the local people responsible for her *do* work on DARPA projects and would have to neglect DARPA business in order to find quarters. Or—but I expect the point is made. No matter what the message, so long as the people involved have some relation to DARPA-sponsored research, you can make a good case that it's in the government's interest to make their lives simpler.

What, though, of people who have no relation to DARPA projects at all?

The ARPANET was designed to handle a certain peak load of traffic, and that capacity must be paid for, even when it is not all used. In fact, it costs the government precisely nothing to allow semiofficial business to take up the slack, so long as the outsiders don't get in the way. A few institutions, particularly universities, quietly arranged for demonstration, or tourist, accounts for people who might have something to contribute.

Some outfits tightly controlled these tourist accounts. Other places were quite generous with them. After a while, the ARPANET attracted an amazingly diverse group. Many, but not all, were hackers. Most were young, but again not all. What they had in common was an interest in explor-

(continued)

Alas, the ARPANET that I knew has vanished. I suppose it was inevitable.

ing what could be done with a resource like this.

It was the first major experiment in computer-mediated human communication, and it was fascinating. In no time at all, the ARPANET developed into a free-swinging intellectual community in which nearly anything could be said and often was. Arguments developed. Discussions ranged from the profound to the utterly trivial. Then, slowly, a consensus of what was and was not appropriate behavior evolved. Even though there was a high turnover in network participants—most were students—the network as a group learned much about how to use this resource. Standards developed. The standards were group-enforced, not imposed from above.

At periodic intervals some bureaucrat would ask, "What good does this do the taxpayers?" It was easy to show that the subject matter of the ARPANET discussions was far less important than the interest. The government greatly benefited from even the maddest discussions because most ARPANET addicts, official or tourist, were computer enthusiasts maniacally bent on improving the system. They thus wrote, at no cost to the government, a great deal of the software that is now in standard use. With minor exceptions, the network was left in peace.

Participation in the old ARPANET was one of the most exciting experiences of my life. Quite reasonably, unofficial users couldn't log on until late at night. Once on, there was an endless variety of stuff. Speculations on the future of computing. News. Arguments and conversations. And always, new information on things you could do with computers: big computers, small computers, minis, micros, all of them. It was all very wonderful.

Some of the excitement abated when capabilities that began on big minis were transferred to microcomputers. Soon we all had spelling checkers, intelligent text editors, and the like. The network remained interesting. Some achievements still need big machines, at least for their development. One that really fascinated me was MACSYMA, the symbolic-algebra program. If I'd had that available when I was an undergraduate, I'd probably have become a theoretical physicist. I can't wait to get a micro version.

I'd never have known about MACSYMA if it hadn't been for the ARPANET. There were other such gems, and the conversations were enormously stimulating. In those days, it was hard waiting until it got late enough to log on. Alas, the network that I knew has vanished. I suppose it was inevitable.

Rascals in Paradise

The ARPANET was largely designed to be easy to use. Easy to use also means easy for unauthorized users to get onto. About 50,000 people had some connection with the system, and few saw much reason for tight security. It was no wonder that unauthorized people "broke into" the ARPANET, and not even surprising that many of them were kids. Alas, some journalists would rather write a sensational story than check the facts. Periodically, you'd see some silly story about how a bunch of teenage hackers had "broken into the defense network." Worse, since the ARPANET has nodes at Los Alamos and Lawrence Livermore Labs, both of which have top-secret research projects, and the network address of those facilities is easy to come by, some journalists would color their stories by saying that the kids had gotten into atomic-research facilities.

All true, but irrelevant: all the kids ever got to see was unclassified research files, and not all that many of them. Nuclear research was done

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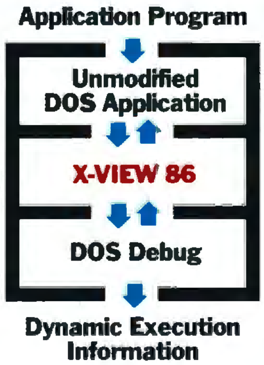

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on entirely different machines that weren't even connected to the network; it would have been impossible to get at the information on those without physically breaking into the lab. That didn't make for much of a story, though, and journalists kept hammering at the matter. Eventually, DARPA was pressured into doing something about it; and as all bureaucracies do, they overreacted. The old ARPANET was chopped into chunks, passwords were required for nearly all uses of the system, and semiofficial accounts were pruned out.

Some of the pruning was done by quite young graduate students acting, as far as I can tell, on whim. In any event, it became much harder to get an ARPANET account. The old community magic was broken. Network traffic got more official and less interesting. By the time my account was (rather rudely and abruptly) closed, I'd almost stopped using it.

BIX

Coincidentally, they began testing the BYTE Information Exchange (BIX) about the time my ARPANET account vanished. I've long paid for The Source and CompuServe accounts, but in practice I seldom logged onto them, mostly because the ARPANET account was more useful. About a year ago, BYTE tried out a conferencing system—not BIX—and the software was, to be kind, not well-designed; in fact, it was downright user-punishing. When BYTE asked me to try BIX, I was dubious.

"All new," said Phil Lemmons, our editor in chief. "Greatly improved. Try BIX, you may like it."

When my ARPANET account vanished, it seemed reasonable to try BIX, so I did—and found the excitement is back again, but even more so. Next thing I knew, I was a BIX junkie—and I wasn't alone: BYTE and *Popular Computing* editors and staff; computer programmers from a variety of companies; writers, teachers, historians, journalists. Men and women from a wide cross section of occupations,

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many but certainly not all of them computer-related, have become compulsive BIXies and can be found logged on at any hour of the day or night.

It's hard to say precisely why BIX is so fascinating. Certainly there are conferences on interesting topics, one of which is the theory of computer conferencing; but that can't be all of it. One of the most popular conferences is about cats; it's so popular that when the BIX managers tried to close it down in the interest of economy, Cats went underground, after which it was revived by popular demand. If you'd told me a month ago that I'd spend time reading people's tales about their cats, I'd have said you were crazy.

Partly it's the people. I've always found BYTE readers an interesting lot, and nearly all the BIXies are avid BYTE fans. Even so, while I enjoy meeting readers at conventions, it's not the same.

The medium changes everything. Electronically mediated conferences allow a *lot* of people to take part in a conference. Indeed, "a conference" is a misnomer because most conferences end up with half a dozen related but separable trains of thought all going at once. The result can be a heady mixture indeed—and unlike most face-to-face conversations, the results are automatically recorded and transcribed, available for later reference or publication.

The software helps. BIX has the best conferencing software I've ever seen. That isn't just my opinion. Friends, old and new, who have been addicts of other conferencing systems for a long time now greatly prefer BIX. The software isn't finished, either. It was designed by Alastair Mayer, who grew up in science-fiction "fandom"—his father was a member of the old Science Fiction League and also published some of Arthur C. Clarke's first stories—and Al logs onto the system. (In fact, he's there so often I suspect he has clones.) For the past couple of months, the BIX users have been interactively improving the software.

The instructions help, too. Donna Osgood, of BYTE's West Coast office, has done a marvelous job of designing a learning conference and putting the manuals on line, where they're being critiqued and refined and revised by a whole bunch of BIX junkies, including me.

So. The real reason I'm behind in my computer research is BIX addiction. I'd have thought the spell would wear off, but so far it hasn't. I'm about to take off for Europe, and one of my main concerns is being sure I can get a periodic BIX fix while I'm there.

Of course, things will get complicated when tens of thousands of BYTE readers climb aboard. Computer-conferencing literature calls the phenomenon "information overload." We're working on ways to handle it. BIX will almost certainly absorb much of the time I now put into reading mail. Apologies, but I see no way out. However, at present we can publish only a tiny fraction of the truly interesting letters I get; BIX will let lots of readers interact not only with me, but with each other. I don't know where that leads, but I like the idea a lot.

Electronic conferencing is important: in a real sense, it's an electronic implementation of the first amendment. Also, I'm having a ball.

Taking Stock

It happens a lot at shows. A reader comes to the BYTE booth, and we get into a discussion.

"You've used a lot of machines. What's the best?"

"That depends."

"On what?"

"Mostly on what you want it for, but there's also a lot of just plain preference and taste involved."

"Yeah, sure, but look, I'm trying to write a book, and I know I need a computer, so I'm trying to figure out what I should get."

Last time it happened, though, I got a new question: "If you had to get rid of all your computers but one, which one would you keep?" I thought about that one. "Okay," I said. "I'll answer that, but fair warning, the

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answer isn't going to be as useful as you think."

Since then I've gotten half a dozen letters asking almost the same question. I don't know if it's coincidence or a conspiracy. Anyway, here goes, but the warning still applies.

I have, at last count, 29 working computers, including the most state-of-the-art stuff available; yet I'm writing this on Zeke, a CompuPro S-100–bus Z80 CP/M 2.2 machine with 8-inch disk drives. That's archaic, and the rest of the system is more archaic: the video display comes from an old Processor Tech VDM memory-mapped video board, and the keyboard is an ancient Archive one. The display goes onto an 8-year-old Hitachi 15-inch white-on-black monitor.

Zeke is not only old, he's enormous, much larger than most of the more modern—and far more powerful—machines that I have. My new offices are wonderful, but even here space around my desk is in short supply. I'd miss Zeke a lot, but I'm tempted to switch just to make a bit more room.

I don't, though, because I haven't found anything remotely as good as Zeke for creative writing. Other machines are better at nearly every other task; but if I had to get rid of all but one computer, I think I'd keep Zeke in preference to all the others. After all, CP/M 2.2 and a Z80 can handle just about everything I do on computers, and, indeed, for a couple of years Zeke was the only computer I had running. Zeke is more than good enough.

There are two reasons Zeke is the right machine for creative writers. The first is WRITE, the text editor designed by Tony Pietsch with assistance from Larry Niven and me. I've probably spent too much time on WRITE already, so I'll summarize by saying that it's the most transparent text editor I know of. Once you know WRITE well, it's a bit like telepathy: thoughts go on screen painlessly and automatically.

WRITE was crafted in 8080 assembly language and makes use of a number of CP/M's features. In other words, if you want WRITE, you have to stick with CP/M. The editor isn't available for MS-DOS. However, it runs fine on 8/16 dual-processor machines, such as the Zenith Z-100, the CompuPro 286 with Z80 slave (SPUZ) board, or an S-100 system with the Macrotech 286/Z80 board. Moreover, 8/16 systems give you a larger workspace and have much faster disk operations. I have a CompuPro 286/SPUZ, a Macrotech 286/Z80, and a Zenith Z-100, so the question inevitably arises: Why keep Zeke?

Well, it's this way. Larry Niven has a machine identical to mine. If I change primary machines, he pretty

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well has to, and Larry doesn't use a computer for anything except writing. Actually, that's not strictly true: Larry does use his computer to play Infocom games. (He always buys the hints and uses them liberally.) Anyway, whatever I change to had better be at least as good for creative writing as Zeke, or I'll hear from my partner. Nothing is, which once again raises the question, why?

Because of the Processor Tech VDM board, Hitachi monitor, and Archive keyboard, that's why. None of those other machines have software that would let me use that combination; and I won't willingly give them up.

Alas, the Archive keyboard is no longer available. At the 1985 NCC in Chicago I ran into Lee Felsenstein, who designed the VDM board. We speculated that Larry and I may be the last VDM users in the world. The board isn't made anymore, and Lee has the last unused one. It's not even easy to get this model of Hitachi monitor.

I told you that finding out which machine I'd keep wasn't going to be as useful as you thought. Zeke is optimized for one single purpose, creative writing, and besides, most of the components aren't available anyway.

SIDEKICK AND SUPERKEY

I keep a log of which machines I use. A moment ago I got it out and discovered something surprising. For the last month there have been only three: the CompuPro 286/SPUZ, which I used for two hours to pay the bills and do the monthly accounting; Zeke; and Big Kat, the Kaypro machine officially known as the 286i.

That's surprising. Last month I did all my BIXing on Bellerophon, the AT&T UNIX PC, which remains a fine little UNIX box that hasn't had a glitch since it recovered—by itself—from the power failure a month or so ago. I find it easier to stare for hours at Bellerophon's screen than at the Kaypro's, and I *hugely* prefer the AT&T's keyboard to the Kaypro's; yet for all that, lately I've done all my BIXing on

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SAME File commands all computers?	•	N/A	N/A	N/A	N/A
STRUCTURED: Labels, Functions, LONG IF etc.	•	•	N/A	•	N/A
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I'm a very sloppy typist, and writing with computers has given me the habit of rewriting a lot.

the Kaypro, and I've no immediate plans to change.

There's a reason. Make that two reasons. SideKick and SuperKey. I've become enormously dependent on them.

One of the problems with the BIX conferencing system is that in order to keep the costs reasonable, most BIXies have to connect through Tymnet. Tymnet works fine (usually), but in its very nature it has a severe defect: it sends data in bundles and packets. The bundling and packeting make it very difficult for BIX to furnish any kind of sophisticated full-screen-editor capability.

That could probably be overcome, but the multiplicity of terminals and systems employed by BIX users compounds this. They range from 40-column Apples to Liliths with 136 lines of 100 columns each. My account on the ARPANET was based on a large MIT computer that had a number of video-display support programs—Bob Frankston was kind enough to write one to support Zeke and the VDM board—but the BIX machines aren't yet that sophisticated. As a result, Al Mayer says it will be a while before BIX has anything more than a line editor.

That creates a problem. I'm a *very* sloppy typist. Moreover, writing with computers has given me the habit of rewriting a *lot*. For example, the opening sentences of this paragraph have gone through four drafts and may get changed some more before I'm done. (They just were.) Anyone watching me would go nuts, as I write trial sentences, rearrange them, strike words, move things, and generally hack my way through until I've got my thoughts expressed as I want them.

On the old ARPANET we had EMACS, a full-screen editor written at MIT by Richard M. Stallman and put by him in the public domain. EMACS isn't my favorite editor, but it is with good reason the favorite of a lot of programmers, and it's certainly good enough for any kind of writing. Even with EMACS, though, I made a *lot* of typing mistakes, thoroughly irritating some of my fellow network addicts. Worse yet, though, a lot of what I wrote wasn't very clear and certainly wasn't concise, because at 300 baud it's nearly impossible to do the kind of rewriting I generally do.

Given BIX's inadequate editors and my sloppy habits, my first efforts on BIX were painful to watch. I had two choices: go very slowly and fall further and further behind in the conference or emulate the chap who hadn't time to write a short letter. I generally did the latter, typing like hell and hoping people didn't mind the mistakes too much. Most of my friends were polite enough to pretend they didn't mind...

Then one of the BIXies thought of SideKick. It turns out that you can log onto BIX, go into SideKick with Control-Alt, use the SideKick editor to compose a message, and let SideKick squirt the message back to BIX. That sounded great, so I tried it; after which I shut down the AT&T UNIX PC machine and changed to the Kaypro 286i. The SideKick editor is nowhere near perfect, of course, but for long BIX essays I can use Zeke; the important thing is that the SideKick editor works fine for the shorter stuff that dominates BIX communications. The only thing missing is a spelling checker, and maybe I can talk Borland into adding one.

Moreover, SideKick (version 1.5) has the capability of capturing text right off the computer's screen and putting it into the SideKick editor. I can pull off chunks of someone else's message, interpolate my comments, and squirt the whole thing back—which is a sort of electronic analog of my nor-

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MOTOROLA

If you don't have Borland's SideKick and SuperKey, you don't know what you're missing.

mal method for answering mail, namely, to scribble comments on the letter and return it.

The only real problem with using SideKick and BIX in combination is that there are a lot of steps involved. To get text ready to send through SideKick, you must mark the beginning and end of the block, indicate which key will trigger the transmission, and tell SideKick whether to send it in block form or another way. That's a fair number of keystrokes. After a while, though, I noticed that I always do the same thing: go to beginning of text and begin block; go to end of text and end block; tell SideKick to get ready to transmit; tell it to use Alt-P; tell it block mode...

I'd had SuperKey, the SideKick key-macro utility, for several weeks, but I had never used it. Why redefine keys? I have it on good authority that the IBM PC AT keyboard was designed with full awareness of my undying hatred of the original PC keyboard; the designer was told to meet most of my objections. The result was more than good enough. I'd prefer the Escape key in the traditional upper-left corner, but I can sure live with it where they put it. And while I like having the period and comma keys make periods and commas whether shifted or not—my Archive keyboard is the only one I have that does that—I find it no great hardship to have the < and > as Shift-comma and Shift-period, respectively. There seemed to be no need for SuperKey.

Of course, this is sheer laziness. I knew in the abstract that keyboard macros—that is, being able to make a single keystroke generate a long message or control a complex series of actions—could save me a lot of time. But on the other hand, there was never time to learn how to use the darned programs, or so I told myself. Then I found myself doing a lot of BIXing, and on the last trip I went on, I stuffed the SuperKey manual into my briefcase to read on the airplane.

Wow! SuperKey does darned near *anything*. Borland actually offers your money back if SuperKey doesn't increase your productivity by 50 percent. I doubt they get many takers. Moreover, the essence of SuperKey is easy to learn. There are so many features that you may never learn to use them all—I certainly haven't—but so what? The important thing is that it's easy to *use* as well as easy to learn, a distinction that most companies, including Apple, don't seem to be able to make.

If you don't have SideKick and SuperKey, you don't know what you're missing. Get 'em. You can't possibly regret it.

TEMPTATIONS

I now find myself in a dilemma. I once said that if you use a personal computer, you'd soon become dependent on SideKick. That's just as true for SuperKey. And I write on a machine that has neither.

Writing comes first, and so far I have seen no combination of text editor and display that comes close enough to Zeke. It's worse than that. Until recently, I've seen no color display that I could work on day after day: they're all too fuzzy. Most of the monochrome PCompatible stuff I've seen looks good on a small monitor but awful on a large one. The Macintosh has too small a display and no provision for controlling things from

(continued)

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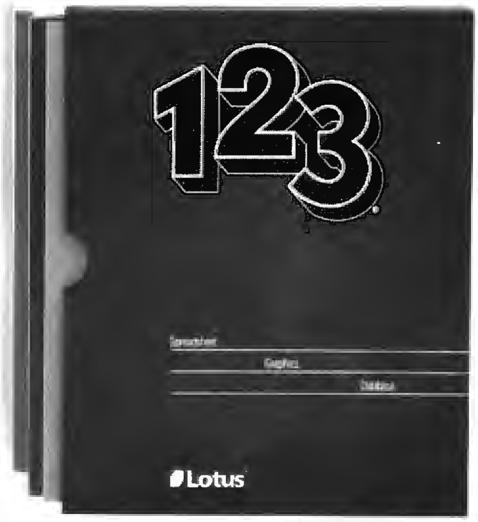

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The PC Video board's output will do when it is piped onto a big screen.

that toy keyboard even if I piped its output to a larger screen and learned to like seeing the watch icon.

The CompuPro PC Video board was designed by Tony Pietsch. It works fine with the CompuPro 286/SPUZ. With Concurrent DOS 4.1, we can run WRITE as well as about 75 percent of the programs written for the IBM PC; indeed, with Concurrent DOS we can run both PC-DOS and CP/M-86 at the same time. The PC Video output isn't quite as nice as the VDM, but it will do when piped onto a big screen. I've been using it with a Zenith VDM-136, which is just a little too small, and a Zenith high-resolution 19-inch color monitor (part of the Video Component System TV), and it's good enough.

Of course, I have odd requirements. I wear bifocals. If I sit close to a monitor screen, I have to tilt my head back to be able to read. I *hate* sitting in that position for hours on end. On the other hand, if I push the average monitor far enough away so I can read it through the tops of my glasses, the letters are generally too small to read. Zeke's screen sits at eye level some 30 inches away, and that's just about perfect. The PC Video board output of the CompuPro 286/SPUZ could probably be arranged to be almost as convenient and readable.

Keyboards aren't a real problem either. The Key Tronic 5151 is a perfectly acceptable keyboard for PCompatibles, including the PC Video board. Both the Wico SmartLine SmartBoard with its trackball and the Enigma Research keyboard with its multiplicity of keys lack a few features that my Archive has, but they also have many features the Archive lacks; it would be easy to get very attached to either. Enigma also plans a model for the AT. I'll do a full review of both the AT and PCompatible Enigmas as soon as I can; certainly I'll post my observations on BIX before you read this.

So, I can get WRITE, acceptable visuals, and an acceptable keyboard if I switch over to the CompuPro 286/SPUZ system, which will also give me about 75 percent PCompatibility. It's tempting—but so far the CompuPro 286/SPUZ system will *not* run SideKick and SuperKey. Everyone keeps telling me that Concurrent DOS is better

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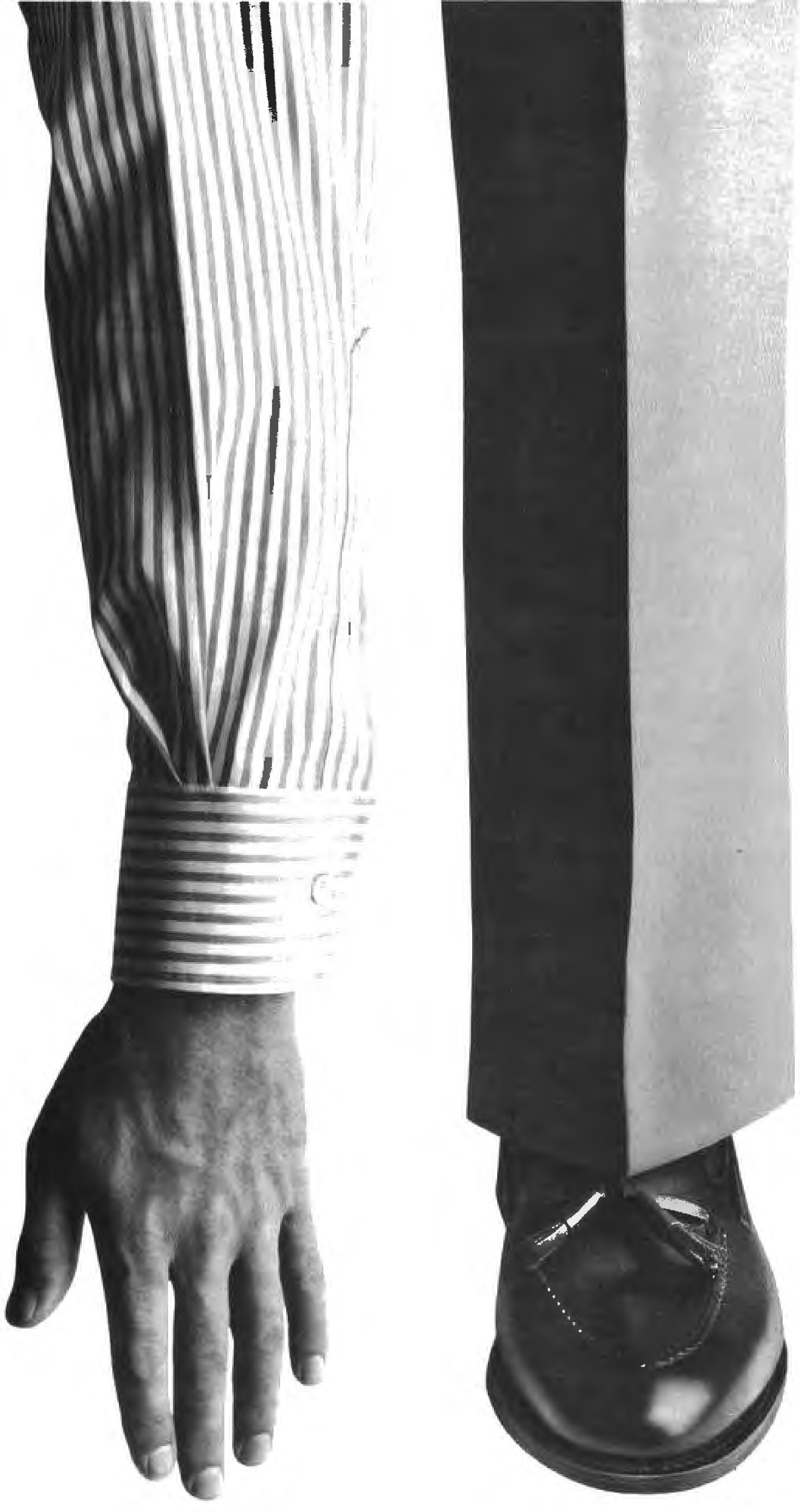

The most exciting thing at the 1985 NCC in Chicago was laser-disk mass storage.

anyway, and I suppose as I learn more I'll come to agree; but here comes BIX again. I need SideKick and SuperKey, or at least a very similar capability, for conferencing.

Maybe there's a way. Maybe Tony or one of the other software wizards at Viasyn will either figure out how to get SideKick and SuperKey working on the 286/SPUZ or how I can drop off line, use a text editor, and send the result out to BIX with the same convenience that I now do it on the Kaypro. I'll also need the ability to pull stuff off the screen and into the editor.

BIG KAT

Meanwhile, the Kaypro 286i gets most of the log time. He's used to test PCompatible software, and so far I've found none that he won't run. Crosstalk came with the OmniTel internal 1200-baud modem—which, by the way, gets *constant* use and has *never* had any glitches I can detect—and works quite well for BIXing. I've been programming Mrs. Pournelle's reading stuff. The PC version of Crush, Crumble, and Chomp runs in BASICA and is a bit too slow on a PC. But it screams along something wonderful on Big Kat, and it's wonderfully relaxing to burn down Washington after a hard day.

I'm still not overly fond of the Kaypro's keyboard. The layout is the PC AT layout, which is fine; but the keyboard feels just a bit mushy to me. Do note, though, that the Kaypro is something like a sporty GM car, and my Archive is more like having a Ferrari. It's unlikely that *any* keyboard's feel can compare favorably to what I'm used to. I will say, too, that after a month's use I find the Kaypro's feel much better. Probably I'm just getting used to it, but it's significant that I can do that.

For the first few days the Kaypro keyboard had a really annoying habit: I'd be typing along and suddenly everything would be in capital letters, and it would stay that way until I pressed the Shift—not Shift-lock, but Shift—key again. Finally, in rage I took several drops of Tweek, dissolved it in alcohol, and blew the mixture into the system with a can of compressed air. The cure wasn't instant, but within a day the Shift-lock problem stopped, and so did some other glitches; possibly the board just needed to be broken in? Anyway, it works fine now.

There's one other irritating misfeature: there are gaps above and between the two floppy-disk drives on the Kaypro. Not only is it *possible* to push a disk in there in the mistaken impression that you're inserting it into the drive, but I've done it three times. And when you do that, you can't get the disk back out. Each time I had to pick up the machine—which isn't light—and upend it to shake the disk out. It worked, and the disks were unharmed from their misadventure, but I'm thinking of putting gaffer's tape over those slots.

Don't get me wrong, though: I do like Big Kat.

Or did: in the last two days, it has developed the same kind of intermittent and capricious hard-disk errors that IBM PC AT owners report. More next month.

NCC

The 1985 NCC in Chicago had a much lower attendance than anticipated, and coming on the heels of Silicon Valley layoffs, the atmosphere alternated between frantic cheerfulness and gloom. It's just as well I have little space for the report: there wasn't much to write about. The most exciting thing there was laser-disk mass storage, and everyone else will write about that, so I don't have to.

One reason for the lack of excitement was the lack of micro people. Lots of the micro outfits weren't there at all or had much-reduced booths. Given the sheer rapacity of the Chicago unions—I saw one fat, cigar-chewing rigger take 11 minutes to hang and straighten a single 2- by 3-foot picture, after first taking it down because it had been hung by the exhibitor—I don't blame the com-

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panies for staying away. NCC has always had an ambiguous attitude toward micros; I recall when they stuffed all the micro exhibits in the basement of the Disneyland Hotel lest micros contaminate the minis and mainframes in the Anaheim Convention Center.

One impression: IBM brought out the AT as a temporary machine, but it seems to have become "validated." There are a growing number of AT clones, and people are frantically bringing out software and accessories for it. The AT is popular with programmers and hackers (although there's also a large group of same who *hate* it). I've heard many horror stories about Intel's 286 chips, and perhaps they're all true; but NCC convinced me that the 286 is here to stay.

I'm glad I went. I got to meet some more of AT&T's technical people, one of whom assured me that I have the wrong impression of the badge hierarchy used in their booths. Perhaps. My impression of AT&T remains unchanged: tremendous technical skills embedded in a fossilized organization that's groping its way into the marketing jungle. AT&T's pocketbook is deep enough to give them staying power, and some of their technowizards are dedicated enough to hang on until the bosses learn what they're doing. They're here to stay.

The best new program I saw at NCC was Fastback, a hard-disk backup utility running under MS-DOS; it automatically backs up your hard disk onto floppies. Easy to use. Not as fast as a tape drive, but a lot cheaper, and with Fastback you probably *will* make backups of your hard-disk work. Standardly silly licensing agreement, but no one pays attention to those anyway. Recommended.

It was also pleasant to get together with Randy Brukardt of RR Software Inc. RR literally started developing Janus Ada in a garage; now the compiler has been accepted by the U.S. Air Force as the one to use in training USAF Ada programmers. If you're interested in Ada, you ought to learn more about Janus, which remains, as far as I can tell, the most cost-effective micro version, particularly for learning the language. Janus is distributed through Workman and Associates.

WINDING DOWN

As usual, there's too much to write about. I have a new version of Beyond Compare, my favorite PCompatible file-comparator program; it works as well as ever, but now it takes batch commands and wild cards. Neither programmers nor authors can afford to be without this program. Highly recommended.

The game of the month is BIX; computer conferencing is both enlightening and entertaining. The boys had a

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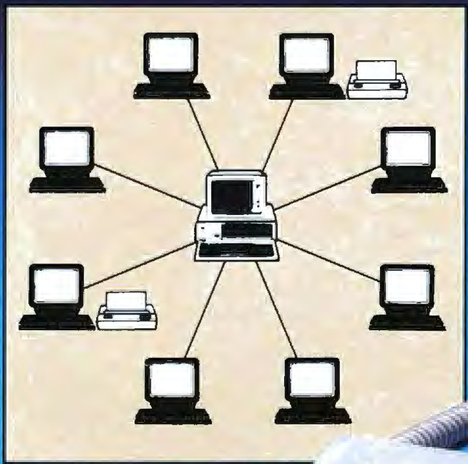

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lot of fun with Infocom's Seastalker, which is said to be "junior level" but is quite cleverly done; I recall a couple of months ago I spent a pleasant evening with it.

It isn't the book of the month because it's mine, but the second collection of these columns is out from Baen Books (distributed by Simon and Schuster). Like the first one (*User's Guide to Small Computers*), *Adventures in Microland* is a bit more than a collection of columns. While I haven't changed the original columns, I have inserted some comments generated by hindsight.

The real book of the month is *The Inklings* by Humphrey Carpenter (Ballantine Biography, reissued 1981). The Inklings included C. S. Lewis, Maj. Warner Lewis, J. R. R. Tolkien, and Charles Williams, as well as many others, and used to meet in Lewis's rooms at Magdalen College in Oxford. Lewis's views on science are not mine, but they're more than worth keeping in mind in these times of scientific magic. Nothing about computers, of course.

I'm now frantically trying to put together a system to take with me to Europe; it looks as if it'll be Percy, the NEC PC-8201 lapboard computer augmented with Purple Computer's wonderful SideCar memory package; lots more on that next month. Wish me a bon voyage. ■

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE *Publications, POB 372, Hancock, NH 03449. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.*

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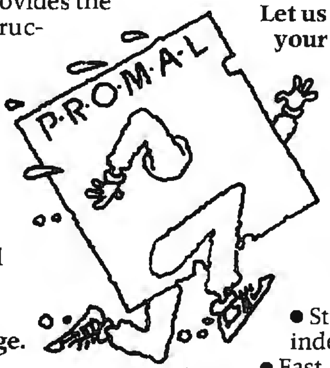

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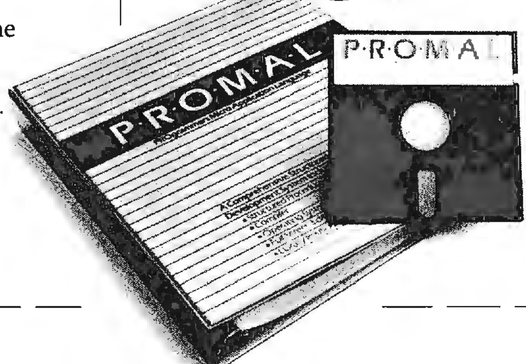

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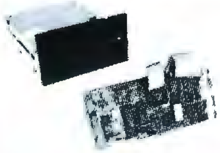

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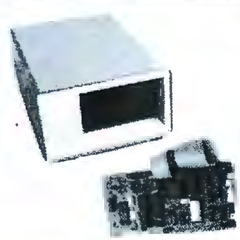

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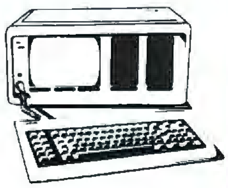

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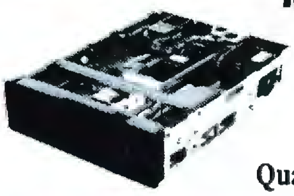

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Editor's note: Due to space limitations, we are able to publish only a sampling of the great amount of mail Jerry receives each month.

COMPUTER WORRIES

Dear Jerry,

The story told by Lewis M. Phelps in his letter ("When Will Ada Arrive," March, page 352) is interesting and revealing. It's not the effect of battlefield EMP on aircraft computers that worries me, though. Once things have reached the stage where "Big Ones" are being used, whether in the battlefield or on cities, the fate of a few fighters is probably not of much concern.

What has me much more troubled is the possibility that a poorly designed or inadequately tested piece of software will fail at a time when someone's life, or perhaps the fate of us all, depends on it. This has happened, or come very close to happening, numerous times. Two instances I've seen cited even deal with the F-18 mentioned in the letter. We'd all do well to maintain a high level of skepticism when we hear of wondrous airplanes that can be modified by "simply reprogramming the control computer" (in Ada, which is hand-compiled into assembly language!). Anyone who would use the word "simple" in this context shouldn't be allowed to do such work.

ALAN WEISS
Carpinteria, CA

Computers aren't infallible, but they're probably more reliable than their programmers. This somewhat turns usual experience on its head: we're accustomed to fundamentally sound policies ruined by incompetent subordinates. On the other hand, we have some examples of the reverse . . .

It hardly matters. As the pace of life increases, we find ourselves willy-nilly forced to rely on computers for increasingly important decisions. Finances, transportation, communications—and finally the ultimate decisions of war and peace.

This is why I'm such a strong supporter of a strategy of assured survival, as opposed to the McNamara doctrine of mutual assured destruction, or MAD. In my judgment, MAD leads to computerized launch on early warning. The end of that game was shown in the flawed but still valuable movie WarGames. *Strategic defense will also need rules of engagement, and some of those probably have to be implemented by computers; but the cost of a mistake is a lot less. I hope there will be no mistakes, but I can't be sure of that; and I'd far rather see a rising spacecraft mistakenly shot down by nonnuclear weapons than continue down the road MAD is taking us. (If you want more of my views on this, they're in* Mutual Assured Survival *by Jerry Pournelle and Dean Ing, Baen Books, 1984.)*

Errors will happen. You have sent me a list of them. I know of others. Try as we might, we're not going to eliminate all mistakes. We can think out the consequences of error and build systems that fail in the least dangerous ways.

Best.—Jerry

GRADING

Dear Jerry,

In regard to the letter from D. L. Fruehling ("Magazine Information," March, page 352), at least one peripheral device is already available for machine-grading multiple-choice examinations. Chatsworth Data Corporation (20710 Lassen St., Chatsworth, CA 91311, (213) 341-9200) makes such a reader. Included is software (written in BASIC for the IBM PC and clones; software for other machines may be available) for grading the answer cards. I am sure that with little effort the results from each exam could be plugged into a grading program.

R. S. NEUMAN
St. John's, Newfoundland, Canada

I'll have to look into that. Thank you.
—Jerry

HACKER DERIVATION

Dear Jerry,

Regarding your description of Hackercon in March: As one who was there when the words "hacker" and "to hack" were first applied to programming, I may be able to shed more light on the subject.

In 1965 I was at MIT, doing what amounted to postdoctoral work after getting a mathematics degree from Berkeley. I asked one day about the student sleeping on the table in the PDP-10 room. I was told that his name was Richard Greenblatt and that he was working on a chess program. In time I got to know Greenblatt and a couple of his friends, named Nelson and Gosper, and I became fascinated by the argot they spoke. For a true argot it was, as full of neologisms as any Parisian slang.

Actually, "hack" is much closer than you might think in origin to "hack writer." Greenblatt and his friends loved to write programs fast. Not programs that *run* fast, you understand, just programs that took a very short time to write. The resulting programs, as one might expect, were often rather inelegant, and they knew it; so they started referring to them as "hacks." In those days, elegance in programming meant writing in ALGOL 60, and Greenblatt's group had little interest in ALGOL 60 (which endeared me to them, since I was similarly inclined). They, then, were the outsiders, the self-described "hackers," trusting in their ability to write assembly-language artificial-intelligence programs that would outperform anything written in ALGOL 60—as, indeed, they did.

The prototypical variable names FOO and BARF served the same purpose in the argot that "John Doe" and "Richard Roe" do for lawyers. Thus, one might say, "If you have the ALGOL statement FOO:=BARF, you have to load BARF and store it in FOO." There was also "moby," meaning "big." Greenblatt was "writing this moby hack to play chess." The argot also took the place of conventional cussing. I never heard "goddammit" from Greenblatt or Nelson or Gosper; I heard "Foo! Barf!" or sometimes "Moby foo" or "Moby barf."

In time I went on to teach at Berkeley and lost contact with the hackers until I read about the success of Greenblatt's chess program, which the media called MacHack; actually, it was "MAC hack," meaning "a hack (or program) developed at Project MAC."

W. D. MAURER
Washington, DC

Fascinating. Thanks.—Jerry ■

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Memories

Monster Mac

Megamax C

Future Mac Designs

Amiga

Tecmar T-card

Atari 520ST

Proper Balance

NCC

Optical Disks

BY BRUCE WEBSTER

This column is a first for me, or more properly, a first for my Macintosh. You see, up until now I have done these columns on my Compaq portable. My usual excuse has been that I haven't had my Mac hooked up for telecommunications, i.e., cable plus modem plus telecom software. That changed some weeks back with the arrival of an Apple Modem 1200 and MacTerminal . . . but I was still reluctant to do my columns on the Mac. The Compaq was more comfortable and, with 640K bytes of RAM (random-access read/write memory), half of which went to a RAM disk, faster. So I had little incentive to change. Until now.

A week or so ago, I had my Mac upgraded to 2 megabytes. Yes, you saw that correctly: 2 *megabytes*. What's more, that does not mean that I have just a 512K-byte Mac with a 1.5-megabyte RAM disk. The full 2 megabytes is available for applications. But I get ahead of myself. Anyway, because of the upgrade I am now switching to the Mac for major word processing, instead of limiting it to correspondence. Of course, I may decide that I like things better on the Compaq anyway, but I'm willing to give it a shot.

PRODUCT OF THE MONTH: LEVCO MONSTER MAC

As you might guess, I have chosen the 2-megabyte upgrade as the product of the month. Known as the Monster Mac, the upgrade comes from Levco, a small firm located in San Diego. If you'll pardon the cliché, the only thing small about the upgrade is the price: $900, installed, for a 512K-byte Mac. If you've got a 128K-byte Mac, Levco will do the upgrade to 512K bytes for a reduced fee of $200. When you consider that as of right now (the start of August), Apple is still charging $700 for an "official" upgrade to 512K bytes, the price seems downright minuscule.

The upgrade itself is a daughterboard, roughly 3 by 4 inches, that plugs into the 68000 socket on the motherboard. The 68000 processor then plugs back into the daughterboard, which contains the 1.5-megabyte RAM, some ROMs (read-only memories), and a little more circuitry. This approach gives Levco some decided advantages. First, memory access on the daughterboard is somewhat faster. Since the video circuitry reads only the RAM on the motherboard, the 68000 doesn't need to time-slice while reading the RAM on the daughterboard.

Second, Levco can put the ROMs in there to intercept the boot sequence and make the necessary patches (relocation of video RAM, etc.) to ensure 2 megabytes of contiguous RAM. This means that you don't need any special software—especially not a custom system file—to run on the Monster Mac. You just power it on. Period.

Third, the daughterboard has a series of connectors—little holes, really—along one side, with signals coming over from the 68000. This is for planned add-on products. Believe it or not, customers have already started asking Levco about a 4-megabyte Mac. However, Levco is now working on a hardware floating-point board for the Mac. It's based on the now-available 32081 floating-point chip, while the 68000-family chip is slower, more expensive, and not available in production quantities.

Fourth, it appears that Levco is considering dropping in a higher-end 68000 processor. Unfortunately, many Mac software packages use sequences of instructions that are not allowed on the 68010, etc., so that is on hold for the time being. As the "Future Macs" section below indicates, Apple appears to be planning an upgrade to those chips as well, so the software companies better get their act together it they want their programs to run on future Mac products.

While the full 2 megabytes is available for applications, it certainly doesn't hurt to use part of it as a RAM disk. I have a boot disk with the Mac Memory Disk software from Assimilation Process on it; on power-up, it

(continued)

Bruce Webster is a consulting editor for BYTE. *He can be contacted c/o* BYTE, *425 Battery St., San Francisco,* CA 94111.

ACCORDING TO WEBSTER

creates a 1-megabyte RAM disk, copies all the system files onto it, and makes it the "start-up" disk. Combined with the improved System and Finder from Apple, it makes for a very fast, responsive system. For example, when I leave Microsoft Word, it takes about 5 seconds flat to go from releasing the Quit command in the menu to having the desktop up and available. Getting back into Word—from double click to being able to edit—takes about 6 seconds. Both of those times are with no disks in any drive. But even with disks in both the internal and external drives, the exit time is only about 12 seconds. The start-up time with disks in both drives was about 14 seconds the first time; after that, the system "remembered" the disks, and start-up went down to 6 seconds again.

By comparison, starting up Word on a single-disk 512K-byte system took about 11 seconds, and coming out took 23. With two drives, and disks in both of them, both start-up and exit times were around 28 to 29 seconds. In all cases, the new System and Finder were used, so you can see what a performance difference the 1-megabyte RAM disk/1-megabyte application RAM combination makes.

Likewise, while using Word on the Monster Mac, there were never any annoying pauses while some chunk of the program was loaded in from the disk. I don't know if this was because Word was able to load itself completely into the 1 megabyte of application RAM, or just that the RAM-disk accesses were so fast as to be unnoticeable. It doesn't really matter—the end result is the same.

Using Megamax C on the Monster Mac was even more exciting. I set up a 1.5-megabyte RAM disk (which left 512K bytes of application RAM) and copied all the utilities (editor, compiler, linker, RMaker, etc.) as well as my source files onto it. Megamax C has a pretty fast compile/link time anyway, but the Transfer function (which allows utilities to bypass the Finder) combined with the large RAM disk results in an awesome development speed that seems to be limited only by how fast you can type and move the mouse.

However, using Megamax C also pointed out one of the dangers of RAM disks. I edited, compiled, linked, and ran a go program that I've been converting from MacAdvantage: UCSD Pascal. The program had a bug, and I got the System Error box. Not only did I have to reboot, but since I had been keeping the source file on the RAM disk, I lost it. Moral: Use the Save As function before transferring over to the compiler.

The most significant use of the Monster Mac doesn't have anything to do with the RAM disk. It's when you use Andy Hertzfeld's Switcher program to load multiple applications into RAM. And with 2 megabytes of RAM to work with, you can get quite a few applications in there or—better yet—two or three applications with 512K bytes of application RAM *each*. The people at Levco feel that this is the best use of the Monster Mac, especially when combined with a hard disk to speed up any segment swapping or file access. And by making the Finder one of the

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loaded applications (with a minimum of application RAM), you can quickly get to the desktop and back for file deletions, transfers, and so on.

Unfortunately, not every program works with the Monster Mac. One problem is that a few programs ignore the video-RAM pointer and write directly to the video-RAM region. The Monster Mac relocates the video RAM to provide contiguous application RAM, so that causes a problem. Of course, the same programs are going to have problems with upcoming Macintosh models from Apple (see "Future Macs" below), so Levco isn't alone with this problem. There is, by the way, at least one solution. If you hold down the Interrupt button (the one farthest from you) while powering on or resetting, then release it when you hear the "bong," your Monster Mac will come up as a normal 512K-byte system. A power-down/power-up or reset will give you a 2-megabyte Mac again.

Another interesting side effect of the Monster Mac is that you can challenge the assertions of various software companies that "our program would run much faster if the Mac had enough memory/faster disk drives!" The folks at Levco mentioned several examples where that turned out not to be true. Even with the entire program loaded into RAM, and any file access coming off a RAM disk, performance was still pretty mediocre. I won't mention any names until I've verified it myself, but look for some possible balloon-popping in future columns.

Incidentally, the Monster Mac runs cooler than a regular 512K-byte Mac. That's because Levco installs a piezoelectric "butterfly" fan. This fan has no moving parts, at least in the normal sense of moving. Instead, it has two strips of piezoelectric material, each roughly the size and shape of a Band-Aid, that vibrate back and forth as electric current is passed through them. The fan is quiet and apparently never wears out. An interesting note: The firm that makes the fan told Levco that they had been approached by Apple many months earlier. Apple was apparently ready to order large quantities of the fan, presumably for the Mac, but the deal was nixed at the last minute.

The Levco Monster Mac upgrade goes a long way toward turning the Mac into what it should have been in the first place: a high-powered, high-speed personal computer. Frankly, given the memory demands of a graphics-based computer and the speed bottleneck of a complex operating system, I would think that a Mac should have a *minimum* of 1 megabyte of RAM, and preferably more. It is still hard for me to understand what the folks at Apple were thinking about when they released the Mac with 128K bytes and no slots, then instituting such an outrageous fee for the upgrade to 512K bytes (which is still not enough RAM).

The Monster Mac upgrade actually comes in several sizes. You can buy the unpopulated board (i.e., everything but the RAMs) for $500; each bank of 512K bytes costs another $100, so the full 1.5-megabyte board costs $800. Installation charge is another $100. Note that you must

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have a 512K-byte Mac in order to use this board; as noted earlier, Levco will do the upgrade from 128K to 512K bytes for an additional $200. That gives you a total upgrade price of $900 for 512K-byte Macs and $1100 for 128K-byte Macs—not a bad price, indeed.

FUTURE MACS

Speaking of future Macintosh designs, I received an interesting document in the mail the other day. Many months ago, I sent in my money to Apple for *Inside Macintosh* and the *Mac Software Supplement*. The latter was as important as the former because it guaranteed that I got all the updates to *Inside Macintosh*, the latest tools and supplements for Lisa and Mac development, and lots of informative notes about the Mac. Well, the latest—and last—update showed up the other day, and buried in the documentation was a six-page section entitled "Future Macintosh Architectures." Very interesting reading. Essentially, it's a questionnaire for developers who are bypassing Lisa Pascal (and, to some extent, the Toolbox) and who write lots of low-level assembly-language routines. The questions fall into the format, "Are you doing *x*? If so, then be aware that it might change; you should probably do *y* instead." The idea is to warn the developers away from practices that might make their programs incompatible with future machines.

Careful examination of the questions gives some indication of what Apple may be up to. Reading between the lines (or, in some cases, the lines themselves) suggests the following changes in future Macs:

1. A move to "higher" 68000 chips (68010, 68020, etc.)
2. More memory, i.e., greater than 1 megabyte
3. Larger screen displays
4. Higher clock speeds
5. Higher-capacity (and possibly faster) disk drives
6. Shifting around of the memory map
7. Some serious cleaning up of the operating system and Toolbox

None of this should come as much of a surprise, given the persistent rumors about the "Turbo" Mac and other future products, but it does show that Apple recognizes that it needs to come out with a high-performance machine. Good for them. I've been a strong Mac supporter all along—I consider the "real men don't use icons" argument a lot of hogwash—but it's been frustrating to see a marvelous user interface limping along in a deliberately crippled closed box. Recent changes in high-level Apple management have apparently opened the door for the reintroduction of Macintosh and Lisa technology with appropriate hardware. Unfortunately, it's about two years late, and Apple will have to suffer the consequences of some bad decisions. And maybe we'll finally see a Mac with slots and a fan.

A few months ago, I mentioned Apple's planned policy of denying 128K-byte ROM upgrades to Mac owners who

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had non-Apple RAM upgrades. Well, since those administrative changes at Apple, the policy appears to be undergoing a reversal, and there may be a good chance that Apple will do what it can to make the upgrade available to all Mac owners. Of course, it looks like the ROM upgrade won't be made available until this coming January, and possibly not even then. Of course, I got my 2-megabyte upgrade before hearing about this, but it is nice to know that I may be able to get the new ROMs anyway.

Update: Amiga and Atari

The next generation of 68000-based systems is hitting the market. Commodore officially unveiled the Amiga at a press conference in New York that was very ritzy, with lots of expensive food and famous people. One of the BYTE editors who attended said it was the kind of introduction that is usually given to cover up a mediocre product. What was amazing, he reported, was that the Amiga was the most impressive part of the introduction.

It looks like the Amiga will hit the market at a price of $1295 for a 256K-byte machine. That is too little RAM, but the upgrade to 512K bytes costs only $200 and can be installed in a few seconds; you just plug a cartridge into the front of the machine. A smart move, and another lesson learned from Apple's mistakes. Even so, you'll probably want to add even more RAM to your system. Luckily, Tecmar has announced the T-card, a slim box that plugs into the expansion bus on the side of the Amiga.

The T-card (estimated cost of $300 to $500) can hold up to 1 megabyte of RAM. Also, it has a clock/calendar chip and serial and parallel/SCSI (small computer standard interface) ports on the back. These, of course, let you plug in the Tecmar 20-megabyte hard disk (about $1000) and the Tecmar 300/1200/2400-bps modem (about $500 to $700) without tying up any of the Amiga's ports. You can plug together multiple T-cards, giving up to 8 megabytes of RAM (in addition to the 512K bytes inside the Amiga) and a whole lot of ports and clocks in the process. In fact, Tecmar ought to come out with another model of the T-card without the ports and clocks and holding more RAM (2 to 3 megabytes). Tecmar says that all these products (along with a 20-megabyte tape backup unit for less than $700) will ship "when the Amiga does."

This is all nice, but I still don't have my hands on an Amiga yet. Maybe by next column. In the meantime, I'll try to control my enthusiasm until I can really use one.

One firm that has no enthusiasm about the Amiga is Atari, which is finally starting to ship the 520ST, after missing several "firm" deadlines. I hope to get an ST soon and put it through its paces, doing some head-to-head comparisons with the Mac and the Amiga.

The Golden Triangle

I harp on memory size a lot, but I am continually amazed at the lack of foresight shown by computer designers. A computer system has to correctly balance three areas: pro-

(continued)

cessor power, RAM, and mass storage. The 128K-byte single-drive Macintosh is a prime example of a powerful processor—the 68000, with a 16-megabyte direct address space—crippled by too little RAM and mass storage. The graphics orientation of the machine, along with the large operating system, just make matters worse. Ironically, three months after the Mac appeared, Apple introduced a machine with an excellent balance: the IIc, also with 128K bytes of RAM and a single drive. For the 6502 and the body of existing Apple II software, that was plenty of room. Even so, the IIc would have been better served with a double-sided drive—140K bytes just isn't enough space—but the balance was still better than the Mac's.

There also needs to be a balance between RAM and mass storage. Specifically, too little of one can limit how useful the other is. You can usually get away with having "too much" mass storage—look at all the 10-megabyte hard disks running on 64K-byte Apple IIs—but not always. A case in point: The various hard disks for the Mac have had problems because you could create more files than the Finder could keep track of in memory. This is actually more a flaw of the Finder than of the lack of RAM, but it is a real problem.

The other balance is more necessary and yet more easily compensated for. If you have lots of memory and limited mass storage, a lot of the memory tends to be wasted. A microcomputer with 2 or 3 megabytes of storage and one or two floppy-disk drives can't do much with all that memory unless, of course, you have some way of adjusting the balance. With a RAM disk, you can convert extra memory into mass storage, striking the proper balance for your needs. If you have a task that is memory-intensive, you can load up your RAM with the application and data; if you don't, you can build a RAM disk of some size and increase performance and storage at the same time. You still may have problems: A memory-intensive application may be too big to fit itself and its data onto floppies.

The 2-megabyte two-drive Mac I have now is in much better balance, though hooking it up to a Bernoulli Box would bring the mass storage up to par with the RAM. This Mac no longer gets in my way, no longer bores me with slow disk accesses or interminable waits for the desktop to appear. Had Apple come out with a 1-megabyte Mac at the start, many of the Mac's problems—performance complaints, lack of software, etc.—would never have appeared.

Perhaps the reason I'm so excited about the Amiga is because it seems to be in excellent balance right from the start. The 880K-byte built-in drive holds more than a Mac with two drives, and DMA (direct memory access) disk I/O (input/output) means that access time is much shorter. As mentioned, 256K bytes isn't really enough for the Amiga, but the 512K-byte upgrade is cheap, easy, and available *now*. And if Tecmar does indeed start selling its peripherals at the same time the Amiga ships, even more RAM (up to 8 megabytes) and mass storage (20 megabytes for

(continued)

ACCORDING TO WEBSTER

$1000) will be there for the users. Jay Miner, one of the key designers of the Amiga, said in a recent interview that he anticipated cheap RAM three years ago and designed the machine around that assumption. Would that more computer firms were so farsighted.

Interestingly enough, the IBM PC represents a system where the processor is holding back RAM and mass storage. Hard-disk drives for the PC and compatible machines are incredibly cheap, and there isn't much excuse for not having the full 640K bytes of normally usable RAM. Indeed, the problems with the PC and its successors seem to lie more with the difficulties of MS-DOS and the processor itself to deal with large amounts of memory and disk space. Intel and Lotus recently announced their "standard" to let 1-2-3 and Symphony use up to 4 megabytes of RAM through a complex method of bank switching, which seems laughable when you consider that the 68000 can directly address 16 megabytes without a single segment or base register. The IBM PC AT, with its 80286 processor, doesn't have the 1-megabyte limit of its predecessor, but it still has the funky segments, and many of the MS-DOS programs can't take advantage of all that extra RAM.

The real irony is that Apple, with the Mac, could have penetrated into the business market by offering a machine with a large (1 to 8 megabytes) usable memory, a feature that IBM would have had a hard time matching (indeed, *still* has a hard time matching). Likewise, the large memory would have allowed business software to be written much more quickly, since developers wouldn't have to cram their programs into such a tiny space. Apple has finally realized that, or at least appears to have, but they've lost two years and the advantage of surprise. And, despite all the doom and gloom I've seen in the press about the Amiga coming into a tough market, I think it's going to give everyone a good run for their money. Wait and see.

THE VIEW FROM NCC

I attended National Computer Conference in Chicago a few weeks ago. I won't go through a list of the products shown—that's being covered elsewhere—but some comments are in order. First, the show itself seems to be dwindling on the vine. NCC used to be a mainframe/minicomputer show, with microcomputers relegated to the back of the bus. Now the show is dominated by micros and micro-related products, and in the process, NCC has lost its identity. The large (literally) computer people feel that the show has gone to the micros, while the micro people find the show too general, i.e., not specific enough to the micro market. And NCC is caught in the middle.

While the show itself was underattended and not terribly exciting, some interesting trends pointed a few years down the road. In particular, a lot of people were showing prototypes (and, in some cases, shipping versions) of optical-disk storage devices, laser printers, document scanners, high-resolution monitors, and graphics-oriented soft-

(continued)

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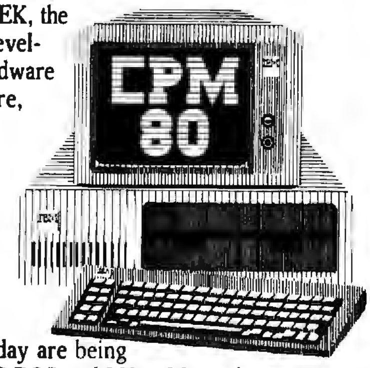

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While the optical-disk technology is fascinating, there are some serious implications, especially in telling an original from a copy.

ware. They point to the second or third generation beyond the Macintosh, personal systems that allow you to easily convert documents from paper to phosphor and back again, with no real trace of the conversion. I'm not sure the "paperless office" will ever come about—there's something too satisfying and reassuring about holding a physical document—but the technology pushing toward the market now will forever blur the distinction between a document on disk and one on bond.

While the technology is fascinating and eagerly awaited—I would love to have all my college notes on an optical disk—there are some serious implications. Combining the technology above with advances in the digital processing of photographs, you start to approach a world where there is no distinction between original and altered copy. Think about it. If you take a legal document, scan it, edit it graphically, then print it out using a laser printer on identical paper, who can tell which is the original? Already, xerographic technology has reached the point where some counterfeiters are using copiers (instead of engraved plates) to make money. As a result, the U.S. Treasury is seriously looking at issuing new currency printed on multicolored paper (possibly with metal threads woven into it). Similar or related techniques may be needed for other important documents to ensure against indetectable alterations. I always get disgusted when people mention Orwell's *Nineteen Eighty-four* and computers in the same breath, but I can't help but remember what Winston Smith's job was: altering official documents to reflect current political reality.

In the Queue

Because I'm in the process of moving, things are in a state of upheaval around here. Hopefully, I can sit down long enough to look at the small mountain of software that has been growing in my office. I won't make any promises or predictions about what I'll get to. My schedule is too unsettled, and I've usually been wrong in the past. Once I move, I hope to have a lot more things to look at (and a lot more time to look at them).

By the way, I've been getting a fair amount of mail (mostly electronically) in response to my first few columns. I appreciate the feedback; please keep it coming. However, I've found that some of the ARPANET/uucp addresses that you've given just don't work, and my replies don't get through. If you've sent me some mail via ARPANET/uucp

(continued)

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By the way, some of you have written actual physical letters. Many, many thanks, but be warned that they are the hardest to answer (and the most likely to get lost). My apologies to any of you who have had your letters vanish, never to be heard from again.

Well, that's it for this month. The column's time lag is shrinking (mostly due to my missing deadlines), but (unabashed plug) you can get more timely information by getting onto BIX. To find out more about BIX, send a letter to BYTE Information Exchange, BYTE Magazine, 70 Main St., Peterborough, NH 03458. BYTE subscribers will be receiving information in the mail about BIX (if you haven't received it already). Hang loose, and I'll see you on the bit stream. ■

It'll be a warm day in Prague before most Americans learn to spell correctly. And no wonder. "I before E unless it's preceded by C, or sounds like A" . . . It's enough to drive anyone to defect.

But now, in a burst of American ingenuity, CYMA/McGraw-Hill introduces Final Draft, the word processor that makes spelling as easy as ABC.

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Living C-Personal

A real-time C debugging environment

BY DICK POUNTAIN

The C language is one of the success stories of the 1980s. From its origins as the system compiler in an (at that time) obscure minicomputer operating system, it has become the premier system (and perhaps application) programming language in the microcomputer industry. For instance, it has been adopted as the house programming language by both Microsoft and Digital Research, the leading purveyors of microcomputer operating systems.

The reasons for the acceptance of C are not hard to analyze (whether you approve of them or not). It's a modern block-structured language that provides user-defined data structures and the benefits that come from good program design. C also gives you unlimited access to the underlying machine and its memory via bit-manipulation operators and pointers. As a fairly simple language, it can be compiled into fast and efficient code, and that code can be easily hand-optimized or linked to assembler segments in those cases where it's not efficient enough. C strikes a compromise between the strongly typed rigor of Pascal and the anarchic freedom of expression of assembly language, which seems to appeal to professional programmers. It's also more portable than most supposedly machine-independent high-level languages.

The one drawback of C is that it was designed to be used in the environment provided by the UNIX operating system. This environment is multitasking, so you can edit a file (using one of the system editors) while a compilation is in progress. It includes a wide range of software tools, including a program checker (lint), a source-code management utility (make), and even some program generators (like yacc, the comiler). You can bolt all these utilities together and more or less automate their operation by writing UNIX shell programs that pipe the output of one tool into the input of the next. In such an environment, C is a very productive software-development language.

The problem is that C is now being used under more primitive microcomputer operating systems that lack these tools, like CP/M and PC-DOS, and without these tools C provides a truly horrible programming environment. To be more accurate, it provides a kit of parts and not an environment at all. Some C compilers require you to run three or more separate programs merely to compile a source file. Separate compilation figures heavily in the C programming methodology, so you soon end up with a disk full of dozens of files for a single program. When using a separate editor, it can take around 10 minutes for each pass through the compile-link-run-crash-edit-recompile cycle.

Even in the UNIX environment things are not quite perfect. C, like FORTH, can tempt programmers into writing tricky and terse code, and this code is scattered among a multitude of source files. Some C programmers also tend to the view that the source code is documentation enough. The maintenance of other people's programs is not easy, even with all those software tools, unless it has been documented by a saint.

This state of affairs has provided a powerful motive to design friendly C programming environments. In the U.S., a variety of C interpreters have emerged recently whose purpose is to allow programs to be interactively developed before final compilation.

Living C-Personal is a C editor, interpreter, animator, and tracer/debugger, all rolled into one menu-driven windowing environment. It's equally useful for teaching C, developing C programs, and maintaining existing C programs.

Living C-Personal was developed in the U.K. by Living Software Ltd. It runs under PC-DOS 2.0 and 3.0 and costs $99.

THE ENVIRONMENT

The Living C system is constructed around a full-screen editor, whose design influences are closer to the EMACS family than to

(continued)

Dick Pountain is a technical author and software consultant living in London, England. He can be contacted c/o BYTE, POB 372, Hancock, NH 03449.

WordStar. For instance, it employs a delete buffer whose contents can be inspected, and even edited, in a window separate from the main text window.

Cursor movement is performed using the IBM cursor-pad keys. Insert or overwrite mode can be selected by pressing either Ins or End, rather than the more usual toggling on Ins. An unusual, but nonetheless useful, feature of the editor is that it recognizes word boundaries; when you delete characters from a word it does *not* pull the rest of the line to the left but only the affected word.

As this is a program editor, there is no word wrap. Instead, long lines cause the screen to scroll sideways. The Ctrl-B and Ctrl-Z commands jump to the left or right end of a line, scrolling the screen if necessary. Long lines are flagged by a + sign at the left or right end. A Goto Line function permits jumping directly to place in the program, though no line numbers are displayed.

Some functions that are especially useful in the formatting of C programs are provided. For instance, F8 joins the next line onto the end of the current line without the need to go and delete the end-of-line character. F9 causes the next character typed to be repeated 4, 16, or 64 times, depending on how many times you press it; it's great for adding lines of asterisks to delimit comments. F10 is an escape key that allows control characters to be entered as literals into source programs.

Editor commands are initially selected from pop-up menus invoked by pressing F1, F2, F3, and F4. Hitting the space bar kills any menu that is no longer required. However, the mode of command selection can be customized to the user's level of experience using the help-level menu of F2.

In the default Full Help mode, all menu selections must be made by typing a letter to move to a selection and then pressing the carriage return. Choosing the Quick Select option removes the need for the carriage return, making selection faster but allowing no time for afterthoughts.

The next level is Command Line Help, usable once you have learned the names of the commands in all the menus. This dispenses with the menus altogether and enables you to press the appropriate function key followed by the single-character command. A certain amount of help is still given, as your command will elicit a prompt phrase on the command line. The least-help level, No Help, dispenses even with these prompts.

F1 brings up the help menu. From there you can choose help texts that explain the options on the other menus, activate or deactivate error

(continued)

messages, and summon help on C-language errors. It also contains the Next Error command for use in debugging. Error messages are displayed on the command line at the foot of the main window, while help messages appear in pop-up windows.

The block buffer permits all the usual cut and paste operations on blocks of code, which are defined by start and end markers placed from the F3 menu. Unfortunately, marked text is not highlighted in any way. Marked text must be explicitly copied to or from the block buffer. The contents of this buffer can be displayed in a window below the main text window and directly edited or written to a file. Extra text can be appended to the end of the buffer.

Search and replace of a simple kind is provided. Replacement can be performed globally or within the currently marked block with or without prompting, but no wide cards are permitted.

Pressing the Escape key summons up the file menu, from which you can exit the editor, with or without updating the current file. Other options let you read, write files, or change to a new file (useful for writing include files). On exiting the editor, you are placed into the main menu, from which you can run and debug programs.

COMPILING, ANIMATING, AND TRACING

The main menu contains the option Run. When this option is activated, Living C compiles your program into an intermediate code, which is then executed by a built-in interpreter. If any syntax errors are encountered, Living C will report them one at a time, unlike the average C compiler, which can be tripped into issuing a huge stream of error messages by a single missing semicolon.

When an error message is received, pressing F1 brings up the help menu. Pressing the carriage return selects the default option, which is "help with the latest error," displaying a window that explains what the error was and the correct C usage (occasionally you will encounter a syntax error too obscure to analyze, whereupon F1 apologizes for not being precise enough). Help for any error can always be had by entering its error number from the F1 menu.

After the program detects an error, it will return to the editor with the cursor pointing at or near the source of the error so you can correct it. Once this error is dealt with, selecting the Next Error command will take you on to find the next one. Errors are thus caught and corrected in a highly civilized step-by-step fashion. If preferred, you can set a compiler option that scans a whole file and reports all the errors at once, writing the messages to a file.

Once the program is free of syntax errors, the source code reappears accompanied by a new menu (see figure 1), while the command line informs that the program is "interrupted by startup in yourfile.c." This interrupt menu is the control panel for debugging operations. The message merely means that Living C has automatically set a breakpoint at the beginning of the program to give you the opportunity to choose one of the above options before it runs. You can return to the interrupt menu at almost any time during program execution by hitting the Break key; it doesn't work when the program is waiting for I/O (input/output), though.

Interrupt Code

C Continue	S Single step	Z Zoom	D set Debug
V Variable	A Alter data	T Trace speed	F Function level
Q Quit execution	X Exit Living C		

Figure 1: *Living C-Personal's interrupt menu. This is the control panel for debugging operations.*

Help for any error can always be had by entering its error number from the F1 menu.

Continue runs the program in animation mode. The source code is displayed on screen and the cursor hops around pointing to the statement currently being executed, like one of those bouncing balls that traced out song lyrics for sing-alongs. The speed of animation can be altered by the Trace speed option, which is measured in "ticks" of around 100 milliseconds.

Zoom stops the animated display and makes the program run ahead at full speed, while Single step executes one step and then waits for a key press before executing another.

When first using the animator, I was surprised at the way the cursor weaves around in a quite convoluted fashion rather than proceeding forward smoothly through the source code. For instance, if it encountered the expression a = b + c;, the sequence of cursor movements would be:

a = b + c; a = b + c; a = b + c;
a = b + c; a = b + c;

This behavior arises because the animation must precisely follow the order of C-expression evaluation; in the preceding example it describes a tree-like path in which operators are identified, then their left operands, and finally their right operands.

As a result, it's not as straightforward as you might expect to follow what's happening in a program; many of the cursor movements are redundant from the point of view of someone interested in the flow of control.

The Variable and Alter data options permit inspection or alteration of the

(continued)

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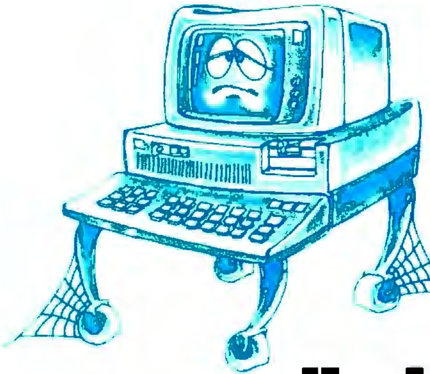

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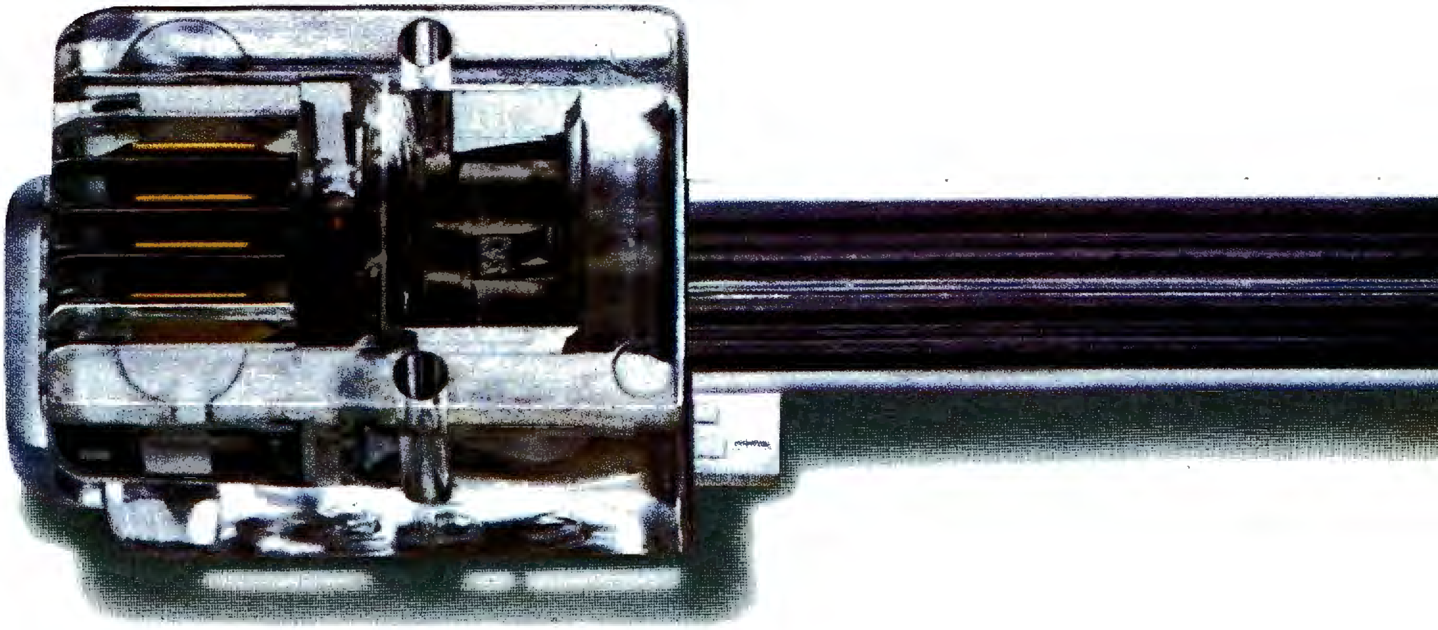

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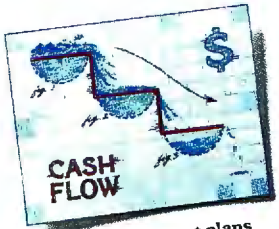

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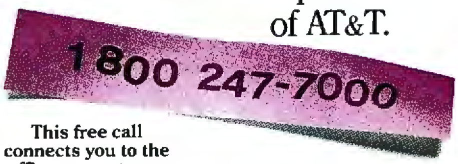

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Since the monitor and I/O windows are separate, debugging information is clearly distinguished from normal program output.

value of any variable in the program by entering its name. Function level enables you to set the depth of nested function calls that are to be traced.

When a program has been set running, any input or output takes place through a standard I/O window that opens up at the top of the screen. This window acts as the console during tracing.

DEBUGGING

You can perform a tracing of a more selective nature than that just described by inserting markers to set breakpoints, data monitors, and ranges. These markers are inserted by choosing the set Debug option, which presents the source code as if in the editor. Markers can be placed using the F4 menu commands, but the source itself cannot be altered. Markers are visible in the text as a letter followed by a digit (e.g., <B1> for breakpoint 1) and can be hidden or revealed by the O command on the interrupt menu.

A breakpoint behaves just like the Break key, stopping the program and displaying the interrupt menu. Breakpoints must be set at points that the cursor will touch during its journey, that is, on a variable name or an operator.

A data monitor is a marker attached to the name of a variable that causes the value of that variable to be continuously displayed in a special data-monitor window when the program is traced. Monitors can only be applied to scalar variables, not to arrays or structures. Since the monitor and I/O windows are separate, debugging information is clearly distinguished from normal program output.

A range is set by placing a start and end marker, like those for block moves. Tracing is then confined to the code between the markers, the rest of the program proceeding at full Zoom speed. This feature is enormously time-saving, since you do not need to sit for minutes watching the animation of parts of the program you are not interested in.

(continued)

There are limits on how many of these markers can be used, though. Only one data monitor, two breakpoints, and two ranges may be set at any one time.

Command Lines and Files

Living C supports the full Kernighan and Ritchie model of the language, including all the preprocessor commands (see *The C Programming Language* by Brian Kernighan and Dennis Ritchie, Prentice-Hall, 1983). However, it is a monolithic, interactive environment, whereas normal C is a "kit of parts" based on separate files used at the DOS level. This calls for some special tricks in Living C to maintain full compatibility with normal C.

Compiler directives normally issued on the command line are simulated by a file called LC_CMDS that can be edited from the main menu using the standard editor. This file is passed as a command line when you enter Living C. Among the compiler directives it supports are:

—I <dir<	Look for #include files in directory <dir>.
—D <name>	Treat <name> as if it has been #defined to value 1.
—S	Don't stop on errors; put them all in a file.
—E <filename>	Put errors in this file.

Other directives set the maximum space available for static data, local variable frames, and external references. All the directives have sensible default values so the feature is optional.

A similar facility using the file LC_UCMD permits a simulated command line to be passed to a compiled program at run time, containing arguments to be bound to argc and argv.

Living C directly supports top-down coding of programs, as it can compile and run a program with unresolved external references. When such a reference is encountered during program tracing, execution stops and a prompt on the command line requests a value. If you enter a value, Living C pretends that this value has been returned by the external function and carries on executing happily.

Source files are given the default extension .c, and the compiled pseudocode files extension .t. When the Run command is given, the source file is compiled to a .t file that is kept on disk. Subsequent runs will not need to be compiled, unless the editor detects that the source file has been changed. There is a complication, however, because Living C supports the inclusion of source files with #include, and they are separately

(continued)

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compiled to .t files. The editor cannot detect that an included file has been updated if the main file has not. For this reason the main menu contains an option to make .t files manually in these cases.

CONCLUSIONS

The version of Living C-Personal that I reviewed was an early beta release (version 1.02) that still contained some obvious bugs and some loose ends, such as unsightly screen updating in the editor. I'm assured by Living Software that all of these have been dealt with in the final-release version, which may also contain enhancements not mentioned here.

That being the case, I am impressed by Living C. It provides a tool for teaching and learning the C language, which I feel is otherwise a miserable chore. The animation facility is such a powerful aid to comprehension that all serious languages ought to have one.

Living C can be used equally as an environment for testing and developing programs prior to compiling them for production using one of the industry-standard compilers. I had neither the resources nor the time to check the claims for compatibility, but Kernighan and Ritchie is a pretty safe starting point.

Perhaps the most interesting application for Living C, though, is in the maintenance of existing programs. C does not encourage the writing of particularly readable programs, but now you can always understand how someone else's otherwise obscure code works by animating it and watching the bouncing ball.

Living C-Personal is the first of a family of Living C programs. A UNIX version of the program is likely to follow soon, and more tools aimed at professional programmers including source code and version control would not be too surprising.

At its price of $99, I foresee a future for Living C up there with Turbo Pascal and the other software bargains of our time. ■

SOFTWARE MENTIONED

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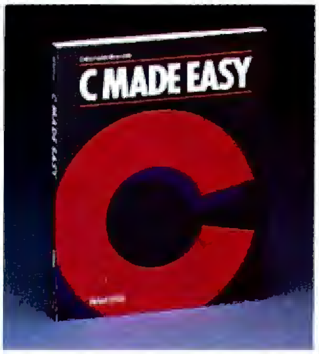

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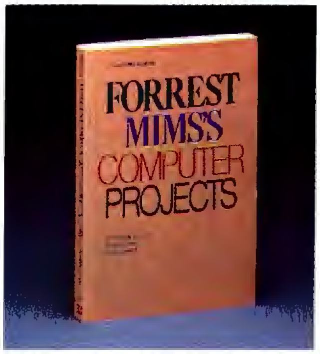

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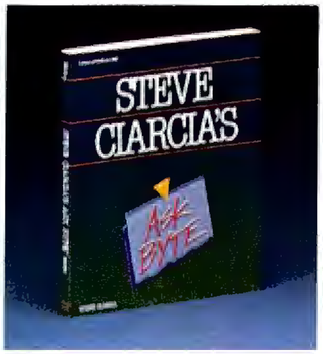

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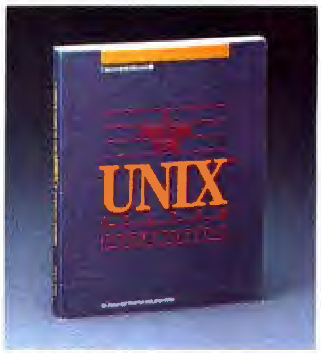

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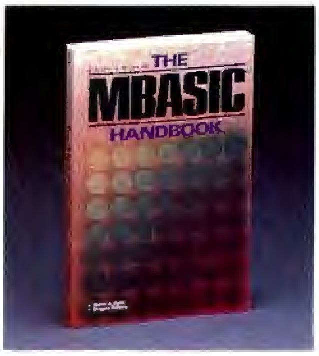

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Repeating Decimals

Cycles, sequences, and late repeaters

BY ROBERT T. KUROSAKA

Early in our educational career, we all discovered that $1/3 = 0.33333\ldots$ (abbreviated to $0.\overline{3}$ in this column) and that $2/3 = 0.\overline{6}$. Some of us went even further and found that $1/7 = 0.\overline{142857}$ and $1/11 = 0.\overline{09}$. While some fractions have terminating decimals ($1/16 = 0.0625$), most fractions have nonterminating decimals with a portion, or cycle, that repeats endlessly. (Actually, there are a countably infinite number of each kind of fraction, but it's best not to think too much about paradoxes of infinity. For our purposes, I'll say that there are more of the second kind and pretend that I know what I'm saying.) It has been proven that all fractions have either terminating decimals or cyclically repeating decimals.

The English mathematician William Shanks calculated the cycle lengths for all prime denominators less than 120,000. Shanks is known for his prodigious work in calculating π to 707 places in the 1870s. He is even better known for having an error in the 528th place (found by another Englishman, Ferguson, in 1947).

This month's column will explore some of the properties of repeating decimals. While I will limit the discussion to unit fractions (those with a numerator of 1), the program in listing 1 deals with any fractions that have a positive whole-number numerator and denominator, up to the limit of your computer's memory.

In base 10, only fractions with denominators of the form 2^a5^b will have terminating decimals; that is, the denominator is composed of factors of 2 and 5 only, such as 2, 4, 5, 8, 16, 20, 25, 32, 40, 50, and so on. The length of the terminating decimal will be either a or b, whichever is larger. All other denominators will have repeating decimals. In other bases, those denominators that are of the form $p_1^c, p_2^k, \ldots p_n^m$ where the ps are prime-number factors of the base, will terminate. For example, in base 14, denominators that are expressible as 2^a7^b will form terminating decimals.

We have noted that 1/7 has a 6-digit cycle. If we divide out 1/17, we find a 16-digit cycle: $0.\overline{0588235294117647}$. Similarly, we see that 1/19 has an 18-digit cycle: $0.\overline{052631578947368421}$. Boldly, then, we conjecture that for any prime p, the decimal of $1/p$ will have $p-1$ digits in its cycle. But we are wrong—we overlooked two earlier examples: $1/3 = 0.\overline{3}$ and $1/11 = 0.\overline{09}$.

Fractions with composite (nonprime) denominators will also have repeating decimals, but denominators containing factors of 2 or 5 will repeat only after a few decimals that are not part of the cycle ($1/88 = 0.011\overline{36}$, $1/75 = 0.01\overline{3}$). These decimals are called late repeaters. If we express these denominators as $2^a \times 5^b \times p_1^c, \ldots p_n^m$, the length of the delay will equal either a or b, whichever is larger (sound familiar?). For example, $88 = 2^3 \times 5^0 \times 11^1$, $a=3$, $b=0$, $3>0$, so the cycling portion begins after the first three digits. Further, in the simple case where the denominator can be expressed as $2^a \times 5^b \times p^c$, the length of the cycle will be equal to the length of the cycle of $1/p^c$ (for example, 1/88's cycle length equals the cycle length of 1/11).

Thus, the question arises: What rule governs the lengths of the cycles? We can answer part of this question with a little thought. Consider the successive steps in the division of 1/13, as shown in table 1. Each subtraction leaves a remainder: After the 1, we have 10, 9, 12, 3, ... We can expect to see a maximum of 12 different remainders (1, 2, 3, ..., 12); we will not see a remainder of 0 since we know that the decimal will not terminate. If we continue to divide to 12 decimal places, one of two things will happen. We will see all 12 remainders and the next division will produce a previously seen remainder, or a previously seen remainder will appear before the twelfth division. In either case, we will have found the repeating cycle in, at most, 12 divisions. We have found the maximum length of the cycle. In general, for any

(continued)

Robert T. Kurosaka teaches mathematics in the Massachusetts State College system. He invites your correspondence c/o BYTE, POB 372, *Hancock*, NH 03449.

Table 1: *The first four steps in turning 1/13 into a decimal number.*

0.	0.0	0.07	0.076
13)1.00000	13)1.00000	13)1.00000	13)1.00000
0	0	0	0
—	—	—	—
1	10	10	10
	0	0	0
	—	—	—
	10	100	100
		91	91
		—	—
		9	90
			78
			—
			12

Listing 1: *A program to calculate the cycle for repeating decimals.*

```
10 '**********************************
20 '*      FRACTION-CYCLE GENERATOR   *
30 '*            BY BOB KUROSAKA      *
40 '**********************************
50 CLS
60 PRINT "THIS PROGRAM CALCULATES THE CYCLE OF REPEATING
   DECIMALS"
70 PRINT "FOR POSITIVE FRACTIONS. ANSWERS ARE PRINTED AS
   #.##__##..."
80 PRINT "WHERE THE NUMBERS BETWEEN '__' AND '...' ARE REPEATED
   INFINITELY."
90 PRINT :PRINT
100 INPUT "ENTER THE FRACTION'S NUMERATOR";N:NUMERATOR=ABS(N)
110 INPUT "ENTER THE FRACTION'S DENOMINATOR";D:DENOMINATOR=ABS(D)
120 REM 'TERM' HOLDS THE VALUE OF EACH DIGIT IN THE DECIMAL.
    'REMAINDER' HOLDS THE LOCATION OF THE FIRST OCCURRENCE OF A
    REMAINDER, I.E., REMAINDER(1)=9 MEANS THE REMAINDER 1 WAS
    FIRST USED TO CALCULATE THE NINTH TERM.
130 DIM TERM(DENOMINATOR), REMAINDER(DENOMINATOR)
140 REM CALCULATE THE WHOLE-NUMBER PART, STORE IN TERM(0).
150 TERM(0)=INT(NUMERATOR/DENOMINATOR)
160 REM CALCULATE THE REMAINDER, FLAG THAT NUMBER'S FIRST
    OCCURRENCE AS 1.
170 REMAINDER=NUMERATOR-TERM(0)*DENOMINATOR:REMAINDER
    (REMAINDER)=1
180 REM WHEN WE'VE SEEN A REMAINDER BEFORE, NEW.REMAINDER$
    WILL BE SET TO 'NO.'
190 NEW.REMAINDER$="YES"
200 WHILE NEW.REMAINDER$="YES"
210      REM 'DIGIT' KEEPS TRACK OF THE DECIMAL PLACE OF THE TERM.
220      DIGIT=DIGIT+1
230      DIVIDEND=10*REMAINDER
240      TERM(DIGIT)=INT(DIVIDEND/DENOMINATOR)
250      REMAINDER=DIVIDEND-TERM(DIGIT)*DENOMINATOR
```

(continued)

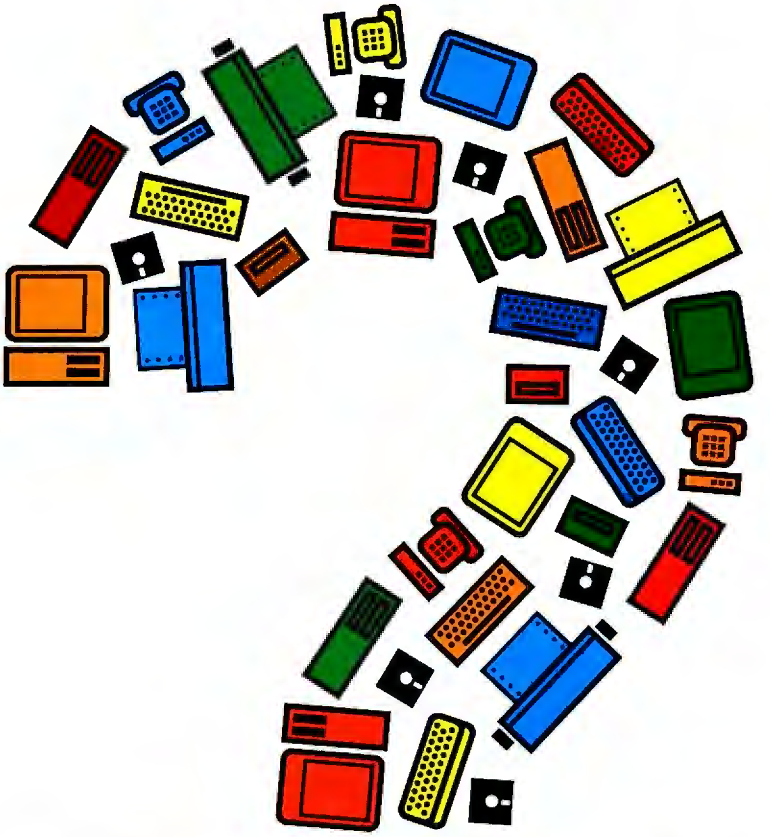
denominator d of a repeating decimal, the decimal $1/d$ will repeat in, at most, $d-1$ places.

Our next question is which denominators have cycles of length $d-1$ and which have shorter cycles. Sorry, there is no concise answer to this question. This is one opportunity for some personal exploration with the program in listing 1 (available for downloading from BYTEnet Listings; call (617) 861-9774 before November 1 and (617) 861-9764 thereafter).

The program works in a manner analogous to what we did with the fraction 1/13 in table 1. In general, since the repeating cycle will exceed the precision of our computer, some extended precision is required. In our program, the digits of the decimal expansion are stored in the array TERM, one at a time as they are determined. The remainder is tested after each division to see if it equals one we have had before. To do this, we use a flag array REMAINDER, where the subscript of the array element corresponds to the remainder and the contents of the array element correspond to the first occurrence of that remainder. In table 1, remainder 1 was used to calculate the first digit. Therefore, REMAINDER(1) will be set equal to 1. Remainder 10 was used to calculate the second term, so REMAINDER(10)=2, etc. When the remainder finally equals one we have had before, as indicated by the relevant REMAINDER element being nonzero, the contents of the TERM array are printed out and the beginning of the cycle (the term denoted by the contents of REMAINDER (REMAINDER)) is marked.

The size of the denominator you can handle is limited by the available memory. If you're feeling ambitious, you can use the information presented on delay length for late repeaters to eliminate the REMAINDER array, thereby nearly doubling the available memory. If, in addition, you print out each term as it is calculated rather than storing it in an array, you can deal with denominators as large as precision or time will allow.

(continued)



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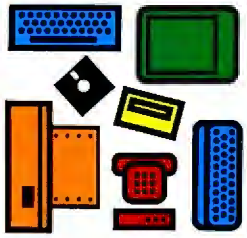

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```
260      REM IF THE DECIMAL TERMINATES, SET THE 'EXACT$' FLAG AND
           PREPARE THE 'REMAINDER' ARRAY TO TERMINATE THE LOOP AT
           LINE 290.
270      IF REMAINDER=0 THEN EXACT$="YES":REMAINDER(REMAINDER)
           =DIGIT
280      REM IF THIS IS A NEW REMAINDER, STORE THE TERM IT'S
           ASSOCIATED WITH IN THE APPROPRIATE 'REMAINDER' ARRAY
           LOCATION. OTHERWISE, WE'VE COMPLETED ONE TRIP AROUND
           THE CYCLE AND CLOSE THE WHILE/WEND LOOP.
290      IF REMAINDER(REMAINDER)=0 THEN REMAINDER(REMAINDER)=
           DIGIT+1 ELSE NEW.REMAINDER$="NO"
300 WEND
310 REM PRINT RESULTS.
320 PRINT NUMERATOR;"/";DENOMINATOR;"=";
330 REM FIRST, THE WHOLE-NUMBER PART.
340 PRINT TERM(0);". ";
350 REM THEN THE PART BEFORE THE CYCLE, SUPPRESSING LEADING
    BLANKS.
360 FOR I=1 TO REMAINDER(REMAINDER)-1
370      PRINT USING "#";TERM(I);
380 NEXT I
390 REM IF THE DECIMAL CYCLES, MARK THE BEGINNING OF CYCLE WITH
    '_'.
400 IF EXACT$<>"YES" THEN PRINT "_";
410 REM NOW PRINT THE CYCLIC PART.
420 FOR I=REMAINDER(REMAINDER) TO DIGIT
430      PRINT USING "#";TERM(I);
440 NEXT I
450 REM PRINT THE CYCLE LENGTH.
460 IF EXACT$<>"YES" THEN PRINT "...":PRINT : PRINT "THE CYCLE
    LENGTH IS";DIGIT-REMAINDER(REMAINDER)+1
470 REM IF THE DECIMAL DOES NOT REPEAT, SAY SO.
480 IF EXACT$="YES" THEN PRINT:PRINT:PRINT "THIS IS A NONREPEATING
    DECIMAL."
490 END
```

Here are some well-known properties of repeating decimals:

- While 1/97 has a 96-digit cycle and 1/1861 has an 1860-digit cycle, some large denominators have remarkably short cycles: 4649 has a 7-digit cycle; 513,329 has an 11-digit cycle; and 265,371,653 has a mere 13-digit cycle.
- Since 1/11 has a 2-digit cycle and 1/37 has a 3-digit cycle, it is not surprising that their product, 1/407, has a 6-digit cycle ($0.\overline{002457}$). But while 1/7 has a 6-digit cycle and 1/101 has a 4-digit cycle, their product, 1/707, does not have a 24-digit cycle but a 12-digit cycle. It seems that the length of the product's cycle is the least common multiple of the two cycle lengths, but I have not seen a proof of this.
- If a prime-number denominator's cycle has an even number of digits, such as $1/13 = 0.\overline{076923}$, the cycle can be "bisected" into 076 and 923, and the two halves add up to "999." That is, in any even-digit cycle of prime denominators, the two halves are 9-conjugates of each other. If we know the first half of a cycle, we can immediately find the second half—just perform a "subtract from 9" for each digit of the first half. But first we must know when we've reached the middle of the cycle, and we must know in advance that the cycle has an even number of digits. Any suggestions? With composite denominators, this bisection may or may not apply. For example, the cycle of composite denominator 407 discussed in point 2 is even but does not bisect into two 9-conjugates.
- If the denominator is a power of a prime, yet another pattern emerges. For example, 1/7 has a 6-digit cycle;

(continued)

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its square, 1/49, has a 42-digit cycle; and its cube, 1/343, has a 294-digit cycle. The pattern becomes clear when we note that $42=7\times6$ and $294=7^2\times6$. Similarly, 1/11 has a 2-digit cycle; its square, 1/121, has a 22-digit cycle ($22=11\times2$); its cube, 1/1331, has a 242-digit cycle ($242=11^2\times2$); and its fourth power, 1/14641, has a 2662-digit cycle ($2662=11^3\times2$). In general, if the denominator is a power of a prime, p^n, and $1/p$ has a k-digit cycle, $1/p^n$ will have $p^{n-1}\times k$ digits in its cycle. Unfortunately, there are exceptions to this rule: 1/3 and 1/9 have a 1-digit cycle, and 1/487 has a 486-digit cycle, as does its square, 1/237169. These are the only primes less than 1000 with this property.

At this point, it seems reasonable to stop, catch our breath, and ask what good all this may be. I do have

(continued)

Table 2: *By "stacking" the Fibonacci sequence, beginning with 0.01 and moving one place to the right each time, then adding the numbers up, we get the fraction 1/89. The decimal representation of 1/89 has a 44-digit cycle, only part of which is reproduced in the table.*

```
0.01
   1
    2
     3
      5
       8
       13
        21
         34
          55
           89
           144
            233
             377
              610
               ....
__________________
0.011235955056.....      = 1/89
```

Table 3a: *The algebraic method of converting repeating decimals to the corresponding fraction, demonstrated for* $0.\overline{123}$.

1. Let x = the repeating decimal	x	= 0.123123123. . .
2. Multiply 1. by 1000 (this time)	1000 x	= 123.123123123. . .
3. Subtract 1. from 2.	999 x	= 123
4. Solve for x and reduce	x	= 123/999 = 41/333

Table 3b: *The method of table 3a applied to the late-repeating decimal* $0.13\overline{27}$. *Notice that you will generally have to multiply the numerator and denominator by some power of 10 to clear the decimal in the numerator before reducing the fraction.*

1. Let x = the late repeater	x	= 0.132727. . .
2. Multiply 1. by 100 (this time)	100 x	= 13.272727. . .
3. Subtract 1. from 2.	99 x	= 13.14
4. Solve for x and reduce	x	= 13.14/99 = 1314/9900 = 73/550

a few suggestions. First, a decimal with a long cycle, like 1/1861, may be a convenient source of pseudorandom numbers. One word of caution—if you use this approach, remember that the first few digits will always be 0s. Therefore, don't use the first few terms as part of the random sequence.

Second, particular repeating decimals have some interesting and potentially useful properties. For example, 1/89 has a 44-digit cycle that can be formed by "stacking" the numbers in the Fibonacci sequence, as shown in table 2. The question arises: Since we know that the decimal "encodes" the Fibonacci terms, and since we also know the values of as many of the digits in the decimal as we want, can we exploit this information to retrieve the nth term of the Fibonacci sequence without actually expanding the sequence? (Notice that the expansion begins with the zeroth term of the sequence, so that the 440th to 442nd digits of the decimal expansion are 0,1,1. This is not the same numbering system we used for the terms in our program, where the first 0 was called the first term.) This question has considerable generality. Repeating decimals can always be viewed as encoding some infinite series in a similar manner.

As you explore these possibilities, you may find it useful to be able to reconstruct the fraction from the repeating decimal. I have not written a program to do this, but the algorithm is quite simple. Here are the steps, using the repeating decimal $0.\overline{123}$ as an example (see table 3a). First, let x equal the repeating decimal. Next, multiply both sides of the equation by 10 to the length-of-the-cycle power (in the example, the cycle length is 3, so multiply both sides of the equation by 10^3, or 1000). Subtract the first equation from the second, thus clearing the repeating part of the decimal. The denominator of the possibly unreduced fraction will be the coefficient of x, and the numerator will be the value on the right-hand side. All that remains to be done is to reduce the fraction by eliminating common factors of each. By the way, this algorithm works for late repeaters as well, although you may have to multiply the numerator and denominator by some power of 10 to clear decimal values before reduction (see table 3b).

I hope that you are already eager to explore the realm of repeating decimals on your own so that you can discover many of the fascinating patterns. One exciting side trip is examining repeating decimals in bases other than 10. I look forward to hearing of your findings. ■


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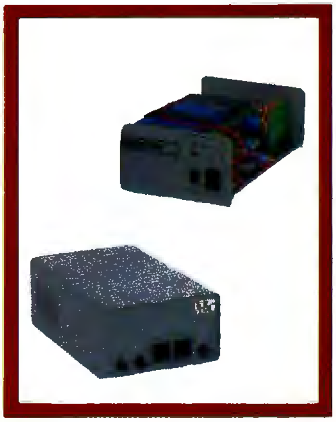

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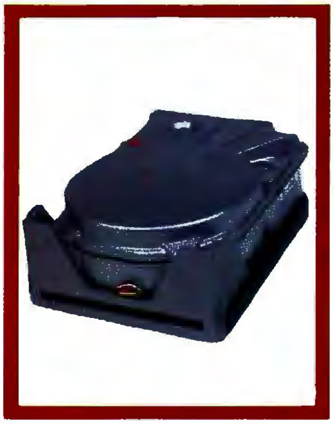

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Comparing Fujitsus

The Fujitsu FM-16β and an update on the NEC PC-9801M2

BY WILLIAM M. RAIKE

I did it. I bought myself a new computer! I took delivery on my new Fujitsu FM-16β the Friday before last and was using it for daily production the next day. You'll recall that I was enthusiastic when I got my Fujitsu FM-11BS (see January BYTE, page 429). Well, I'm even more enthusiastic about the FM-16β.

One of the more reassuring things about the FM-16β is that nearly every piece of software I own and ran on my old Fujitsu runs perfectly (and a lot faster) on the FM-16β. The FM-16β's floppy-disk format is identical to that of the older computer, and its main processor, an 80186, is totally software-compatible with the 8088-2 in the FM-11BS. The CP/M-86 Level 4 operating system on the new machine is practically identical to the Level 3 that was supplied with the FM-11BS. The only differences between the two machines seem to be a few extensions to the FBIOS (Fujitsu basic input/output system) to provide access to the calendar/clock, timer, interrupt, and hard-disk features. And the CP/M-86 error messages in this version are displayed in Japanese instead of English.

QUIRKS

But there are always quirks. One had to do with the FM-16β's cursor. Just as in my FM-11BS, the FM-16β "wakes up" with an underline cursor after the power comes on. I happen to prefer a blinking block cursor—it's a lot easier to see. It was easy to change the cursor style on the FM-11BS; to reset the cursor attributes, it was only necessary to TYPE a file (I called it CURSOR.SYS) containing a 4-byte sequence of control characters. To do that automatically, I added the line TYPE CURSOR.SYS to the AUTOEXEC.SUB file that gets run immediately after power-up. The same trick and the same file worked fine on the FM-16β; the only problem was that every time a program ended and returned control to the operating system, the system displayed the prompt (A>) and then proceeded to reset itself to an underline cursor!

After an hour or two of frustration and annoyance, I decided to do something. It turned out that many critical parts of the operating system were contained in a disk file named CPM.SYS. Using my debugger, I searched through that file to try to locate the 4-byte sequence that set up the underline cursor. Success! Changing one byte of that sequence gave me the block cursor I wanted.

Another of the FM-16β's quirks has to do with Fujitsu's documentation, not the hardware or software itself. Japanese products have been known for the poor quality of their documentation, which is often vague, poorly written, and incomplete. In this case, the key word is "incomplete." For example, even though the FM-16β contains over 6000 Japanese characters in kanji ROM (read-only memory), and the CP/M-86 operating system supports Japanese-language input and output through Digital Research's Foreign Language System Extension called FSX-86, the manuals contain little valuable information, other than terse descriptions of certain features of Fujitsu's FBASIC dialect. The manuals do tell you how to use these features from application programs, how to issue operating-system calls to get Japanese characters from the keyboard, and so on. But the net result of the documentation is to reduce vast areas of the operating system to "undocumented features."

The situation is similar regarding graphics: Digital Research's Graphics System Extension (GSX-86) is supplied, but there is absolutely no information regarding its capabilities or how to use it. For a machine with such powerful graphics and Japanese-language features, Fujitsu's cavalier approach to documentation is disappointing.

GRAPHICS CAPABILITIES

Besides the 80186 main processor, running at 8 MHz, this machine, like the FM-11BS, has an MBL68B09 coprocessor to manage

(continued)

William M. Raike, who has a Ph.D. in applied mathematics from Northwestern University, has taught operations research and computer science in Austin, Texas, and Monterey, California. He holds a patent on a voice scrambler and was formerly an officer of Cryptext Corporation in the United States. In 1980, he went to Japan 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, POB 372, Hancock, NH 03449.

the keyboard, screen, and other peripheral chores. But for some reason, the FM-16β manages to update the screen much faster.

The difference is obvious when you are using a screen editor. I don't personally have very much to do with graphics, but a graphics demonstration program comes with the computer. This machine has several custom LSI (large-scale integration) chips for speeding up graphics processing, and the result is, almost literally, blindingly fast. The quality is excellent, too; the resolution is 640 dots horizontally by 400 dots vertically. And, in addition to the 512K bytes of standard memory, you get 192K bytes of graphics video RAM (random-access read/write memory).

To let you exploit at least some of the graphics abilities of the FM-16β, Fujitsu includes a program called β-Paint. Written in BASIC, it lets you use a mouse (a mouse interface is standard) to draw pictures, set up various fonts, etc. It's similar to the MacPaint program written for the Macintosh—pull-down menus and all. I didn't buy a mouse, but Fujitsu includes a demonstration program that shows some of β-Paint's features.

THE HARD-DISK MODEL

The FM-16β comes in three versions: the FD, SD, and HD models. The most common is the FD version, which includes two built-in 1-megabyte 5¼-inch floppy-disk drives. Main memory is expandable to a full megabyte, and kanji-character support is excellent—both the JIS No. 1 and No. 2 standard character sets are supported from ROM, giving a total of over 6800 characters in addition to the full alphanumeric and kana character sets. This version sells for just under $1700. The SD is a stripped-down version with less Japanese-language capability, less memory, and less expandability; it sells for about $300 less than the FD model. I bought the HD model, which has a thin 5¼-inch 10-megabyte hard-disk drive that replaces the topmost floppy-disk drive. The hard-disk interface occupies one of the four expansion slots but also leaves open the possibility of directly connecting an additional external hard-disk drive.

This is my first personal computer with a hard disk, but after only 10 days or so, I wonder how I ever managed without it. When I want to power up the computer, I don't have to look through boxes of disks to find and insert the appropriate ones—I just turn on the machine. Fujitsu supplies a utility program that lets you configure the FM-16β to boot up from the hard disk if there's no floppy disk in the machine or if there's a floppy disk that doesn't contain the operating-system tracks. Another easy-to-use utility lets you "partition" the hard disk into several (up to seven) subdisks.

I decided to partition my hard disk into five disks and assign them to logical drives A through E. Drive A is a 2-megabyte partition that contains all my system utilities, word processor, editor, debugger, etc. Drive B is another 2-megabyte disk that contains language processors, software-development tools, and the like. Drives C, D, and E are archive disks, with respective capacities of 3, 2, and 1 megabyte. I may change this organization in the future, but it seems to group my files conveniently according to function while keeping the total number of files on any single disk (and the size of the directory) down to a manageable level. It also makes it fairly painless to back up files onto floppy disks at regular intervals, since most of the files in drives A and B will change only rarely.

The floppy-disk drive is assigned to drive F, while the RAM disk, or memory disk, is drive M. This computer comes with 512K bytes of RAM, and until my 512K-byte expansion board arrives next month, I've got 256K bytes allocated to the RAM disk. That's not as much as I want for program development, but on the FM-16β my compiler runs just about as fast using the hard disk as it did from the RAM disk on the FM-11BS.

BENCHMARKING REMARKS

Just for fun, I ran some impromptu benchmarks on the old FM-11BS. Using my trusty stopwatch as a timer

(continued)

UPDATE ON THE NEC PC-9801M2

A reader from Osaka pointed out a couple of errors in my description of NEC's popular PC-9801M2 in the May BYTE Japan (page 355). I said that all 256K bytes of standard RAM (up from 128K bytes in the earlier PC-9801F2 machine) were on the main board. I was wrong; a 128K-byte memory board is installed at the factory in one of the PC-9801M2's expansion slots. For owners who don't want to use up scarce expansion slots for memory boards, there are 512K-byte memory boards available from several manufacturers. I can't say for certain, but it's highly likely that they will also work in NEC's APC III sold in the U.S.

I've remarked several times that the maximum of 640K bytes of memory that the PC-9801 series allows really isn't enough if you want to use 512K bytes as a RAM disk. Well, there are several ways around this limitation. A Japanese technical magazine recently carried an article describing user-installed device drivers running under the MS-DOS operating system, and it gave an interesting example: It showed how to write and install a device driver that lets you use the 192K bytes of graphics video RAM included in the NEC machine as an additional RAM disk. In another approach, the same Osaka reader recently sent me information on some commercial RAM-disk software from Megasoft Inc. that accomplishes the same thing and more. Using boards from another Japanese vendor, it can manage up to 15 banks of 512K bytes each under MS-DOS, giving a maximum of 7.5 megabytes of RAM-disk space.

WOULD YOU BUY A PACEMAKER FROM MATTEL?

IBM/PC-based LOGIC LINE-1™ artificial intelligence software is so advanced, that competitive products are toys by comparison.

There aren't very many who'd stake their lives on a toy-store pacemaker. Luckily, we won't have to worry about their rancid cells polluting mankind's gene pool very long anyhow. Such brain-damaged geeks tend to die young.

If you've recently spent money on artificial intelligence software, you might be wishing a few programmers had croaked before writing that blithering swill they named AI and palmed off onto you. What they call an "inference engine" is nothing more than an IF-THEN decision tree that can't even do a very good job of arithmetic.*

We're Clarity Software, and we're introducing a product that can take a massive amount of text from any machine-readable source, and mathematically distill thought processes for query and analysis. This process, as distinguished from *expert systems*, is referred to as *natural-language intelligence*.

In this ad, we're going to explain to you why you'd be crazy not to have our package in your portfolio of data-manipulation assets.

DERIVE THE DNA/RNA OF ANY WRITER'S THOUGHT PROCESSES.

LOGIC LINE-1 was the result of the interaction between a couple of cyberneticists and a physicist, with combined experience in high-performance learning and pattern-recognition programming. The physicist was responsible for one of the first DNA/RNA-tracking systems (the *RNA-of-thought* assertion is more than just an advertising creation). We are not your ordinary bunch of yahoos.

Imagine having the collected thoughts of Voltaire online. If you were interested in viewing Voltaire's thoughts on "job security," you would enter that term in the search menu.

Now you're thinking: "Nuts! These yahoos are trying to sell me something my supposedly *toy* text editor can do with a search command. Right?"

Wrong, pussycat. Your inference process was a little quick on the trigger. Never, in any of Voltaire's writing, was there ever the phrase "job security."

"Ok," you reply. "You have a dictionary of synonyms, eh?" Wrong again. LOGIC LINE-1 has no dictionary. Interesting?

Essentially, LOGIC LINE-1 uses a series of mathematical transformations on text, the output of which is cataloged in a database analogous to a biological DNA/RNA imprint of that text.

There are approximately one dozen parameters that make up a *thought's DNA/RNA*. Some transformations fingerprint syntax patterns; some look at subject/predicate relationships via a small dictionary of several dozen *noise* words.

After setting up the above Voltaire "job security" query, LOGIC LINE-1 will present you with high-possibility "hits." You will type "Y" when they are relevant, and "S" for skip, when they are not.

The first several "hits" might be rejected, since the term "job security" will not be found. Once you get an acceptable entry, however, and lock onto an acceptable *RNA-of-thought* pattern, the accuracy of LOGIC LINE-1 will be staggering. Or we'll refund your money. Simple enough?

"I'M NOT INTO VOLTAIRE," YOU SAY. "WHY DO I NEED LOGIC LINE-1?"

How would you like to be able to turn any textbase into an expert system? For example, most PC users rely upon word processing. The problem is, we store our correspondence in files with names like "LT062185" or "REJECT21" or "RANDOMTH." As a result, we reinvent the wheel with each letter we compose. Why do this?

Using LOGIC LINE-1, you can append all your written correspondence into one textbase file. Sure, any word processor could do a straight search for a term like "quality." But none can do this search as fast as LOGIC LINE-1. And none could turn up the "quality" references if queried for the term "workmanship!"

Thus, when writing letters and speeches, use LOGIC LINE-1 to collect previously articulated thoughts on any given subject. Whatever your profession, be it law, medicine, engineering or information management, LOGIC LINE-1 is an indispensable tool for true thought processing.

Now that thousands of textbases are publicly available, LOGIC LINE-1 is the key to their intelligent use. Once the computer establishes associative links in a large body of material, many creative applications are possible.

TRUE AI! CLONE THE GREAT MINDS ON YOUR PC.

Did Bacon write Shakespeare? Did Albert Einstein have anything relevant to say on the subject of "generation gap?" How many congressmen consistently contradict themselves in the *Congressional Record?*

The uses of LOGIC LINE-1 are limited only by the availability of textbases, and by your imagination.

Do you dare send a student to college without LOGIC LINE-1 and a PC? Would YOU care to compete in business with someone else who has this leading-edge, decision-support software?

Einstein should write your papers on relativity. Alfred North Whitehead should write your papers on philosophy. And Shakespeare should write your love letters.

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This is our very first, and only, announcement ad. For the rest of this year, you may obtain LOGIC LINE-1 for only $100 (note, we didn't try to fool you with a $99.95 price tag; we *do* give you, as well as your computer, some credit for intelligence). As of January 1, 1986, LOGIC LINE-1 will retail for $250.

To find out more about LOGIC LINE-1, call 216/729-1132. You may order by phone by calling 800/621-5839 (or in Illinois, call 800/972-5855). Return the product for any reason whatsoever within 30 days for a full refund. If you are with the US government or one of the intelligence *spook shops*, LOGIC LINE-1 is available to federal/DOD buyers through IBIS Corporation, 131 Elden Street, Herndon, VA 22070 (call 800/532-3344 or 703/478-0300).

You COULD spend your next $100 for other software. You could also ask Weird Al Yankovic to install that terrific new pacemaker from your kids' *Young Doctor* toy kit. Call today and save more than just money.

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(216)729-1132

*The only other package out there worthy of the label "artificial intelligence" is from Teknowledge in Palo Alto, and we don't compete with them. They build "expert systems," while our emphasis is on "natural language" systems. We mention them in passing, because they're one of the few "good guys." Copyright © 1985 by Clarity Software. LOGIC LINE-1™ is a trademark of Clarity Software, and requires a 128K IBM PC with at least one diskette drive and runs under MS/DOS 2.1 and up. IBM™ IBM Corp. MATTEL™ Mattel. We hope the swell people at Mattel can take a joke. Advertising & PR by TRBA, 408/258-2708.

An 80286 *board will be available for the* FM-16β *this autumn.*

(meaning that the measurements were accurate only to within ¼ second or so), I measured the average time it took to copy files among the various disk drives on each of the machines as well as the time needed to compile my communications program (written in C) and the time WordStar took to move from the beginning to the end of a medium-size text file. Since the floppy-disk drive on the FM-16β is identical to the ones on the FM-11BS, the measurements gave me a rough idea of the increased speed of the 80186 processor and also of the speed advantage of the hard disk.

For the file-copy measurements, I used a text file 28K bytes long and copied it (using the CP/M-86 PIP utility) from both the floppy disk and from the hard disk into the RAM disk. On the FM-11BS, it took 6.02 seconds to copy the file from floppy disk to the RAM disk. On the new computer, that time was 4.34 seconds. It took only 2.40 seconds to copy the same file from the hard disk to the RAM disk. So, for this kind of common task, the hard disk gives me approximately double the speed of a floppy-disk drive, the 80186 processor is about 25 percent faster than the 8088-2 (both running at 8 MHz), and the new computer is about 2½ times faster than the old one. I ran several other programs on both machines using the floppy disk in both cases; all the tests seemed to confirm these rough speed ratios.

For the same 28K-byte text file, I measured how long WordStar took to move from the beginning to the end of the file. In all cases, the WordStar program itself resided in the RAM disk. On my older machine, it took 10.86 seconds. On the FM-16β, that time went down to 7 seconds when the text file was located on the floppy disk and to only 3.89 seconds when it was on the hard disk. When I use a word processor, I find that this task, along with saving the current text on the disk, occurs frequently, so the difference in speed is noticeable in everyday use.

Finally, I measured the time it took for the Digital Research C compiler to compile my communications program. On the FM-11BS, I had 512K bytes available for the RAM disk, while I was limited to 256K bytes in the FM-16β. That was enough for the compiler files but not enough for the linker and standard library files, so the times I got are for compilation only and don't include linkage editing. With all the files located in the RAM disk, including the source file and the object (output) file, the old computer took 45.24 seconds to compile the program. The FM-16β managed it in 21.3 seconds, less than half the time, which indicates that the difference between the speeds of the 8088-2 and 80186 processor is much greater than 25 percent for a central-processor-intensive task like this one. By comparison, with all files on the hard disk instead of the RAM disk, the FM-16β performed the compilation in only 42.3 seconds—even faster than the old computer working out of the RAM disk. All in all, I expect to save a lot of time using the new computer. And it's just as quiet as the old one.

Even though I had no trouble rationalizing the purchase on the basis of speed and convenience, one of my major reasons for buying the FM-16β was that an 80286 board will be available for it this autumn, along with ASCII-Microsoft's XENIX enhancement of UNIX. I hope that this will give me a UNIX machine without my having to abandon all my existing applications software; I think UNIX is going to be the operating system of the future here in Japan for computers at all levels—from microcomputers all the way to mainframes.

The best news is that, after a 25 percent discount (not hard to find), I paid only about $2250 for the machine.

COMING UP

Next month, I'm off to Taiwan to report on the Computex '85 computer show. I also plan to explore the issue of software piracy in that country. ■

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Conducted by Steve Ciarcia

GLITCHES?

Dear Steve,

In regard to "Understanding Linear Power Supplies" (January BYTE, page 98), specifically the uppermost section of figure 1 on page 100, have you invented a new basic circuit for getting DC from AC without a rectifier? Or could it be that a diode got left out of the drawing?

Also, figure 3 on page 101 might have been clearer if the sine wave on the output side of the transformer had been shown with a smaller amplitude. Better yet, the primary side could have been shown with much greater amplitude than it was.

ELBERT S. MALONEY
Pompano Beach, FL

Thanks for the feedback. That diode must be one of the new micro-micro units! As you correctly observe, a diode is needed between the transformer and the load resistor in the top leg of that circuit.

Figure 3 is an illustration of the transformer-rectifier-capacitor filter relationship. As such, it could be a step-down, step-up, or one-to-one transformer. Granted, these days we usually use step-down transformers, but only a few years ago you would have expected the output voltage to be larger. It is not usual practice to make the waveform symbols proportional to the relative voltages but rather to label the input and output lines with the correct voltages.—Steve

READING FOR POWER

Dear Steve,

Thanks for your article on power supplies in the January BYTE. I have a great deal of interest in the subject. In fact, I would like to try reaching an expert level in power supplies. Could you please recommend additional reading?

MIKE HELF
Seal Beach, CA

Several interesting books on power supplies have been published. Regulated Power Supplies, *3rd edition, by Irving M. Gottlieb discusses linear and switching power supplies and the operation and architecture of solid-state regulators. You can obtain a copy of this book from*

Priority One Electronics
9161 Deering Ave.
Chatsworth, CA 91311-5887
(800) 423-5922

Another book that provides a good source of information on three-terminal regulators is Voltage Regulator Handbook, *published by National Semiconductor. It offers extended-use applications for three-terminal regulators and discusses power-transformer and filter specifications. You can obtain a copy of this book from one of the following:*

Digi-Key Corporation
Highway 32 South
POB 677
Thief River Falls, MN 56701
(800) 346-5144

National Semiconductor Corporation
2900 Semiconductor Dr.
Santa Clara, CA 95051
(408) 721-5000

—Steve

DESPERATELY SEEKING SWITCH

Dear Steve,

In "Understanding Linear Power Supplies" in the January BYTE, you mention using a thermostatic switch to control a fan that would supply additional cooling when the heatsink temperature rises above 130°F.

I have tried several electronics supply stores in my area, but none of them seem to have or understand what I am looking for. If you could give me the part number for this switch, or for an equivalent device that operates at 90°F, I would greatly appreciate it.

PAUL W. SMITH
Muncie, IN

Thermostatic switches used to control cooling fans in power supplies are similar to the ones used to control common household floor or attic fans. They are usually a simple bimetallic strip that bends as the ambient temperature increases until a preset temperature is met and a switch is closed or opened.

You can obtain a switch of this type from

John J. Meshna Jr. Inc.
POB 62
East Lynn, MA 01904
(617) 595-2275

The Meshna part number for the normally open thermostat is SP-94C; the part number for the normally closed thermostat is SP-94D. Call the company for further information on the availability of these devices.

Also, check with an appliance outlet that sells floor or attic fans.—Steve

SCHEMATIC QUERIES

Dear Steve,

I enjoyed reading "Build the Power I/O System" (December 1984, page 105), and I have a couple of questions about the schematics. Performing a logical AND operation with the zero-voltage switch and the port output is a super idea, but will the output of the zero-crossing detector really drive all those 7438s? You indicate eight of them in figure 19 on page 112.

DAVID KLINGENSMITH
Burnaby, British Columbia, Canada

Most TTL devices can drive several similar devices. To determine the "fan out" capability of a particular device, you have to do some calculations from the specification sheets. First, divide the logic 0 output current of the source device by the logic 0 input current of the destination device. Next, find the same ratio for the currents that corresponds to a logic 1. The lower of these two ratios is the number of inputs that the source device can reliably drive. A typical ratio for most TTL devices is 10.—Steve ■

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

I am interested in hearing from any of you telling me what you've done with these projects or how you may have been influenced by the basic ideas. Write me at Circuit Cellar Feedback, POB 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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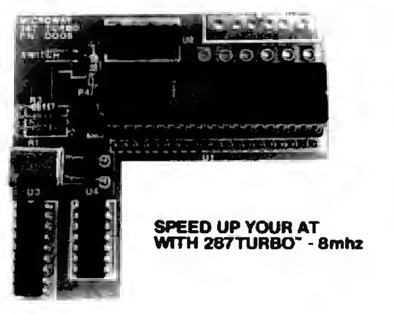

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[1]Requires RTOS or iRMX-86. All Intel compiler names and iRMX-86 TM Intel Corp.

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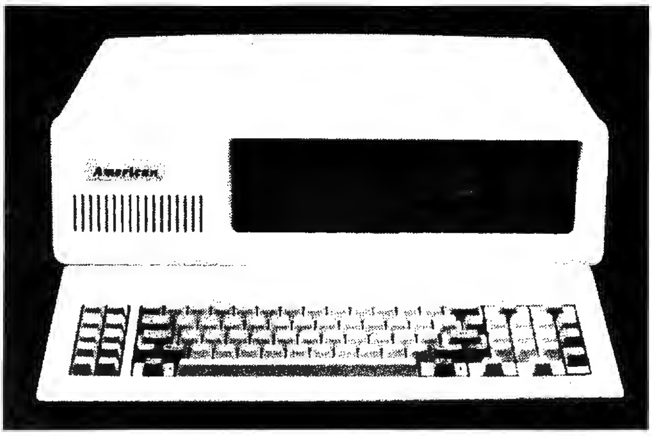
The Dasher/One is compatible with Data General's Eclipse/MV processor product line and the Data General/One portable computer. You can use it as a workstation within a cluster to let you share peripherals and applications with other users.

Standard RAM is 256K to 640K bytes. The basic machine offers three expansion slots, an asynchronous RS-232C/422 communications port, a standard parallel printer port, and a choice of a single 3½-inch floppy-disk drive with an optional second floppy disk or a 3½-inch 10-megabyte hard disk. The Dasher/One has a tilt-and-swivel display and a 12-inch bit-mapped monochrome monitor. The Model 1 provides 640- by 200-pixel resolution in text and graphics modes; the Model 2 has a resolution of 640 by 400 pixels in text mode.

The Dasher/One is available in six configurations with varying amounts of memory and storage. All models have a choice of two detachable keyboards: an IBM PC AT-compatible keyboard or a CEO-compatible keyboard. Both keyboards are available in foreign-language versions.

The Model 1 costs \$2100; the Model 2 is \$2415. Contact Data General Corp., Information Systems Division, 4400 Computer Dr., Westboro, MA 01581, (617) 366-8911.
Inquiry 620.



American Computer and Peripheral's XT *system.*

IBM PC XT-Compatible

American Computer and Peripheral's XT system is functionally compatible with the IBM PC XT. It is built around the 16-bit 8088 microprocessor. The XT features 256K bytes of RAM expandable to 640K bytes on the system board, and it has socket space for 56K bytes of user PROMs.

Two 360K-byte 5¼-inch disk drives are standard; 10- and 20-megabyte hard disks are also available. The 84-key keyboard includes a numeric keypad and 10 function keys. The XT also has eight expansion slots, a 135-watt power supply, an integral speaker, and an automatic self-test of system components.

Retail prices range from \$1150 for a 256K-byte system with two floppy-disk drives to \$2595 for a 640K-byte system with two floppy-disk drives, a 20-megabyte hard disk, a serial port, a game port, a parallel port, a real-time clock, and a color-graphics card. Contact American Computer and Peripheral Inc., 2134 South Ritchey, Santa Ana, CA 92705, (714) 545-2004.
Inquiry 621.

Turbo PC

PC's Limited has introduced its Turbo PC, a system that features a 16-bit 8088-2 with a 4.77- or 6.66-MHz clock speed. The unit has 640K bytes of memory on the motherboard, one 360K-byte disk drive, a 5151 keyboard, a 135-watt power supply, and eight expansion slots.

The Turbo PC reportedly runs software written for the IBM PC and the PC XT 40 percent faster than a standard PC.

The Turbo PC sells for \$795. Contact PC's Limited, 7801 North Lamar, #E-200, Austin, TX 78752, (512) 452-0323.
Inquiry 622.

Wang Advanced Professional Computer

The Wang APC is based on the 8-MHz 16-bit 80286 microprocessor. The entry-level model has 512K bytes of RAM, expandable to 2 megabytes. The APC supports the MS-DOS, XENIX, and IN/ix operating systems and features PC-DOS compatibility. It is also software- and hardware-compatible with the Wang PC.

You can have up to three disk drives in a combination of two half-height disk drives and one Winchester drive. Options include 360K-byte or 1.2-megabyte disk drives and 20-, 30-, or 67-megabyte Winchester drives. A 43-megabyte streaming-cartridge tape drive provides mass-storage backup and recovery.

The Advanced Professional features zero wait states for memory addressing to increase processing speed. It can support up to four workstations in its multiuser mode with XENIX or IN/ix. An 80287 numeric coprocessor is optional.

Wang Professional Computer users can upgrade to the APC by replacing their main system board with the APC system board set. An optional CGI (character/graphics/IBM emulation) card lets the APC combine Wang monochrome characters, Wang monochrome graphics, and IBM monochrome emulation and keyboard control.

Pricing for the Wang APC starts at \$3465 for a single-user system. Contact Wang Laboratories Inc., One Industrial Ave., Lowell, MA 01851, (617) 459-5000.
Inquiry 623.

(continued)

Compiled by Dennis Barker and Lynne M. Nadeau

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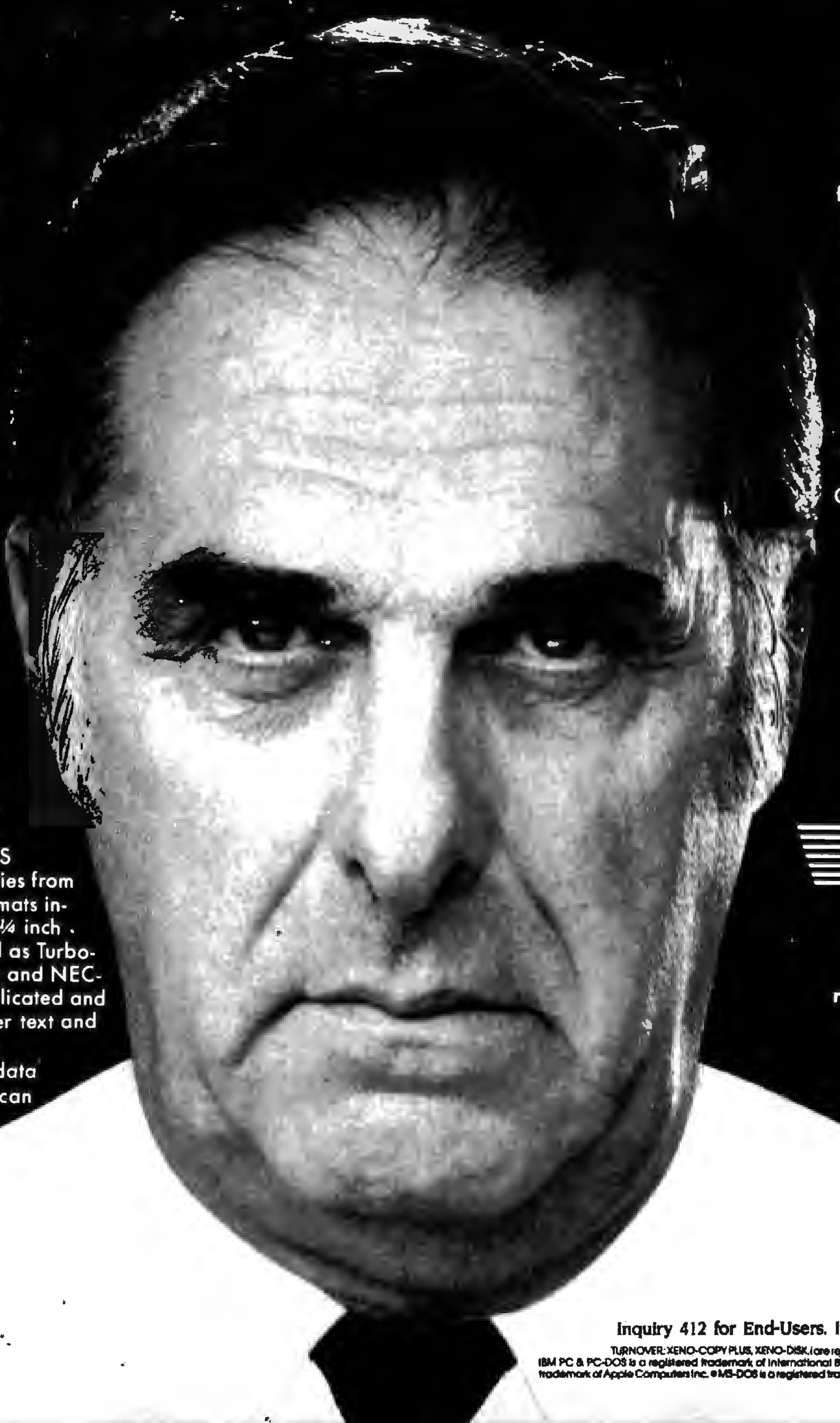

TURNOVER

A "wireless file transfer" package for the IBM PC to Apple II and back, and back again. TURNOVER is a firmware board which fits into any slot in the IBM PC or compatible, and software running under MS-DOS. No modems, no serial links, no hassles, no problems, TURNOVER will format Apple CP/M and Apple DOS 3.3 disks. Leave your IBM and Apple Computers where they are. Simply bring your Apple disk to work and transfer your file to a PC-DOS disk. Allows for modification to text and data files. It's a simple, inexpensive, fast high performance alternative to complicated serial links and modems.

XENO-COPY PLUS

(No Longer Copy Protected)

A "wireless file transfer" software program for your IBM PC and most PC look-a-likes. XENO-COPY PLUS formats, writes to and copies from over 100 different disk formats including 40 and 80 track 5¼ inch CP/M disk formats, as well as Turbo-DOS, TRS-DOS, p-System and NEC-DOS formats. An uncomplicated and inexpensive way to transfer text and data files. Also, allows for modifications to text and data files. XENO-COPY PLUS can be up-graded to XENO-DISK for the price difference.

XENO-DISK

(No Longer Copy Protected)

The high performance model of XENO-COPY PLUS, XENO-DISK also formats, writes to, and copies from over 100 different disk formats including 40 and 80 track 5¼" disks. XENO-DISK contains a powerful table driven text translator, "Text-Tran." For low volume disk production, XENO-DISK includes a track-by-track disk duplicator (which is faster than file by file duplication). Gives you the option to input disk format parameters which allows you to utilize uncommon disk formats.

See your dealer or Call for information:

(213) 938-0857

Vertex systems inc.

6022 W. Pico Blvd.
Los Angeles, CA 90035

Innovation in microcomputer products

Inquiry 412 for End-Users. Inquiry 413 for DEALERS ONLY.

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NEW SYSTEMS

Low-Cost Two-Drive System from Apricot

The Apricot F2 microcomputer is an MS-DOS machine based on a 4.67-MHz Intel 8086. It comes with 512K bytes of RAM and two 3½-inch half-height 720K-byte disk drives. The keyboard has a full QWERTY layout, a numeric keypad, and programmable function keys. The standard keyboard and trackball/mouse input device interface to the main system with infrared transmitters. A monitor is not included. The complete system weighs 13½ pounds and, although not designed as a portable, has an optional carrying bag. The F2 has a footprint of 16.5 by 8.7 inches.

The F2 comes with the GEM Collection—GEM Write, GEM Paint, and GEM Desktop—as well as GW-BASIC, an asynchronous file-transfer utility, an asynchronous communications package, an IBM PC emulator, and Apricot's MS-DOS system software (which includes the GSX graphics layer).

Inside the F2 are two proprietary expansion slots; on the back are a Centronics and an RS-232C port. An IBM 3278 emulation card is available as an option.

The F2 costs $1495. Contact Apricot Inc., 47173 Benicia St., Fremont, CA 94537-5117, (415) 659-8500.
Inquiry 624.

Dual Disk Drive for Commodore

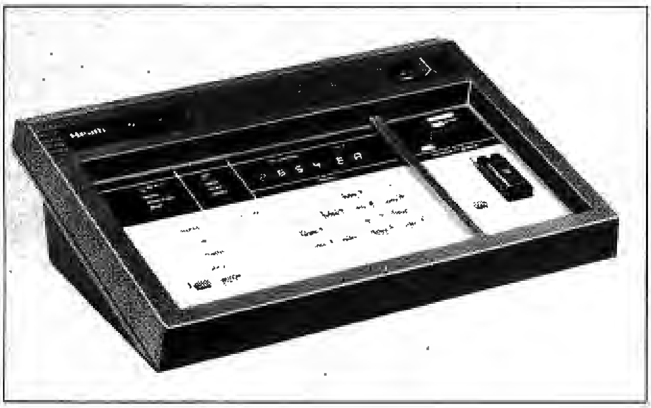
The Clone dual disk drive from HBH Sales lets Commodore 64 users format, copy, and verify a 5¼-inch single-sided single-density disk in less than 2 minutes. Its 6K-byte buffer memory and microprocessor let the computer continue working while the drive is operating.

The Clone has a total capacity of 340K bytes. It is compatible with most Commodore 64 software and includes a utility program for converting incompatible programs to a compatible format.

Suggested retail price for the Clone is $499. Contact HBH Sales Co., 225 West Main, Collinsville, IL 62234, (800) 448-5819; in Illinois, (618) 344-7912.
Inquiry 625.

Heath EPROM Programmer Kit

Heath's ID-4801 EPROM programmer kit can be used on 2500 and 2700 series EPROMs and other compatible devices up to 16K bytes that use a single power supply. The ID-4801 performs 10 functions, some of which require user-wired personality modules for different EPROM configurations. These modules are supplied with the kit.



Heath's ID-4801 EPROM *programmer kit.*

This programmer lets you load an EPROM with data stored in its RAM and verify the transfer. You can also load data from an existing EPROM into the programmer's RAM. The ID-4801 can emulate ROM in an external device when connected by an appropriately wired cable.

You can transmit and receive data between the EPROM programmer and a computer through an RS-232C port. The port allows transfer of data in an Intel hexadecimal format at a rate of 9600 bps. The keypad lets you select any memory address to examine, delete, change, or enter data.

The ID-4801 has a 2K-byte by 8-bit system ROM and 2K-byte by 8-bit system RAM that you can expand to 16K bytes. Six LEDs indicate function selections and six seven-segment LEDs display addresses, data, and prompts.

The ID-4801 kit sells for $349.95. Contact Heath Co., Benton Harbor, MI 49022, (616) 982-3210.
Inquiry 626.

Series 1500 Graphics Display Terminals

Cleveland Codonics' series 1500 Graphics Display Terminals provide a Tektronix 4010/4014 graphics display. Alphanumeric display features include a 14-inch amber or green screen with 24 rows by 80 or 132 columns. You can select any one of four scrolling speeds.

Other features include a tilt-and-swivel screen, a detached keyboard with 16 programmable function keys, block-mode transmission, data-transmission speeds up to 38,400 bps, and a printer port.

The model 1575 Graphics Display Terminal costs $2395 and is compatible with the DEC VT-102; the model 1550 costs $2295 and is compatible with ADM, TVI, ADDS, and Hazeltine terminals. Contact Cleveland Codonics Inc., 18001 Englewood Dr., Cleveland, OH 44130, (216) 243-1198.
Inquiry 627.

Apple II Touch Window

Personal Touch's Touch Window is a four-in-one touchscreen input device for the Apple II series. You mount Touch Window directly on your monitor to convert any Apple II into a see-through touchscreen system. You can easily remove

(continued)

SOME FLOPPY DISKS WILL GIVE YOU A BYTE YOU'LL NEVER FORGET.

You'll find them lurking in stores wherever floppy disks are sold. Those evil denizens of computer drives that are eagerly waiting to devour your valuable information, bit by bit. What they can do to you and your business is too painful to print.

At TDK, we grimace at that thought. Which is why we took great pains to develop an absolutely flawless disk. One that is made with such technical superiority that it meets or exceeds the most rigid industry standards.

Whether you choose our 8-inch, 5.25-inch standard, 5.25-inch High Density or 3.5-inch No-Risk Disks, you'll be assured of consistent error-free performance, through years of extended usage. And although you'll probably never need it, it's nice to know that all our disks are covered by a lifetime replacement warranty.

It's also nice to know that our disks share both the technology and dedication to quality that have made TDK the world's largest manufacturer of magnetic media—including our higher-performance audio and video recording tapes. The fact that millions of people rely on our products is a true testament to our 50 year heritage in the industry.

So, the next time you enter the cluttered jungle of floppy disks, don't pick up something hazardous to your company's health. Avoid a bad byte. Use the TDK No-Risk Disk.

THE NO-RISK™ DISK. TDK®

it for use as a graphics tablet, input pad, or interactive book pad.

Included is the Master Touch I disk, which contains six touchscreen applications. TouchWriter I is a word processor, TouchGraphics is a picture/graphics creator, Expense Account Manager is a spreadsheet application, Bishop's Square is a puzzle, Touch Checkers is a board game, and Window Test is a testing and recalibration program.

Interactive Book I, also included with Touch Window, has illustrated activities. You place Touch Window over or under the book's pages and interact by touching the page. The computer responds with sound, animation, calculations, clues, scores, and instructions.

Touch Window sells for $199.95. Contact Personal Touch Corp., 4320 Stevens Creek Blvd., San Jose, CA 95129, (408) 246-8822.
Inquiry 628.

Desktop Scanners

CompuScan's PCS 230 and PCS 240 scanners read information into IBM PCs and compatibles. The PCS 230 page reader uses advanced OCR technology to enter text. The PCS 240 adds image scanning for handling both text and graphics.

The devices let you scan documents and convert them into a format compatible with IBM PC software packages such as WordStar, MultiMate, Word, and Volkswriter. The PCS 230 and PCS 240 read and recognize a standard page in about 30 seconds. Features include fixed-pitch font recognition and automatic adjustment for right justification, proportional spacing, and special symbols.

The PCS 240 enters graphics in the form of bit-mapped images. Using the software provided, you can scan graphics up to full-page size; display, store, and manipulate the image; annotate the image with comments or legends; and produce composite text and graphics documents.

Pricing for the PCS 230 and PCS 240 scanners starts at $5695. Contact CompuScan Inc., 81 Two Bridges Rd., Bldg. 2, Fairfield, NJ 07006, (201) 575-0500.
Inquiry 629.

ADD-INS

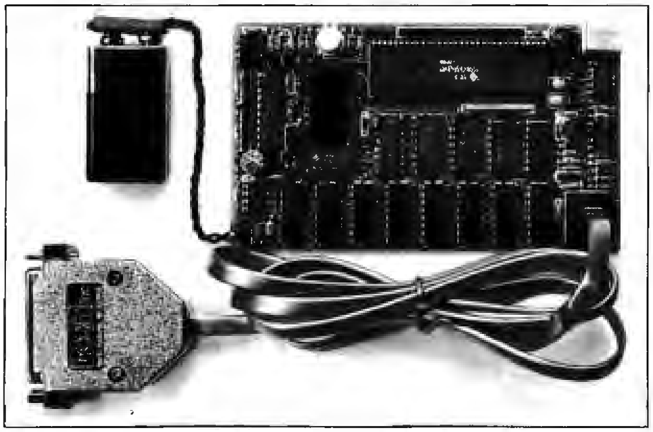
Tattletale Data Logger

Onset Computer Corporation's Tattletale Model II is a 3- by 5-inch data logger. It has eight channels of 8-bit A/D, including on-board temperature and battery sensing, 14 I/O lines, a hardware UART with RS-232C drivers, and a 224K-byte data capacity. Tattletale is designed to run off a 9-volt battery.

This logger comes with an RS-232C interface cable that connects to an IBM PC or compatible. Its prototyping card allows signal conditioning for the analog and digital circuits.

Tattletale runs a 32-bit integer BASIC with over 4100 variables plus data-logging and math functions. Its BASIC interpreter lets Tattletale measure and store the eight analog channels up to 100 times per second.

The data logger supports XMODEM protocol for data transfer to a variety of computers. You can also use BASIC commands to print out formatted results.



Tattletale Model II from Onset Computer.

Pricing for Tattletale is set at $895. Contact Onset Computer Corp., 199 Main St., North Falmouth, MA 02556, (617) 563-2267.
Inquiry 630.

Fiber-Optic Modem for the IBM PC

ICS has announced the FOC1 fiber-optic modem. This plug-in card for the IBM PC features transmission rates up to 19,200 bps and automatic detection of signal loss due to a cable break or failed LED.

The FOC1 functions in the same manner as a PC communications port, so you can use standard software to transfer data between PCs or remote devices. The modem supports full RTS/CTS handshaking.

The FOC1 plug-in card costs $249. The FOC1-K kit, available for $750, contains two FOC1 cards and 250 feet of terminated fiber-optic cable for connecting two IBM PCs. Contact ICS Inc., 8601 Aero Dr., San Diego, CA 92123, (619) 279-0084.
Inquiry 631.

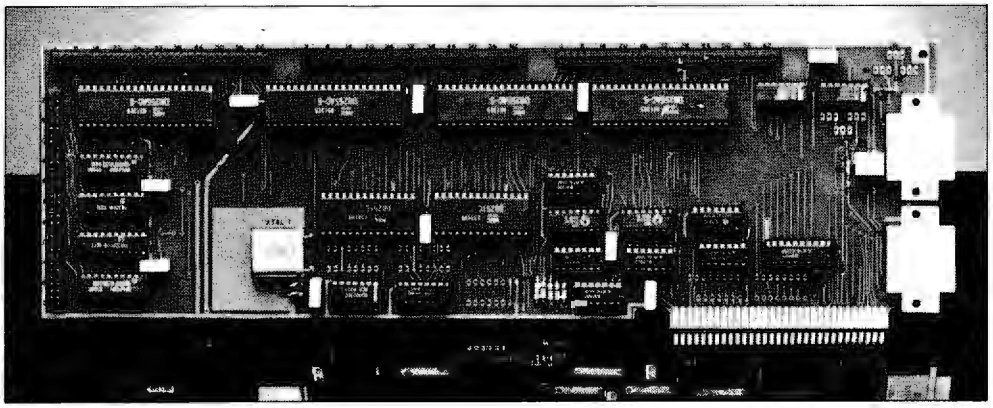
HyperDrive 20 for the Macintosh

General Computer Company's HyperDrive 20 is a 20-megabyte internal hard-disk drive for the Apple Macintosh. As with the older HyperDrive (a 10-megabyte model), Apple Computer has agreed that a HyperDrive 20 properly installed by an authorized General Computer dealer will not void its 90-day warranty or AppleCare coverage on the Macintosh. General Computer offers a 90-day warranty on the HyperDrive, as well as an extended HyperCare warranty that lasts up to three years.

The HyperDrive 20 comes with four disk-management utility programs: Manager, Security, Disk Backup, and

(continued)

ADD-INS



The Model 1018 Multi-I/O Board from Industrial Computer Designs.

Print Spooler. Manager can divide the disk into 32 file drawers (each shown as a separate icon) and can assign a password to each drawer. Security can encrypt files. Disk Backup offers three ways to back up hard-disk data to floppies: full backup (copies entire sections of the disk), incremental backup (copies all files created or modified since last backup), and individual backup (copies specified files). Print Spooler lets the machine print while performing some other task.

Disk Backup and Print Spooler will also be provided free to HyperDrive owners. A new $49 extension of HyperCare guarantees that all software enhancements and new HyperDrive software packages will be mailed directly to the user.

The HyperDrive 20 sells for $2795. Starting December 6, HyperDrive owners can upgrade to the 20-megabyte capacity for $895. Contact General Computer Co., 215 First St., Cambridge, MA 02142, (617) 492-5500.
Inquiry 632.

Model 1018 Multi-I/O Board

Industrial Computer Designs' Model 1018 Multi-I/O Board gives 96 parallel I/O channels to the IBM PC and bus-compatible microcomputers. The board can address 12 individually programmable 8-bit parallel I/O ports. It has dual serial ports with jumper-selectable data rates and four 8-bit parallel input channels.

The Model 1018 supports full bus interrupts and incorporates a crystal-controlled clock for communications timing. It connects to external devices via plug-on connectors with attached ribbon cabling.

The Model 1018 Multi-I/O board is available for $495. Contact Industrial Computer Designs Inc., 31264 La Baya Dr., Westlake Village, CA 91362, (818) 889-3179.
Inquiry 633.

Color Graphics for the Apple II Line

Video-7 has announced three graphics and text adapters for the Apple II family. The two packages from the Enhancer Series let Apples work with IBM-compatible RGB monitors.

The Color Enhancer and the Screen Enhancer are compatible with all Apple II software.

The Color Enhancer provides 16 levels of color and 16 shades of gray on the Apple IIe and IIc. You can display 80-column text and 16-color graphics on the same monitor.

The Screen Enhancer gives 16 shades of gray to the monochrome monitor. The IIe model also adds 64K bytes of internal memory and 80-column text capability. The IIc model brings "colors" to the monochrome monitor through gray-scale differentiation.

The third package, an enhanced version of Dazzle Draw from Broderbund Software Inc., comes bundled with the Color Enhancer. Dazzle Draw is a graphics and illustration package for the IIc and 128K-byte IIe line. It lets you create pictures, graphs, and charts in 16 colors and 30 patterns.

The Color Enhancer with Dazzle Draw for the Apple IIe is $179.95; the same package for the IIc is $129.95. The IIe model of the Screen Enhancer costs $129.95; the IIc version is $79.95. Contact Video-7 Inc., 550 Sycamore Dr., Milpitas, CA 95035, (408) 943-0101.
Inquiry 634.

IntroVoice IV for the IBM PC XT

IntroVoice IV from The Voice Connection is an IBM PC XT-compatible voice-recognition expansion card. It features response to as many as 500 user-defined spoken words or phrases with up to 1000 corresponding key replacements per word or phrase. You can call up to 32,000 words in sets of 500 from the hard disk in less than 5 seconds.

The system has recognition accuracy of more than 98 percent for typical vocabularies and a response time of less than 200 milliseconds. It dynamically subtracts background noise for optimum operation. You can use IntroVoice IV in conjunction with the keyboard. It works with any MS-/PC-DOS application program and has multiuser capability.

Six microphone options, including wireless, are available with IntroVoice IV. The system comes with utility software for vocabulary building, training, and testing. It lets you adjust speaking level, word-match rejection threshold, and word-boundary detection. The system disk contains several predesigned vocabularies for popular software.

With a hand-held microphone, IntroVoice IV costs $895. Contact The Voice Connection, Suite C, 17835 Skypark Circle, Irvine, CA 92714, (714) 261-2366.
Inquiry 635.

(continued)

SOFTWARE • IBM PC

Text Retriever Works with Optical Disks

Reference Technology has added to its Clasix family with STA/F Text, a text-retrieval program for use with databases stored on read-only optical disks. The package lets you use an IBM PC or compatible to quickly search large text databases on optical devices, such as CD-ROM systems.

STA/F Text provides immediate access to documents of any size, in any format, and containing any combination of textual information. The system maintains a detailed index and knows the location of every word in every document.

The program bases its search upon indexes for every word (excluding predefined stop words) in any document in the database. You can perform free-text or structured searches and retrieve documents that contain selected words, phrases, or numbers. The program uses a menu-driven format.

The software works in conjunction with another Clasix package, STA/F File, designed to raise PC data capacity to mainframe levels. STA/F Text also works with the Clasix DataDrive Series 2000 read-only optical-disk drive (using the 12-inch DataPlate) and the DataDrive Series 500 CD-ROM system (using the 12-cm DataPlate). Other requirements are a PC or compatible with at least 384K bytes of memory (512K bytes with a fixed disk drive is recommended) and PC-DOS 2.0 or later.

Distributed on a read-only optical disk, STA/F Text costs $395 (quantity discounts available). Contact Reference Technology Inc., 1832 North 55th St., Boulder, CO 80301, (303) 449-4157.
Inquiry 636.

Cost Modeling for Semiconductor Parts

A trio of cost-modeling and expert-system packages from Fountain Hills Software is designed to help the user avoid paying excessive prices for semiconductor and electronics parts. You can then use this information for planning and budgeting and for purchasing negotiations. The algorithms and equations used in the calculations reportedly are based on actual costs of manufacturing and were checked at semiconductor vendors around the world.

The first program is called Passport. It's a cost/price-modeling package for standard semiconductor parts and sells for $145. The software provides detailed cost data and suggested fair-market prices. You can specify three levels of testing and screening.

Fair-Cost is an expert-system cost/price program for custom circuits. It sells for $495. The package provides the same information as Passport plus details on tooling and prototype costs and market prices. Time schedules and risk factors are also provided. Displays of total system cost compare gate arrays, cell libraries, and modular and full custom approaches with the circuit quantity required.

VLSI-Cost is similar to Fair-Cost but is specifically designed to assist in planning and budgeting for custom military VLSI and VHSIC circuits. The program has three-dimensional and multiparameter graphics for instant display of minimum program cost. You can display these graphics as a function of any variable (for example, the number of units, size of facility, and so forth). VLSI-Cost is available on a lease basis and includes continuous updating and support services.

All three programs run on the IBM PC and true compatibles. Contact Fountain Hills Software Inc., Suite 1000, 6900 East Camelback Rd., Scottsdale, AZ 85251, (602) 945-0261.
Inquiry 637.

Thai/English Word Processor

DuangJan is a bilingual word processor for Thai and English text. It requires an IBM PC or compatible with 128K bytes and a color/graphics adapter, or a Sanyo MBC-550/555 with MS-DOS 2.0 or higher. An Epson RX/FX or compatible graphics printer is required for output.

DuangJan is $19.75 plus $3.25 postage; the price includes manuals in both Thai and English. For more information, contact Megachomp Co., 3524 Cottman Ave., Philadelphia, PA 19149, (215) 331-2748 or 331-8138.
Inquiry 638.

Programs for Chemists

The Chemist's Personal Software Series from Molecular Design Ltd. consists of a database manager, a word processor, and communications software.

ChemBase ($3500) is a database manager for compounds and reactions. Cousin to MDL's mainframe programs (MACCS, REACCS, and DATACCS), ChemBase gives you the capability to create databases for storing and retrieving molecules, reactions, and associated data. It consists of components, or editors, for drawing molecules and preparing structure or substructure search queries, for creating forms used to display a single molecule or reaction and associated data, for creating tables used to display data for one or more entries, and for editing text.

ChemText ($1500) is a graphics-based word processor with two main sets of tools: one for composing and formatting text and one for preparing, sizing, and positioning images within the text. Fonts provide math symbols and Greek characters. The Formula Editor is for preparing multiline math and chemical equations.

ChemTalk ($1000) links a PC and a host computer running MDL mainframe software. The package is designed to function as a user-friendly front end. A terminal emulator turns a PC into a graphics terminal. In conjunction with ChemBase, you can use ChemTalk to transfer portions of databases from the PC to the mainframe and vice versa.

The series runs on the PC, XT, or AT with at least 512K bytes of memory, a color or monochrome monitor, a graphics card, a mouse, and two floppy-disk drives (a hard disk is recommended). The three programs are available collectively for $5500 (a Spring 1986 release date is anticipated). Contact Molecular Design Ltd., 2132 Farallon Dr., San Leandro, CA 94577, (415) 895-1313.
Inquiry 639.

Apple-to-Mac Translator

Abaton Technology's Abaton Transform automatically regenerates Apple II applications for use on the Macintosh. This "transliteration" product converts programs, including screen graphics, at the object-code level regardless of the original's source language. The company says the process takes from 15 minutes to 6 hours, depending on the complexity of the application.

To port a program, you first install the Abaton card in the Apple II and link the Apple with a 512K-byte Mac. After loading the target application into the Apple, you begin executing it on the Macintosh, continuing this process until all the decision points have been exercised. Next, you perform a reset using the Mac interrupt control. At this point, a compile-option menu appears on the screen. Following compilation, the program is complete and ready to run on any Mac.

Abaton Transform works only with software that is not copy-protected. Translated programs can be copied.

Besides the add-in card, the package consists of a 5¼-inch disk and a 3½-inch disk and sells for $1995. Contact Abaton Technology Corp., 1526 Cloverfield Blvd., Santa Monica, CA 90404, (818) 905-9399.
Inquiry 640.

DOS for Apple IIs

Foscil FDOS is a disk operating system for Apple IIe and IIc machines. It provides five extra tracks for each disk made in its format and gives the user 20K bytes of the upper 64K bytes on a 128K-byte system.

The program comes with user-friendly prompting, a help function that lists the most commonly used commands, and a BASIC interpreter. FDOS works with DOS 3.3 commands and has a setup similar to that of MS-DOS.

Suggested retail price of FDOS is $29.95. For more information, contact Foscil Labs/Datacom Media, 406 East 73rd St., New York, NY 10021.
Inquiry 641.

Pascal Pop-up

Running on the Apple II line, *Monitor doubles as a pop-up program and a system monitor for Apple Pascal. It has capabilities found in other convenience programs as well as features of the Apple II ROM monitor.

*Monitor appears within any Pascal program, or from the operating system, at the touch of a key. You invoke its functions with English commands as displayed in a help list. You can keep a notepad and enter notes as keyboard macros. A floating-point calculator offers power, square-root, trigonometric, log, and exponentiation operations. You can enter numbers in hexadecimal or decimal form.

The software's disk-filer functions include a directory list and file load, save, and purge operations. With the editing capabilities, you can recover lost or garbled data and debug programs. The package's miniassembler and disassembler let you interactively assemble, disassemble, and execute machine code.

*Monitor takes up 5K bytes of RAM. It lists for $49 and requires Apple Pascal 1.1 or 1.2. For more information, contact dogStar Software, POB 302, Bloomington, IN 47402, (812) 333-5616.
Inquiry 642.

Animated Simulation

Stella is an animated simulation program that runs on the 512K-byte Macintosh and lets you describe a model, view its behavior, and test alternate hypotheses. It provides an environment that displays the model as a set of interconnected graphical elements; the display changes to reflect the current value of the elements. If a model doesn't mimic a known system behavior, you can analyze the model's deficiencies.

The program can be used to create business models, simulate effects of various factors, or explore subjects as diverse as urban growth and ecological change.

Stella is available for $200 and comes with a user's guide that includes tutorials. Contact High-Performance Systems, POB B1167, Hanover, NH 03755, (603) 643-1228.
Inquiry 643.

Structural Analysis with Mac

MacFrame2D from Design Source Software uses stiffness matrix methods to analyze two-dimensional structural frames. The program, intended to simplify input, storage, and editing of frame and loading data, has a scope of 20 joints and 30 members.

With MacFrame2D, you can verify frame geometry using the screen plot with numbered joints. Printed output includes joint and member input data, member end forces and moments, deflections, and reactions.

The package sells for $150 and comes with a manual that contains examples. Contact Design Source Software, POB 91219, Houston, TX 77291-1219, (713) 820-7026.
Inquiry 644.

Duo for Recording, Graphing Data

Stats Tool Kit, a Macintosh program geared toward researchers, scientists, and physicians, records research data and generates statistical-analysis reports. The package allows generation of random-number files for experimentation and simulation and provides methods for entering, modifying, and saving data.

The program features chi-square, Mann-Whitney U, Wilcoxon's signed rank, and distribution tests, as well as Spearman's rank correlation and Kendall's tau coefficient.

Process Control Chart Tool Kit records numeric-sample data and translates it into charts and graphs based on Deming's philosophy of statistical quality-control systems. Besides P, NP, U, and C control charts, the program generates Pareto charts, trend charts, and histograms.

Both packages run on any Mac with Microsoft BASIC 2.0. They sell for $99 each. Contact Sof-Ware Tools, POB 8751, Boise, ID 83707, (208) 343-1437.
Inquiry 645.

(continued)

SOFTWARE • OTHER COMPUTERS

Assembler, Debugger, Communications for Hitachi Chip

Echelon has released three programs that support Hitachi's high-integration 8-bit chip, the HD64180. All three run on Z80-, NSC800-, and HD64180-based microcomputers.

ZAS is a machine-code relocating macro assembler that produces Intel-compatible HEX and Microsoft REL files. It's compatible with Digital Research's ASM, MAC, and RMAC assemblers, with Microsoft's Macro-80, and with Xitan's TDL. The program converts HD64180 instructions into machine operation codes. ZAS handles the complete Zilog Z80 instruction set. Among its features are nestable conditionals and full expression handling, complete macro expansion, and library insert capabilities.

ZAS sells for $69 and comes with a REL file-linking loader, an Intel-to-Zilog mnemonic translator, a relative-code-file librarian, and a symbol-to-line cross-reference generator.

ZDM is a debugger and monitor for development and maintenance of HD64180 assembly-language code. It has 21 commands for object-code debugging and hardware-port exercising. Capabilities include string searches in hexadecimal and ASCII, verification of identical memory blocks, sending and receiving of I/O port bytes, enable/disable interrupts, and math in hexadecimal. The debugger/monitor sells for $50.

ZAS and ZDM work with CP/M, MP/M, and Z.

Term III is a communications package for Z-System users. It offers interactive communications with remote computers, file transfers between a host and a remote system, control of an auto-dial/auto-answer modem, and access control for remote-system applications. Protocols available are XMODEM with checksum, XMODEM with CRC, and Kermit. Term III sells for $99.

Contact Echelon Inc., 101 First St., Los Altos, CA 94022, (415) 948-3820.
Inquiry 646.

Traveling ROM

Traveling Software has put three of its programs on a ROM chip for laptop computers. Called the Ultimate ROM, the single chip holds Idea!, an outline processor; T-base, a database manager; and T-Writer, a text formatter. The chip plugs into the Tandy 100 and 200 and the NEC PC-8201.

Idea! is described as similar to Living Videotext's ThinkTank. It can organize documents ranging from lists to outlines and offers word-processing and database functions. (With a conversion program that sells for $19.95, you can use Idea! and ThinkTank files interchangeably.)

T-base lets you design relational databases and set up screen files. The program performs math computations and can borrow information from fields in other databases.

T-Writer prints documents written with the chip's built-in Text program. It's capable of justification, underlining, italics, and boldface and can produce form letters and mailing labels. A program called T-Merge inserts text from a second file into a form letter or other boilerplate document.

The Ultimate ROM costs $229.85, which gets you the chip, an overview of the program on audio cassette, a manual, and the Traveling Memory Manager, designed to help you utilize the Tandy or NEC machine memory. The package comes with a 30-day money-back guarantee. Contact Traveling Software Inc., 11050 Fifth Ave. NE, Seattle, WA 98125, (206) 367-8090.
Inquiry 647.

Math Subroutine Library

Quantitative Technology's Math Advantage is a collection of math algorithms for engineering and scientific applications. It's available in object code for either FORTRAN or C. The package contains more than 180 subroutines for use in real/integer-vector, complex-vector, matrix, and signal- and image-processing operations.

Math Advantage runs on a variety of machines, ranging from microcomputers to supercomputers. Source-code licensing agreements are available for large systems. Pricing varies according to the target computer, but microcomputer implementations cost $495 for the IBM PC, XT, and AT, the Hewlett-Packard Integral, and the DEC Professional.

Contact Quantitative Technology Corp., Suite D, 8700 Southwest Creekside Place, Beaverton, OR 97005, (503) 626-3081.
Inquiry 648.

Features Added to Paint Program

Dr. Halo II adds a number of capabilities to Media Cybernetics' paint program. A virtual-page feature lets you merge text and graphics files on-screen. An undo feature, scaling, and several new type fonts have also been added. Dr. Halo II works with IBM's Enhanced Graphics Adapter and laser printers from Hewlett-Packard and Corona. A new "smart eraser" capability lets you delete pixels of only a specified color.

Dr. Halo II runs on the AT&T 6300, the Texas Instruments Professional, and the IBM PC, XT, AT, PCjr, 3270 PC, and compatibles. It is priced at $139.95; owners of earlier versions of Dr. Halo can upgrade for $40.

For more information, contact Media Cybernetics Inc., 7050 Carroll Ave., Takoma Park, MD 20912, (301) 270-0240.
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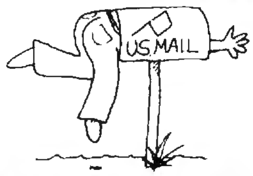

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Introducing Wabash Pinnacle Series Diskettes.

Two years ago, if you'd told me I'd be writing this ad, I would have laughed.

At that time, Wabash diskettes were synonymous with "s—t".

Just saying that quality control was poor would be charitable.

So much was wrong that DISK WORLD wouldn't sell them.

That was yesterday.

Kearney-National Inc., a $202-million division of a much larger company, came into Wabash.

Out went the old management, the old methods, the old production techniques...and in went a lot of new people, ideas, production lines and some really imaginative thinking.

The end result.

Today, I'm proud to offer you the Wabash Pinnacle Series of diskettes at the prices shown.

This isn't evolution in diskette manufacturing: it's revolution.

Here's what you get.

Wabash Pinnacle diskettes are

...certified 100% Error Free

...are coverd by a LIFETIME WARRANTY

...meet or exceed all industry specifications (by quite some distance)

...and are simply the best value in diskettes available today.

The torture test.

Considering Wabash's earlier dubious reputation, I wasn't exactly a true believer when their Director of Marketing came into my office with samples.

So I took a box at random, selected a disk, bent the thing every which way and slipped it into my IBM-PC.

It formatted. It booted. It stored and retrieved data.

That wasn't enough.

I gave samples of the diskettes to Curt Rostenbach and, in turn, to Tom Streit, both hackers of long experience and members of the Waukegan (Illinois) Apple Users Group.

Tom really went at it.

He took a quartz-halogen lamp, aimed it at the diskette until it started to smoke (and melt)...and then formatted, booted the diskette and stored and retrieved data!

The same terribly (and intentionally) mutilated diskette ran on an ITT, Corona and IBM.

Curt was nicer.

He simply bent the diskette every which way...and it still formatted, booted and ran on his Apple.

The best buy I've ever seen.

DISK WORLD!, Inc. sells more flexible magnetic media by mail-order than anyone else in the world.

I, as President of the corporation, won't tolerate a product with a failure rate of more than 1/1000th of 1 percent.

I also don't like companies who try to milk a "quality" or "premium" image for a higher price like Dysan and Verbatim did...until they failed.

As President of DISK WORLD!, Inc., my motto is simple: "the best diskette for the least amount of money."

Wabash is it.

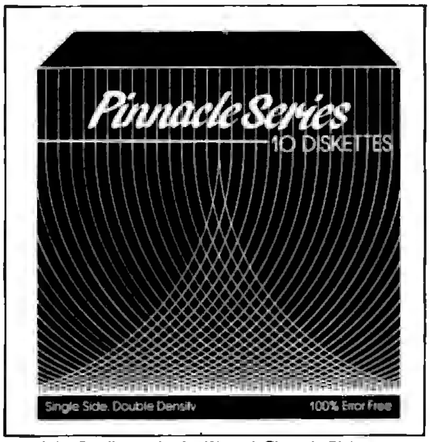
Right now, there is no better value than the Wabash Pinnacle Series of diskettes.

Granted, you have to buy a hundred at a time, but so what? Split the order with friends, relatives, co-workers or even your worst enemies.

The key thing is to get the most diskette for the money.

And this is it.

(Incidentally, as a corporation, we put our money where our



mouth is. Our first order for Wabash Pinnacle Diskettes was 1.5-million units.)

That's an awful lot of faith and confidence.

But, then again, I have the diskette that Tom Streit literally melted...and kept on running.

The truth about $1.00 or less diskettes.

More and more ads are popping up offering diskettes for $1.00 or less.

By the same token, more and more people who were selling used cars a few months ago are now selling diskettes by mail.

We did a little survey of current ads for diskettes advertised for a dollar or less and did some analysis of the market and here's what we found as it applies to 5.25" DSDD diskettes "supposedly" selling for a dollar or less.

VENDOR:	ADVERTISED LOW PRICE:	ACTUAL PRICE PER 100:	ACTUAL MFGR.:
Unitech	.89 ea.	.92 ea.	Unspecified.
Datatech	.99 ea.	.99 ea.	Unspecified.
Computer Club	.95 ea.	.98 ea.	Unspecified.
	.99 ea.	1.02 ea.	Unspecified.
Communications & Electronics	.49 ea.	.80 ea.	Unspecified.
Precision Data	.89 ea.	.93 ea.	Unspecified.
Diskette Connec.	.93 ea.	.93 ea.	Unspecified.
Comp Soft Serv.	.77 ea.	.77 ea. + shpg.	Unspecified.
Computer/Computer	.99 ea.	.99 ea.	Unspecified.
DISK WORLD	.89 ea.	.92 ea.	Wabash Datatech

The real truth about $1.00 or less diskettes.

It costs all diskette manufacturers about the same to produce a diskette. Some may charge more because they want to project a "premium quality" image, ala the late, lamented Dysan who bought their basic media from 3M.

Some charge less because they sell a sub-standard product...and we're not foolish enough to name names here.

But here's the truth about the $1.00 or less diskette market.

It falls into four categories:

1. The DISK WDRLO's of the universe who simply are so big that they can buy first quality product in massive quantities and choose to pass on the savings to you. (Precision Data and Diskette Connection on **BRAND NAME** products also fall into this category.)

2. The people who buy "cosmos"...stuff from major manufacturers that usually hits quality control standards, but is cosmetically blemished and thus can't be packaged and sold under the manufacturer's own name.

3. "Duplicator Quality". Uncertified media, usually below manufacturer's own standards and frequently below ANSI and IBM standards. Sold on an "as-is" basis with the understanding that the manufacturer's name will never be divulged. Usually about a 20% reject rate...as compared to DISK WORLD's standard of less than 1/1000th of 1% reject/return rate. Next to garbage, this is the source of most diskettes advertised at a dollar or less.

They may work...and then again they may not. (Frankly, the odds at the Blackjack table in Las Vegas are more in your favor.)

4. Garbage. Stuff that shouldn't be sold at all. But some manufacturers are hurting for cash, so they sell it anyway. (After all, they want to meet their payroll. Look what happens when you don't: you become a Dysan or Verbatim. Lots of history, but no money.) More and more garbage is being dumped into the market as manufacturers become pressed for cash and are motivated into selling anything and everything they can manufacture. (Read the article in FORBES about Verbatim and its "Bonus" brand.)

Finally, the Taiwanese counterfeiters are moving into the act. Perfect duplicates of the packaging of major manufacturers with one exception: the quality isn't there.

The Critical Factor.

Only DISK WORLD!, Inc. offers fully brand-identified, LIFETIME-WARRANTY product for less than a dollar.

Every one else offering 5.25" product for less than a buck doesn't tell you who makes it.

We do.

And that ought to tell you a lot right there.

Ordering & Shipping Instructions

SHIPPING: Wabash Pinnacle Diskettes are sold in multiples of 100 only. Shipping charges are $3.00 per 100, regardless of type or size.

PAYMENT: VISA, MASTERCARD and PREPAID orders accepted. Corporations rated 3A2 or better and government and quasi-government open accounts are accepted on a NET 15 basis.

C.O.D. orders are subject to a $5.00 special handling charge. (Sorry for the increase, but too many people have been refusing C.O.D. orders or using bad checks. It's a classic example of a few "bad eggs" making life more expensive for everyone else.)

APO, FPO, AK, HI & PR ORDERS: Include shipping as shown and an additional 5% of the total amount of the order to cover PAL and insurance.

No other non-continental U.S. orders are accepted.

TAXES: Illinois residents only, add 7%.

MINIMUM ORDER: $35.00

All orders subject to acceptance.
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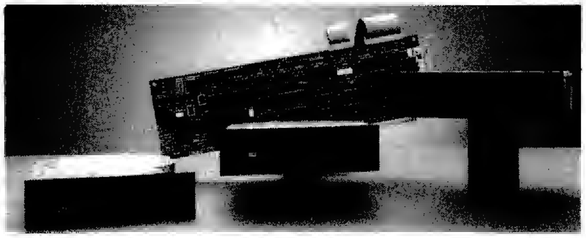

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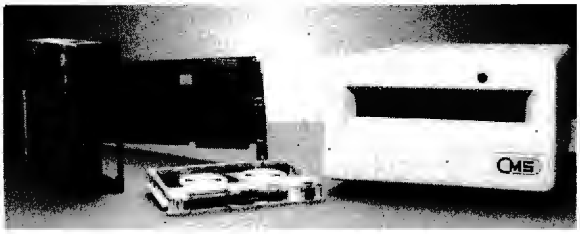

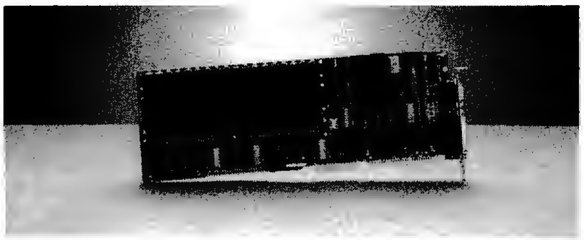

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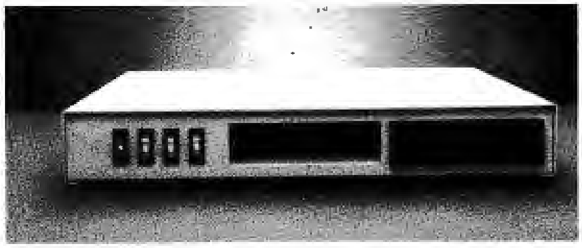

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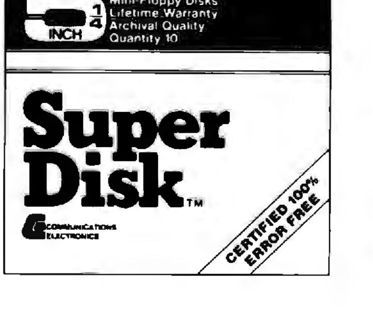

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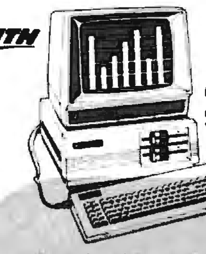

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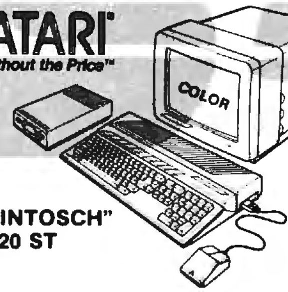

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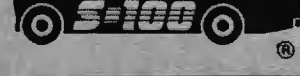

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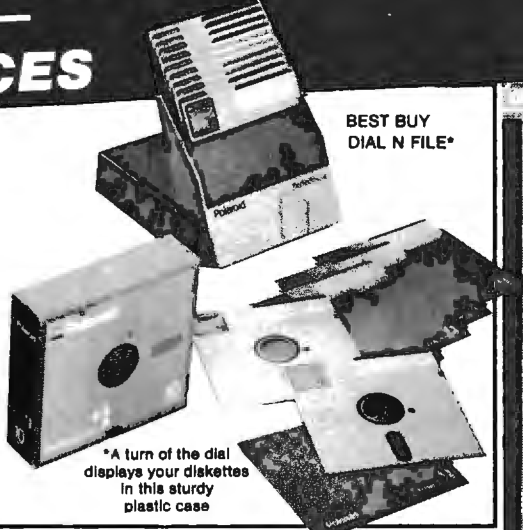

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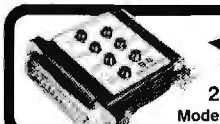

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How to cut diskette prices ...without cutting quality.

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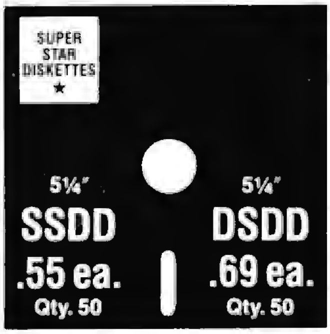

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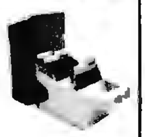

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The TEC F-10 Daisy Wheel printer is the perfect answer to a reasonablly priced 40 character word processing printer. While this printer is " extremely" similar to C.Itoh's F-10/40 Starwriter printer. Legal counsel for the C.Itoh Company have advised us that we should refrain from referring to the TEC printer as a Starwriter.

This 40 character per second printer auto installs with Wordstar and Perfect Writer. Features extensive built-in word processing functions that allow easy adaptability and reduced software complexity. Industry standard Centronics Interface provides instant compatibility with all computers equiped with a parallel printer port. The TEC F-10 accepts paper up to 15 inches in width.

These printers were originally priced to sell at over $1400. Through a special arrangment California Digital has purchase these units from a major computer manufacturer and is offering these printers at a fraction of their original cost.

Options available include sheetfeeder, tractor feed, buffered memory and an assortment of printer cables for a variety of computers.

$99

TEAC 55B 48 TPI

Five Inch Double Sided Drives	One	Two	Ten
TEAC FD55B half height	99	95	89
TEAC FD55F 96 TPI, half ht.	119	115	109
CONTROL DATA 9409 PC	169	159	155
SHUGART SA455 Half Height	99	95	89
SHUGART SA465 ½ Ht. 96TPI	99	95	89
TANDON 100-2 full height	129	125	119
TANDON 101-4 96TPI full ht.	199	189	179
MITSUBISHI 4851 half height	139	135	129
MITSUBISHI 4853 96/TPI½ Ht.	155	149	139
MITSUBISHI 4854 8" elec.	295	285	275
QUME 142 half height	119	105	99
Eight Inch Single Sided Drives			
SHUGART 801R			
SIEMENS FDD 100-8	119	115	109
TANDON 848E-1 Half Height	369	359	349
Eight Inch Double Sided Drives			
SHUGART SA851R	495	485	475
QUME 842 "QUME TRACK 8"	319	319	313
TANDON 848E-2 Half Height	459	447	435
REMEX RFD-4000	219	219	209
MITSUBISHI M2896-63 ½ Ht.	459	449	409

FREE PROBE

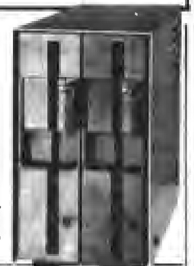
California Digital is offering this $17.95 value 12 MHz Logic Probe absolutely FREE with any purchase over $50.

The Logic Probe is a LED applied instrument that operates from circuits under test and gives instantaneus logic level indications.

To receive your FREE Logic Probe your order must be placed by MAIL before the end of the month, payment must accompany your order and the free logic Probe must be requested.

DUAL SHUGART SUBSYSTEM

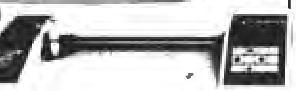
$239



The dual Shugart subsystem features two SA465 (96 tpi) 5¼" double sided disk drives. Also supplied within the subsystem is 50 watt power supply and a shielded signal cable.

PLOTTER

$219



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, Vision and Apple business graphics already support this plotter

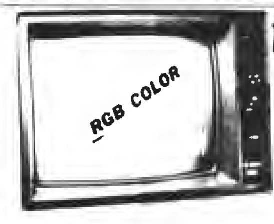
The Comscriber I features programmable paper sizes up to 8½ by 120 inches, 6 inch per second plot speed and 0.004 step size Easy to implement Centronics interface allows the Comscriber I immediate use with the printer port of most personal computers

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 [illegible] at $795 for only $219.

Also available is a support package which includes demonstration software, interface cable, a multicolor pen assortment and a [illegible] material.

NEC RGB COLOR MONITOR

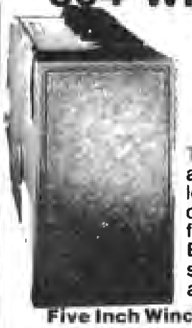
$219



The NEC JC-1401D is a 13" medium high resolution RGB monitor suitable for use with the Sanyo MBC 550 555 or the IBM PC The monitor features a resolution of 400 dots by 240 lines Colors available are Red Green Blue Yellow Cyan Magenta, Black and White The NEC monitor carries the Litton-Monroe label and was originally scheduled for use in their "Office of the Future" equipment A change in Monroe's marketing strategy has made these units excess inventory which were sold to California Digital We are offering these "new" RGB monitors at a fraction of their original cost Sanyo compatible NEC-1401/S, IBM P C Computer compatible NEC-1401 PC

Shugart 604 WINCHESTER

$99



These 6.7 Megabyte drives are new units recently released by the Shugart division of Xerox. The Shugart 604 is fully 506 industry compatible. Each drive is tested before shipment and is supplied with a 90 day warranty. SHU-604

Five Inch Winchester Hard Disk Drives			
FUJITSU M2235AS	27 Meg.	899	859
RODIME RO-208	53 Meg.	1589	1493
MAXTOR XT10140	140 Meg.	3895	3785
SHUGART 712	13 Meg. ½ Ht	495	465
SHUGART 604	6.7 Meg.	99	89
TANDON 502	10 Meg.	419	395
TANDON 503	19 Meg.	695	675
SEAGATE 225	25 Meg.	695	625

PRINTERS

MATRIX PRINTERS

Star Gemini-SG10 120 char/sec	STR-SG10	239.00
Star Gemini-SG15, 100 char/sec 15" paper	STR-SG15	389.00
Star Gemini Delta 10, 160 Char/sec	STR-D10	359.00
Citizen MSP/10FT 160 char/sec	CIT-MSP10	289.00
Toshiba P1351 192 char/sec letter quality	TOS-1351	1495.00
Okidata 182A serial & parallel 9½" paper	OKI-182A	257.00
Okidata 192A parallel interface 160 char/sec	OKI-192A	345.00
Okidata 84P parallel 15" paper	OKI-84P	789.00
Epson LX-80 10" 120 Char/sec	EPS-LX80	239.00
Epson FX80FT, 10" 160 char/sec with graphtrax	EPS-FX80	369.00
Epson RX100 + 15" withGraphtrax	EPS-RX100	389.00
Epson FX100FT 15" 160 char/sec with graphtrax	EPS-FX100	489.00
Epson LQ1500, 15" corespondence quality	EPS-LQ1500	895.00
Epson JX80 Color printer	EPS-JX80	519.00
Prowriter 8510 parallel 9½" paper	PRO-8510P	329.00
Dataproducts B-600-3, band printer 600 LPM	DPS-B600	6985.00
Printronix P300 high speed printer 300 lines per minute	PTX-P300	3995.00
Printronix P600 ultra high speed 600 lines per minute	PTX-P600	5795.00

WORD PROCESSING PRINTERS

Starwriter F10 parallel, 40 char/sec	PRO-F10P	499.00
NEC8810 55 char/second, serial interface	NEC-8810	1659.00
NEC8830 55 char/sec, par'l interface	NEC-8830	1659.00
NEC3550 popular printer designed for the IBM/PC	NEC-3550	1589.00
NEC2050 designed for IBM/PC 20 char/sec par'l	NEC-2050	689.00
Silver Reed EXP500, 14 char/sec par'l interface	SRD-EXP500	319.00
Silver Reed EXP550 17 Char/sec par'l interface	SRD-EXP550	429.00
Diablo 630 40 char/sec serial	DBL-630	1569.00
Diablo 620, proportional spacing, horz & vert tab, 20 cps	DBL-620	769.00
Juki 6100, 18 char/sec	JUK-6100	399.00
Juki 6300, 40 char/sec	JUK-6300	699.00
Comrex CR2 5k buffer, proportional spacing par'l	CRX-CR2P	395.00

TERMINALS

Freedom 100 split screen, detachable keyboard	LIB-F100	495.00
Qume 102 green phosphor terminal	QUM-102	539.00
Ampex Dialogue 125 green screen	APX-D125G	675.00
Ampex Dialogue 175 amber screen two page, func. keys	APX-D175A	719.00
Wyse 50 14" green phosphor	WYS-50	495.00
Wyse 300 Eight color display split screen	WYS-300	1159.00
Zenith 29 terminal VT52 compatible detachable keyboard	ZTH-Z29	765.00
Televideo 910 Plus block mode	TVI-910P	575.00
Televideo 925 detachable keyboard 22 function keys	TVI-925	759.00
Televideo 950 graphic char. split screen 32 func	TVI-950	950.00
Televideo 970 14" green 132 column European	TVI-970	1095.00

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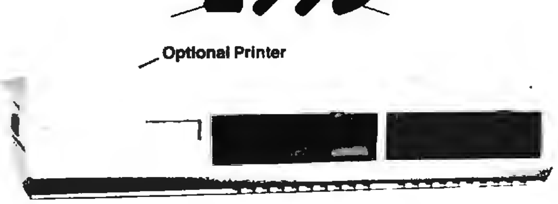
~~$2995~~



The Xerox Sunrise 1810 is by far the best value we have ever seen in a micro computer. This is a self contained battery and AC operated portable. The Sunrise was originally priced at $2995. Xerox has since elected to drop the computer from their product list. California Digital has purchased all the remaining inventory and is making the unit available at a fraction of its original cost.

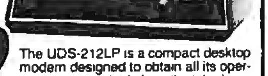
This portable features a built in 80 column liquid crystal display, along with both RF monitor and television outputs. The internal 300/1200 baud modem includes an auto dial telephone assembly. The units has both centronics parallel and a serial port programmable to 19,200 baud.

The self contained micro cassette is capable of capturing data from the keyboard as well as doubling as an recorder for dictating messages.

An optional dual floppy disk drive module, pictured above, is available for only $219. (when purchased with the Sunrise 1810). Also available, for $59 is an 80 column printer that mounts in the drive module. The Sunrise features a CP/M operating system which allows the operator to use any CP/M program in Xerox 5¼" disk format and over 5000 CP/M programs available in public domain.

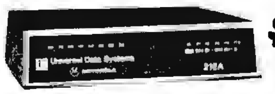
1200 BAUD MODEMS

UNIVERSAL DATA



$119

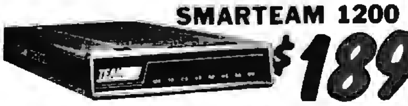
The UDS-212LP is a compact desktop modem designed to obtain all its operating power entirely from the telephone line thus eliminating the need to connect to an external AC power source. NOT Hayes compatible but the ideal 1200 baud modem to connect to any CRT terminal or computer when accessing dial up data bases.
The Universal Data Div. of Motorla original suggested list price on the 212/LP was $495. but California Digital is offering at only $119.



$159

The Universal Data 212A is manufactured for the minicomputer market. This modem is both 300 and 1200 baud auto answer. An industrial quality modem originally priced at $595. NOT Hayes compatible.

SMARTEAM 1200



$189

The Team 212A offers all the features of the Hayes Smart Modem 1200 for a fraction of the price Now is your opportunity to purchase a 1200 baud modem at the price of a 300 baud modem
California Digital is so confident of your complete satisfaction that we will allow the return the Team 212A and apply the full credit towards the purchase of any other modem

UltraLink 1200 $159

The UltraLink is a Hayes compatible 300/1200 modem designed for the IBM/PC market place. The UltraLink adds a voice/data demension to your PC. Manufacturers original suggested price on this modem is $795. California Digitals price is only $159.

MODEMS

Universal Data 212LP, 1200 duplex, line powered	UDS-212LP	119.00
Universal Data 212A, 300/1200 baud, industrial	UDS-212A	159.00
Universal Data 103JLP, line powered auto answer	UDS-103LP	29.00
Hayes Smartmodem 2400 baud modem	HYS-2400	599.00
Fujitsu 2400/1200 baud auto everything	FUJ-1935D	439.00
Team 1200 Hayes Compatible, 300/1200 baud	TEM-SM1200	189.00
UltraLink 1200 data and voice on same line	UTL-1200A	159.00
CTS 212AH 1200 baud, auto dial	CTS-212AH	239.00
Terminal software for CTS 212AH	CTS-212SFT	35.00
Prometheus 1200 super features	PRM-P1200	319.00
Prometheus 1200B internal PC	PRM-P1200B	279.00
Signalman Mark 12, 1200 baud, Hayes compatible	SGL-MK12	239.00
Signalman Mark VI, 300 baud internal PC	SGL-MK6	59.00
Hayes Smart Modem 1200 baud, auto dial	HYS-212AD	389.00
Hayes 1200B for use with the IBM/PC, 1200 baud	HYS-1200B	369.00
Hayes Smartmodem, 300 baud only, auto dial	HYS-103AD	199.00
Hayes Chronograph, time & date	HYS-CHR232	199.00
Penril 300/1200 industrial quality	PEN-12AD	395.00

XEROX/XT

Fully IBM Compatible

$1985

Includes:

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- 10 Meg. Winchester
- 256K RAM Memory

This 10 Megabyte XT system was manufactured for the XEROX Corporation by Toshiba. The XEROX / XT operates all IBM software including Lotus 1-2-3 and Flight Simulator.

Built into the XEROX / XT Computer is a RS-232 serial port, Centronics parallel printer port, RGB and composit monitor output. The XEROX / XT also includes 256K/Byte of memory expandable to 640K, and a high resolution 14" RGB color monitor. The computer provides three IBM expansion slots for adding a modem or other boards. XEROX has also included a mouse along with operating software. Complete with 90 day warranty.

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The system is not a Taiwan or Korean knock-off. Each component is specifically designed and specified to meet the highest performance and reliability standards in the industry. It represents the best that Japanese craftsmen have to offer and you will be equally proud to own one of your own. ACP has a limited quantity of these systems in several different configurations. IBM™ PC-DOS™ v1.1/2.1, MS-DOS™ v2.11 and Concurrent v3.1 compatible. We have found no known incompatibility with any IBM™ PC application. Our technical staff has 8.5 Megabytes of various MS-DOS software packages installed including Lotus 1-2-3 and Flight Simulator. Each system comes complete with a 90 day warranty.

ACP Base System Consists of:

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Base System A (as above) $995.00

	SYSTEM CONFIGURATION	Est IBM List*	Your Price
SYSTEM A	Base System (see left) PC with 360K Floppy, Keyboard & Mouse.	$2100.00	$995.00
SYSTEM B	Base System (see left) plus Add'l 360K Floppy Drive	$2295.00	$1099.00
SYSTEM C	Base System plus 12" Green Monitor with Detachable Tilt/Swival Base.	$2575.00	$1399.00
SYSTEM D	Base System plus 12" Color Monitor with Detachable Tilt/Swival Base.	$2995.00	$1699.00
SYSTEM E	Base System plus Clr Monitor, 10Mb Hard Disk and Boot Diagnostics.	$5000.00	$1985.00
SYSTEM F	Base System plus 80 Col. x 25 Line LCD Screen	N/A	$1299.00

*Assumes required add-in boards to provide same capacity

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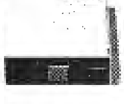

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ISB3220 16K CMOS RAM	750	119.95
ISB3330 Z80 PIO (D mating)	210	49.95
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ISB3610 EPROM Programer	280	79.95
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ISB3830 12 Bit A/D	720	269.95

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IDC 36 Pin Female	9.49
Solder 36 Pin Male	7.49
Solder 36 Pin Female	6.95

(CALL TOLL FREE FOR IDC's)

IDC CONNECTORS

IDC TYPE	ACP NO	NUMBER OF CONTACTS 10	20	26	34	40	50
Solder Header	IDHxxS	.79	1.20	1.65	2.10	2.40	3.00
Rt Angle Solder Header	IDHxxSR	.79	1.20	1.65	2.10	2.40	3.00
Ribbon Header Socket	IDSxx	.75	.95	1.35	1.50	1.85	2.10
Ribbon Header	IDMxx	—	5.25	5.95	6.75	7.25	8.25
Ribbon Edgecard	IDExx	1.70	2.15	2.50	2.60	3.70	3.95
Wirewrap Header	IDHxxW	1.80	2.90	3.75	4.25	4.95	6.50
Rt Angle W/W Header	IDHxxWR	1.99	3.10	4.10	4.20	4.60	7.15

NOTE: To order insert number of contacts in place of xx in ACP part number.
ORDER QUANTITY OF 50pcs (mixed) AND TAKE AN ADDITIONAL 10% OFF.

OKIDATA PRINTERS

Okimate 20 Color Printer	$139.00
Plug-N-Print for Okidata 20	69.00
Okidata 182 (120cps, Graphics)	259.00
Okidata 192 (160cps, Graphics)	349.00
Okidata 193 (160cps, 15" Paper)	549.00
Okidata 92 (160cps, Graphics)	349.00
Okidata 93 (160cps, 15" Paper)	599.00
Okidata 84 (200cps, Parallel)	$799.00
Okidata 84 (200cps, Serial)	949.00
Tractor for Okidata 192	44.00
Tractor for Okidata 92	54.00
2K Serial Board for Okidata 192/193	69.00
2K Serial Board for Okidata 92/93	99.00
Extra Ribbon	5.00

6800

68000	$19.95	6810	$ 2.85	6850	$ 3.25
68000L10	39.95	6820	3.75	6852	5.65
6800	2.90	6821	2.90	6860	7.90
6802	7.75	6828	14.50	6875	6.75
6803	18.85	6840	12.75	6880	2.20
6809E	9.50	6845	11.95	68047	22.95

6500

6502	$4.50	6504	$8.75	6522	$5.25
6502A	6.90	6507	9.75	6532	9.50
6502B	9.50	6520	4.25	6551	11.50

8000

8035	$ 5.75	8214	$ 3.75	8259	$ 8.75
8039	5.75	8216	1.95	8271	69.95
8080A	2.85	8224	2.20	8275	26.95
8085A	4.90	8226	1.95	8279	8.75
80C85A	9.95	8228	3.40	8282	6.25
8086	24.50	8237	13.75	8283	6.25
8087-2	129.95	8237-5	15.95	8284	5.50
8088	17.50	8238	4.25	8286	6.45
8089	88.95	8243	3.95	8287	6.45
8155	6.75	8250	10.50	8288	11.95
8156	6.75	8251	4.25	8289	44.95
8185	29.95	8251A	5.95	8292	12.95
8202	23.95	8253	6.75	8741	27.95
8203	37.95	8255	4.25	8748	24.50
8205	3.25	8255A	5.95	8749	24.50
8212	1.95	8257	5.75	8755A	34.95

Z-80

	2.5MHz	"A" 4.0MHz	"B" 6.0MHz
Z80-CPU	2.25	2.75	6.95
Z80-CTC	2.50	3.75	9.25
Z80-DART	7.50	8.50	17.95
Z80-DMA	8.00	8.95	17.95
Z80-PIO	2.95	3.50	9.50
Z80-SIO/0	8.50	9.50	22.95
Z80-SIO/1	8.50	9.50	—
Z80-SIO/2	8.50	9.50	22.95
Z80-SIO/9	8.50	9.50	—

Z8030	$34.95	Z8001	$34.95	Z8132	$32.95
Z8530	34.95	Z8002	34.95	Z8671	37.95

DISK CONTROLLERS

uPD765	$24.95	1797	$21.95	6843	$28.95
1771	15.95	2791	32.95	8272	19.95
1791	22.75	2793	32.95	1691	6.95
1793	21.50	2795	32.95	2143	6.95
1795	21.50	2797	27.95	9216	12.95

CRT CONTROLLERS

6845	$11.95	8275	$28.50	TMS9918	$39.50
68B45	17.95	7220	34.95	8350	39.95
6847	11.50	5027	17.95	6545	14.95
46505	14.75	5037	21.95	8002	19.95
68047	19.50	NEC7220 Graphics			34.95

UARTS/USARTS

1602B	$3.95	2350	$ 8.95	IM6403	$ 8.75
1013A	3.95	8250	10.50	TMS5501	14.85
1015A	6.75	IM6402	7.75	2651	8.95

EPROMS

1702 (1mS)	$ 3.90	2732A-4 (450nS)	$ 4.50
2708 (450nS)	3.65	2732A (250nS)	6.95
2758 (5V)	5.50	2732A-2 (200nS)	8.85
2716 (450nS)	3.75	2764 (450nS)	4.50
2716 (350nS)	5.50	2764 (250nS)	6.50
2516 (5V)	5.50	2764 (200nS)	8.50
TMS2716	7.50	TMS2564 (450nS)	9.95
TMS2532	5.60	MCM68764 (450nS)	19.95
2732 (450nS)	4.60	MCM68766 (350nS)	21.95
2732 (250nS)	6.00	27128-3 (300nS)	9.50
2732 (200nS)	8.00	27128 (250nS)	15.95
CMOS EPROMS		27C32	$9.95
27C16	$8.95	27C64	12.95

STATIC RAMS

2101 (450nS)	$1.69	MK4118	$4.95
21L02 (450nS)	.99	TMM2016-2 (200nS)	3.10
2102-1 (450nS)	.79	TMM2016-15 (150n)	3.85
21L02-2 (250nS)	1.39	TMM2016-1 (100nS)	3.00
2111 (450nS)	2.75	HM6116P-4 (200nS)	4.75
2112 (450nS)	2.75	HM6116P-3 (150nS)	3.25
2114 (450nS)	1.45 8/9.50	HM6116P-2 (120nS)	5.75
2114L-4 (450n)	1.69 8/12.50	HM6116LP-4 (LP)	3.60
2114L-3 (300n)	1.79 8/13.30	HM6116LP-3 (LP)	3.95
2114L-2 (200n)	1.89 8/13.90	HM6116LP-2 (LP)	3.95
2147 (55nS)	4.50	Z6132 (300nS)	32.95
4044-4 (450nS)	3.25	HM6264P-15 (150)	14.95
4044-3 (300nS)	3.75	HM6264LP-15 (LP)	16.95
4044-2 (200nS)	4.35	74S189 (35nS)	1.85
UPD410 (100nS)	3.75	93415 (50nS)	3.95
5101 (CMOS)	3.50	93425 (50nS)	3.95

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4027 (250nS)	$1.29	TMS4406 (200nS)	$6.95
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4116N-2 (150nS)	1.29 8/ 9.95	41256-150 (150n)	8.85
4116N-3 (200nS)	1.19 8/ 8.25	41256-200 (200n)	7.95
4116N-4 (250nS)	.89 8/ 5.99	TMS4050 (300nS)	1.85
4164N-150 (150n)	1.59 8/11.95	TMS4060 (300nS)	1.95
4164N-200 (200n)	1.49 8/10.00	MM5280 (300nS)	1.85
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DISK SPECIAL (IBM PC DSDD)
$1.00 EACH — PACKAGE OF 25 — "IBM PC®" DS/DD Hub Rings Tyvac Cover Major Mfgr. — **WOW!** Supply Limited

5¼" DISKETTES	1 Box	10 Box
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4001	.22	4029	.75	4060	.85	4506	1.10
4002	.22	4030	.39	4066	.39	4507	1.10
4006	.79	4031	3.25	4069	.28	4508	1.90
4007	.22	4032	2.16	4070	.35	4510	.79
4008	.95	4034	1.91	4071	.28	4511	.79
4009	.39	4035	.79	4072	.28	4512	.79
4010	.39	4037	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	.86
4014	.75	4043	.85	4078	.35	4520	.75
4015	.39	4044	.69	4081	.29	4555	.95
4016	.35	4046	.80	4082	.29	4556	.96
4017	.65	4047	.89	4085	.95	4586	1.35
4018	.79	4048	.99	4086	.95	80C95	1.50
4019	.39	4049	.35	4093	.45	80C97	.49
4020	.89	4050	.34	4094	2.95	MC14408	12.95
4021	.69	4051	.75	4098	1.90	MC14409	12.95
4022	.69	4052	.75	4099	1.65	MC14410	9.95
4023	.25	4053	.75	4501	.69	MC14411	11.95
4024	.59	4055	3.95	4502	.95	MC14412	12.95
4025	.25	4056	2.95	4503	.49	MC14419	4.95
4027	.45	CALL FOR 74HC					

74C00

74C00	$.29	74C74	$.65	74C161	$1.15	74C373	$2.35
74C02	.29	74C85	1.89	74C175	1.15	74C374	2.35
74C04	.29	74C90	1.15	74C240	1.89	74C901	.59
74C08	.35	74C93	1.15	74C244	1.89	74C922	4.45
74C10	.35	MORE 74C IN STOCK — ALSO IN CATALOG					

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LM108AH	$3.95	NE590	$2.46	LM3909	.98
LM300H	.99	NE592	2.70	LM3914	$2.95
LM301N	.35	LM709N	.58	LM3915	2.95
LM304H	1.69	LM709H	1.90	LM3916	2.95
LM305H	.95	LM710	.68	MC4024	3.75
LM306H	4.75	LM711	.75	MC4044	4.35
LM307N	.40	LM715	3.85	RC4131	3.75
LM308CN	.65	LM723N	.55	RC4136	1.19
LM310CN	1.65	LM723H	.75	RC4151	3.75
LM311CN	.62	LM733	.98	CA3023	2.75
LM312H	1.75	LM739	1.85	CA3039	1.26
LM318CN	1.45	LM741CN	.33	CA3046	1.25
LM318H	1.55	LM741H	.40	CA3059	2.85
LM319N	1.19	LM741N	.29	CA3060	2.85
LM320 (see VRs)		LM747	.85	CA3065	1.69
LM324N	.55	LM748	.55	CA3080	1.10
LM339N	.85	LM1014	1.15	CA3081	1.60
LM340 (see VRs)		LM1303	1.90	CA3082	1.60
LM348N	.95	LM1310	1.46	CA3083	1.55
LM358CN	.65	MC1330	1.65	CA3086	.60
LM359	1.75	MC1349	1.85	CA3089	2.95
LM360N	2.95	MC1350	1.15	CA3096	3.45
LM370N	4.85	MC1358	1.65	CA3130	1.29
LM373N	3.95	MC1372	6.75	CA3140	1.15
LM376N	3.75	LM1414	1.58	CA3146	1.79
LM377N	1.90	LM1558H	2.89	CA3160	1.49
LM380CN	.85	LM1800	2.35	LM13080	1.25
LM380N	1.05	LM1812	8.10	LM13600	1.45
LM381N	1.59	LM1830	3.40	LM13700	1.45
LM382N	1.35	LM1871	5.45	LF347	2.19
LM383N	1.95	LM1872	5.45	LF351	.60
LM384N	1.75	LM1877	3.20	LF353	.99
LM386N	.89	LM1889	1.90	LF355	1.10
LM387N	1.29	LM1896	1.70	LF356	1.10
LM389N	1.15	ULN2001	1.95	LF357	1.39
LM392N	.69	ULN2003	1.49	TL071CP	.79
LM723N	.48	XR2206	3.75	TL072CP	1.35
LM723H	.55	XR2207	2.90	TL074CN	1.90
NE531	2.85	XR2208	2.40	TL081CP	.59
NE555	.35	XR2211	3.75	TL084CN	1.99
NE556	.65	LM2877P	2.00	TL494	4.10
NE558	1.49	LM2878P	2.25	TL496	1.65
NE561	23.50	LM2900	.83	TL497	3.20
NE564	2.85	LM2901	.99	MC3423	1.49
LM565	.95	LM2903	.69	MC3453	4.95
LM566	1.45	LM2907	2.45	MC3456	1.29
LM567	.85	LM2917	2.85	MC3459	3.75
NE570	3.85	LM3900	.55	MC3469	5.25
NE571	2.90	LM3905	1.16	MC3470	7.95

VOLTAGE REGULATORS

7805T Also 5, 12, 15, 24V	.69	7905K Also 12, 15, 24V	1.39
78L05, 12, 15V	.65	79L05, 12, 15V	.75
78M05C	.89	LM309K	1.25
78MG/79MG	1.49	LM317H/K	1.25/3.85
78H05KC	8.75	LM323K	4.85
7805K Also 12, 15, 24V	1.29	LM337K	3.75
7905T Also 8, 12, 15, 24V	.79	LM338K	6.75
		LM350T	4.55
		LM350K	4.75

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34702	12.50	AY52376	11.50	76488	5.75
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5307	10.50	2513-002L	9.50	AY38912	7.95
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8038	3.75	3341	4.50	Votrax	39.95
5369	3.50	11C90	13.25	Digitalker	34.95
58167	12.25	MC15906	2.95	LM13600N	1.95
SP1000 Speech	$9.95	TR1863 5V UART	$4.25		

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ADC0804	3.45	DAC0800	4.75	1408L8	2.65
DAC0808	1.90	DAC0809	2.85	DAC100	7.95
ADC0809	4.45	DAC1020	7.95	DAC08	7.95
ADC0816	14.25	DAC1022	5.65	DAC01	6.96
AD7523JN	1.99	LF353N	1.99	LF13201N	1.99

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7400

7400	$ .18	7446	$ .88	74123	$ .45	74176	$ .69
7401	.18	7447	.65	74125	.42	74177	.69
7402	.18	7448	.68	74126	.44	74179	1.34
7403	.18	7450	.19	74128	.49	74180	.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	.33	74147	1.49	74193	.67
7412	.38	7474	.34	74148	1.19	74194	.67
7413	.34	7475	.38	74150	1.09	74195	.67
7414	.49	7476	.34	74151	.65	74196	.75
7416	.49	7479	4.60	74152	.67	74197	.88
7417	.49	7480	.69	74153	.63	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	.58	7486	.35	74157	.59	74273	1.65
7425	.29	7489	1.95	74158	1.65	74278	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	.65	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	.65	74366	.55
7440	.19	74100	1.60	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	.69	74490	2.25
7445	.66	74122	.44	74175	.69		

74LS00

74LS00	$ .22	74LS113	$ .38	74LS247	$ .74
74LS01	.22	74LS114	.39	74LS248	.98
74LS02	.22	74LS122	.45	74LS249	.98
74LS03	.22	74LS123	.95	74LS251	.59
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	.79
74LS26	.29	74LS156	.69	74LS295	.98
74LS27	.29	74LS157	.69	74LS298	.88
74LS28	.29	74LS158	.69	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	1.38
74LS54	.29	74LS173	.67	74LS374	1.33
74LS55	.29	74LS174	.67	74LS375	.89
74LS73	.39	74LS175	.67	74LS377	1.38
74LS74	.34	74LS181	1.95	74LS385	1.95
74LS75	.39	74LS190	.85	74LS386	.45
74LS76	.39	74LS191	.85	74LS390	1.15
74LS78	.39	74LS192	.78	74LS393	1.15
74LS83	.59	74LS193	.78	74LS395	1.15
74LS85	.69	74LS194	.69	74LS399	1.47
74LS86	.39	74LS195	.69	74LS424	2.95
74LS90	.54	74LS196	.79	74LS668	1.75
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	2.65
74LS112	.39	74LS245	1.49	25LS2569	3.50

74S00/PROMS*

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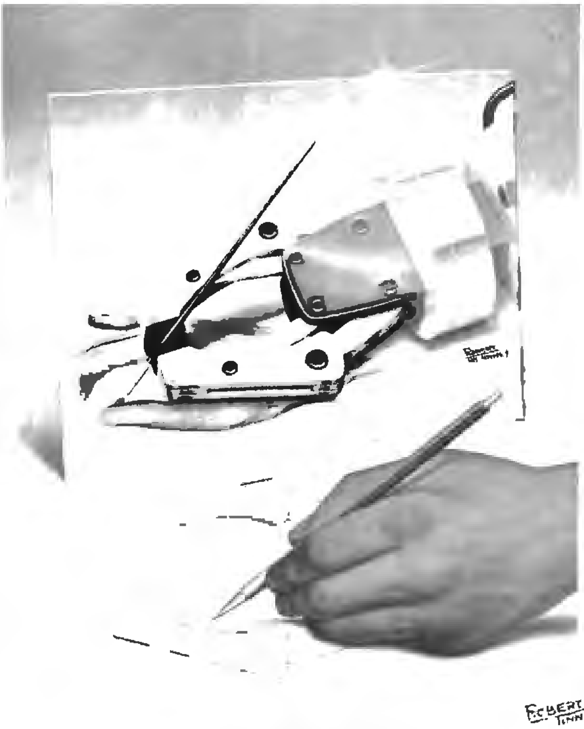
#A



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#B

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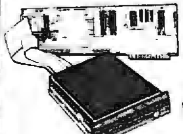

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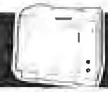

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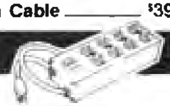

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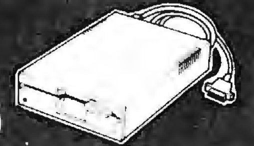

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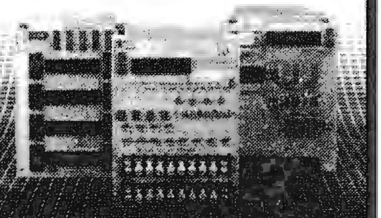

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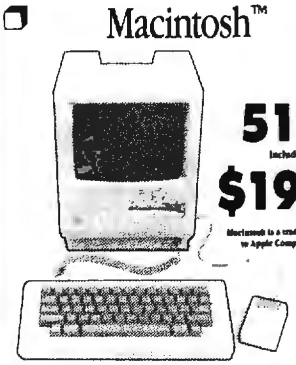

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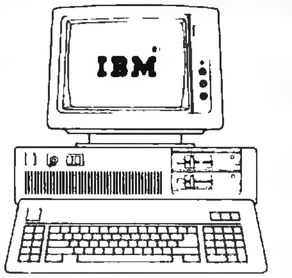

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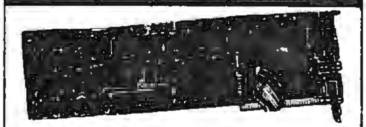

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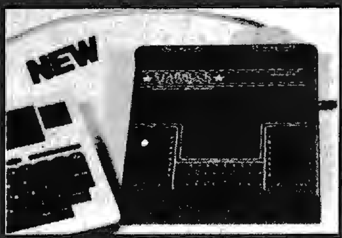

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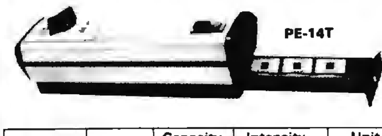

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3341	4.95
MC3470	1.95
MC3480	8.95
MC3487	2.95
11C90	13.95
2513-001 UP	6.95
AY5-2376	11.95
AY5-3600 PRO	11.95

74LS00

74LS00	.16	74LS165	.65
74LS01	.18	74LS166	.95
74LS02	.17	74LS169	.95
74LS03	.18	74LS173	.49
74LS04	.16	74LS174	.39
74LS05	.18	74LS175	.39
74LS08	.18	74LS191	.49
74LS09	.18	74LS192	.69
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS37	.26	74LS256	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.59	74LS259	1.29
74LS48	.69	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.24	74LS279	.39
74LS75	.29	74LS280	1.98
74LS76	.29	74LS283	.59
74LS83	.49	74LS290	.89
74LS85	.49	74LS293	.89
74LS86	.22	74LS299	1.49
74LS90	.39	74LS322	3.95
74LS92	.49	74LS323	2.49
74LS93	.39	74LS364	1.95
74LS95	.49	74LS365	.39
74LS107	.34	74LS367	.39
74LS109	.36	74LS368	.39
74LS112	.29	74LS373	.79
74LS122	.45	74LS374	.79
74LS123	.49	74LS375	.95
74LS124	2.75	74LS377	.79
74LS125	.39	74LS378	1.18
74LS126	.39	74LS390	1.19
74LS132	.39	74LS393	.79
74LS133	.49	74LS541	1.49
74LS136	.39	74LS624	1.95
74LS138	.39	74LS640	.99
74LS139	.39	74LS645	.99
74LS145	.99	74LS669	1.29
74LS147	.99	74LS670	.89
74LS148	.99	74LS682	3.20
74LS151	.39	74LS683	3.20
74LS153	.39	74LS684	3.20
74LS154	1.49	74LS688	2.40
74LS155	.59	74LS783	22.95
74LS156	.49	81LS95	1.49
74LS157	.35	81LS96	1.49
74LS158	.29	81LS97	1.49
74LS160	.29	81LS98	1.49
74LS161	.39	25LS2521	2.80
74LS162	.49	25LS2569	2.80
74LS163	.39	26LS31	1.95
74LS164	.49	26LS32	1.95

HIGH SPEED CMOS

A new family of high speed CMOS logic featuring the speed of low power Schottky (8ns typical gate propagation delay), combined with the advantages of CMOS: very low power consumption, superior noise immunity, and improved output drive.

74HC00

74HC: Operate at CMOS logic levels and are ideal for new, all-CMOS designs.

74HC00	.59	74HC148	1.19
74HC02	.59	74HC151	.89
74HC04	.59	74HC154	2.49
74HC08	.59	74HC157	.89
74HC10	.59	74HC158	.95
74HC14	.79	74HC163	1.15
74HC20	.59	74HC175	.99
74HC27	.59	74HC240	1.89
74HC30	.59	74HC244	1.89
74HC32	.69	74HC245	1.89
74HC51	.59	74HC257	.85
74HC74	.75	74HC259	1.39
74HC85	1.35	74HC273	1.89
74HC86	.69	74HC299	4.99
74HC93	1.19	74HC368	.99
74HC107	.79	74HC373	2.29
74HC109	.79	74HC374	2.29
74HC112	.79	74HC390	1.39
74HC125	1.19	74HC393	1.39
74HC132	1.19	74HC4017	1.99
74HC133	.69	74HC4020	1.39
74HC138	.99	74HC4049	.89
74HC139	.99	74HC4050	.89

74HCT00

74HCT: Direct, drop-in replacements for LS TTL and can be intermixed with 74LS in the same circuit.

74HCT00	.69	74HCT166	3.05
74HCT02	.69	74HCT174	1.09
74HCT04	.69	74HCT193	1.39
74HCT08	.69	74HCT194	1.19
74HCT10	.69	74HCT240	2.19
74HCT11	.69	74HCT241	2.19
74HCT27	.69	74HCT244	2.19
74HCT30	.69	74HCT245	2.19
74HCT32	.79	74HCT257	.99
74HCT74	.85	74HCT259	1.59
74HCT75	.95	74HCT273	2.09
74HCT138	1.15	74HCT367	1.09
74HCT139	1.15	74HCT373	2.49
74HCT154	2.99	74HCT374	2.49
74HCT157	.99	74HCT393	1.59
74HCT158	.99	74HCT4017	2.19
74HCT161	1.29	74HCT4040	1.59
74HCT164	1.39	74HCT4060	1.49

74F00

74F00	.69	74F74	.79	74F251	1.59
74F02	.59	74F86	.99	74F253	1.69
74F04	.79	74F138	1.89	74F257	1.69
74F08	.69	74F139	1.69	74F280	1.79
74F10	.89	74F157	1.59	74F283	3.95
74F32	.89	74F240	3.29	74F373	4.29
74F64	.89	74F244	3.29	74F374	4.29

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HOURS: M-W-F, 9-5 TU-TH, 9-9 SAT, 10-3

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TERMS: Minimum order $10.00. For shipping and handling include $2.50 for UPS Ground and $3.50 for UPS Air. Orders over 1 lb. and foreign orders may require additional shipping charges - please contact our sales department for the amount. CA. residents must include applicable sales tax. All merchandise is warranted for 90 days unless otherwise stated. Prices are subject to change without notice. We are not responsible for typographical errors. We reserve the right to limit quantities and to substitute manufacturer. All merchandise subject to prior sale.

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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	.89
4052	.69	74C163	.99
4053	.69	74C164	1.39
4056	2.19	74C192	1.49
4060	.59	74C193	1.49
4066	.29	74C221	1.75
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	8.95
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	.65
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	.35	74S196	1.49
74S30	.29	74S197	1.49
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	1.39	7905K	1.49
7812K	1.39	7912K	1.49

TO-92 CASE

78L05	.49	79L05	.69
78L12	.49	79L12	.69

OTHER VOLTAGE REGS

LM323K	5V 3A	TO-3	4.79
LM338K	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

DATA ACQ		INTERFACE	
ADC0800	15.55	8T26	1.29
ADC0804	3.49	8T28	1.29
ADC0809	4.49	8T95	.89
ADC0816	14.95	8T96	.89
ADC0817	9.95	8T97	.59
ADC0831	8.95	8T98	.89
DAC0800	4.49	DM8131	2.95
DAC0806	1.95	DP8304	2.29
DAC0808	2.95	DS8833	2.25
DAC1020	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

IC SOCKETS

	1-99	100
8 PIN ST	.13	.11
14 PIN ST	.15	.12
16 PIN ST	.17	.13
18 PIN ST	.20	.18
20 PIN ST	.29	.27
22 PIN ST	.30	.27
24 PIN ST	.30	.27
28 PIN ST	.40	.32
40 PIN ST	.49	.39
64 PIN ST	4.25	CALL

ST=SOLDERTAIL

8 PIN WW	.59	.49
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	see 7900	XR2206	3.75
LM322	1.65	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	1.40	CA3081	.99
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	3.95	CA3089	1.95
LM339	.59	CA3130E	.99
LM340	see 7800	CA3146	1.29
LM350T	4.60	CA3160	1.19
LF353	.59	MC3470	1.95
LF356	.99	MC3480	8.95
LF357	.98	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	4.60	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
CEN36PC	RT ANGLE PC MOUNT	4.95

FEMALE

IDCEN36/F	RIBBON CABLE	7.95

INTERSIL

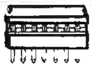
ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	4.95
ICM7207A	5.95
ICM7208	15.95

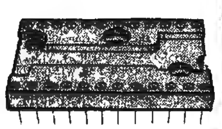
DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	—	.95	.95	—	—	—	1.75	—	2.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE BELOW


ICC16


IDP14


AUGAT 24ST

DIODES/OPTO/TRANSISTORS

1N751	.25	4N26	.69
1N759	.25	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP04	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	.99
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

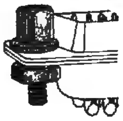
D-SUBMINIATURE

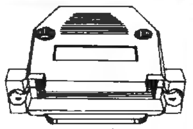
DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.25	1.80	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.50	2.35	4.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	—	1.95	2.65	—
	FEMALE	DBxxSR	1.25	1.55	—	2.00	2.79	—
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	—	3.89	5.60	—
	FEMALE	DBxxSWW	2.76	4.27	—	6.84	9.95	—
IDC RIBBON CABLE	MALE	IDBxxP	2.70	2.95	—	3.98	5.70	—
	FEMALE	IDBxxS	2.92	3.20	—	4.33	6.76	—
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30	—	—
	GREY	HOODxx	.65	.65	—	.65	.75	.95

ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED.

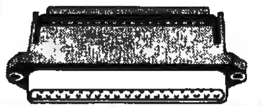
EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR.

MOUNTING HARDWARE $1.00


MTG HDWR


HOOD25


DB37S


IDB37S

LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM CATHODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
MAN-8940	COM CATHODE	.8"	1.99
TIL-313	COM CATHODE	.3"	.45
HP5082-7760	COM CATHODE	.43"	1.29
TIL-311	4x7 HEX W/LOGIC	.270"	9.95
HP5082-7340	4x7 HEX W/LOGIC	.290"	7.95

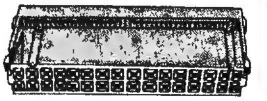
DIFFUSED LEDS

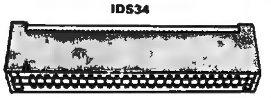
		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.79	.99	1.39	1.59	1.99	2.25
RIBBON HEADER	IDMxx	—	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.65	2.75	3.80	3.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE ABOVE


IDS34


IDE50

SWITCHES

SPST	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
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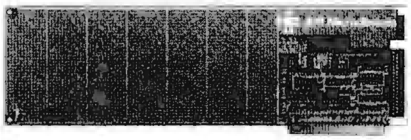

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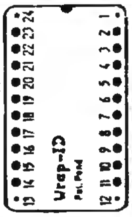

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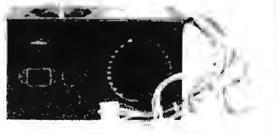
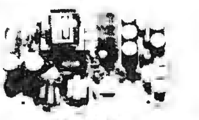


PS-130

PS-A



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33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
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.047μf	50V	.15	.47μf	50V	.25

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RADIAL			AXIAL		
1μf	25V	.14	1μf	50V	.14
2.2	35V	.15	10	50V	.16
4.7	50V	.15	22	16V	.14
10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
100	16V	.18	220	25V	.30
220	35V	.20	470	50V	.50
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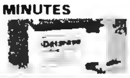

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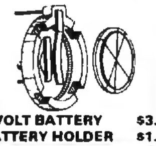

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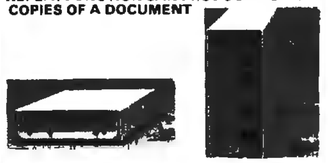
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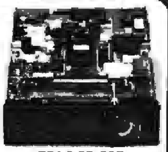
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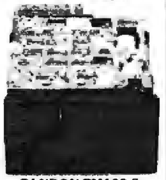
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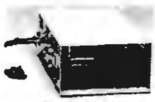
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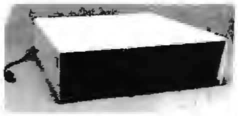
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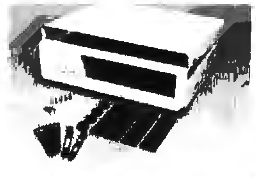

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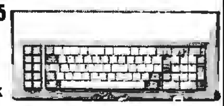

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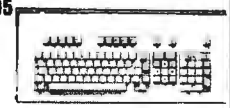

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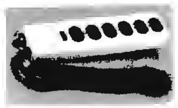

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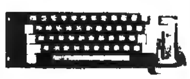

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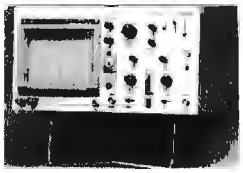

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WANTED: Sheenway School & Cultural Center seeks donations of PCs and printers to develop a computer learning center for inner-city youth. Will pay shipping and provide tax information. Sheenway School, 10101 South Broadway, Los Angeles, CA 90003, (213) 757-8359.

WANTED: Nonprofit community agency seeks tax-deductible donation of IBM PC (or compatible), terminal, and printer to organize and record volunteer placements in schools, nursing homes, and other nonprofit service agencies in and near large retirement area. Mary Glenn, Volunteer Bureau of the Sun City Area, Peoria, AZ 85345, (602) 972-6809.

WANTED: Reb Zalman Schachter-Shalomi's nonprofit national Jewish renewal organization seeks tax-deductible donation of Kaypro 2 or 4 (or similar machine). Will pay shipping and provide receipt. Moshe ben Asher, B'nai Or Religious Fellowship, 6723 Emlen St., Philadelphia, PA 19119, (215) 849-5385.

WANTED: Nonprofit religious organization seeks tax-deductible donation of computer or system (preferably CP/M or MS-DOS) for financial uses. Receipt available; will pay shipping. Church of Jesus Christ of Latter Day Saints, Carrollton Branch, c/o John Johnson, 1816 Oak Grove Church Rd., Carrollton, GA 30117, (404) 834-0904.

FOR SALE: CAD system. Tektronix 4051 computer with 8-inch disk drives, 36- by 45-inch Logic Systems plotter, and more. Make offer. Willing to donate to veritable nonprofit organization. Warren, Process Control Consultants, 5707 Lacey Blvd. #103, Lacey, WA 98503, (206) 459-9163.

NEEDED: Nonprofit foundation needs donations of computers and office equipment for software development. Prefer 68000-type virtual-memory machines. Tax-deductible. Free Software Foundation, 1000 Massachusetts Ave., Cambridge, MA 02138, (617) 876-3296.

WANTED: Any kind of technical manuals of printers, disk drives, and computers. Also, I would like to correspond with other computerists. Jose Carlos Valle, Rua Luiz Goes, 1894 Sao Paulo, Brazil, CEP: 04043.

WANTED: End user needs help from Z80 programmer to modify old CP/M word processor (Apple CP/M, North Star format). Need printer driver, bells, and whistles. Will pay expenses. Robert Greenwald, POB 401, Wheatley Heights, NY 11798.

WANTED: NRI course in microcomputers and microprocessors. Also, NRI master course in TV, video servicing, and other courses. CIE, Heathkit, etc. Incomplete or older courses acceptable. Reasonable. Joseph Wegner Jr., POB 262, Glendale, CA 91209.

FOR SALE: Back issues of *Creative Computing* (June 1979 to September 1985) and *Computers and Electronics* (formerly *Popular Electronics*, October 1977 to September 1985). Some issues missing. $1 per issue or make offer. David Ellsworth, 2732 Durant Ave., Berkeley, CA 94704, (415) 540-9315.

FOR SALE: Heath H-11 with numeric coprocessor, two 8-inch disk drives, H-19 terminal, dot-matrix printer, and more. Very good condition. $1500 or best offer. Curt Franklin, 20 Maple St., Needham, MA 02192, (617) 449-1337.

FOR SALE: H-89/90 with 64K, H-17 and H-37 controllers plus three-port serial card. Two SS/HS H-17 drives, four DS/SS 96-tpi drives. Dustcovers, spare memory chips, documentation, and more. $1200. H-14 printer available; best offer. R. F. Rumpf, 6036 Legion Rd., Stevensville, MI 49127, (616) 429-5628.

WANTED: Documentation, schematic drawings, and public-domain programmed cassette tapes for Interact Model One 16K computer (manufactured by Interact Electronics, Ann Arbor, Michigan). John Griffin, POB 481, Fedhaven, FL 33854.

FOR SALE: HDE Omni-65 microcomputer system: KIM-based, 56K RAM, dual 8-inch drives, 15-slot backplane, EPROM card, Centronics 737-II printer, Hazeltine 1500 VDT, and more, 4 years old. $2500. Bill Hliwa, 603 Charlesgate Circle, East Amherst, NY 14051, (716) 689-7344.

FOR SALE: RB5X robot: $1000 plus UPS costs. Larry Bean, 2873 Grosvenor Dr., Cincinnati, OH 45239.

WANTED: Documentation on the IMSAI MIO board, IMSAI 64K RAM board, and PERSCI 277 drives. Also can DIO controller be switched out to gain access to the 4K it normally occupies? Have CP/M 2.2 BIOS and experience interfacing 8-inch Shugarts to the DIO. Grant Hargrave, 1559 LaFontaine #2, Montreal, Quebec H2L 1V1, Canada.

FOR SALE: TRS-80 computer with 16K RAM, monitor, keyboard, CTR-80 cassette recorder for storing programs, cables, books, and more. $190 or best offer. Dan or Nancy O'Connell, 63 Maple St., Wenham, MA 01984, (617) 774-5047.

FOR SALE: S-100 Ithaca Intersystems DPS-1 CP/M machine with front panel, 64K, two Shugart DS/DD 1.2-megabyte 8-inch drives, and Soroc IQ 140 terminal. Mint condition. Watson Klincewicz, 1020 Ethel Ave., Fairview Village, PA 19403, (215) 539-3775.

FOR SALE: Z80-based MP/M system with 128K RAM, two 8-inch SS/SD drives, two serial ports, one parallel port, and TeleVideo 950 and 910. Best offer. Molly McClure, 3 Ashford Court, Boston, MA 02134, (617) 254-6266.

FOR SALE: CompuPro 816/C with 20-megabyte 8-inch hard disk and terminal. Nearly new, excellent condition. $5000. Robert Mitchell, Solar Systems Design Inc., RD 3, Box 239, Selkirk, NY 12158.

FOR SALE: NEC 3500R letter-quality printer (serial interface, can be used with IBM or Fortune-type micro). Excellent condition. M. B. Motwani, 2741 Binbrooke, Troy, MI 48084.

FOR SALE: Tandy 2000 with 256K, 640 by 400 color graphics, color monitor, and more: $4000. A. Hsia, Unicorn Inc., POB 3228, Kent, OH 44240, (216) 678-4147.

WANTED: RGB monitor for IBM. For sale: Acountic modem: $80. Atari 1200XL computer: $80. Speech synthesizer for Atari computers: $60. Zenith 12-inch amber monitor: $75. Al P. Casper, 3632 CTH I, Saukville, WI 53080, (414) 675-6946.

WANTED: Exchange of information with anyone owning a Netronics Explorer 88 in IBM-compatible version (737 ROM), or am I all alone? Lawrence Wallcave, 6578 Birch Dr., Santa Rosa, CA 95404.

WANTED: BMC if800 users to form group. Jim Stone, 1921 MacArthur St., Rancho Palos Verdes, CA 90732, (213) 643-9900.

FOR SALE: Trump Card, Z8001 CP/M card for IBM PC. (See Circuit Cellar, May 1984 BYTE.) $500. Bob Brumblay, 3512 Crown Blvd., La Crosse, WI 54601, (608) 788-9562.

FOR SALE: MPX-16 single-board computer system (factory-assembled) with keyboard interface adapter, Key Tronic keyboard, power supply, IBM monochrome adapter, documentation, and more. Perfect working condition. $900 or best offer. Tom Lobenstein, 2053 Glencoe Way #2, Hollywood, CA 90068, (213) 874-5703.

FOR SALE: HP 7580 plotter, 24 by 36 inches. Good condition. $9750. Ted Schaefer, (918) 835-1771.

FOR SALE: Thirty 8748s. All unused and purchased directly from Intel. 1K EPROM, 64 bytes of RAM, and 27 I/O lines. $15 each or all for $375. Ken Hoffmann, 2112 110th Lane NW, Coon Rapids, MN 55433, (612) 757-3404.

UNCLASSIFIED ADS MUST *be noncommercial, from readers who have computer equipment to buy, sell, or trade on a onetime basis. All requests for donated computer equipment must be from nonprofit organizations. Programs to be exchanged must be written by the individual or be in the public domain. Ads must be typed double-spaced, contain 50 words or less, and include full name and address. This is a free service; ads are printed as space permits.* BYTE *reserves the right to reject any unclassified ad that does not meet these criteria. When you submit your ad* (BYTE, *Unclassified Ads*, POB 372, *Hancock*, NH 03449), *allow at least four months for it to appear.*

WANTED: Apple computer Time II clock card. Needed for research project; willing to buy, rent, or borrow for one week. For sale: Cipher Data 9-track NRZ computer: $30. Meter movements, rectifiers, and motors: $50 for lot. Apple II drive: $150. Other equipment available. Donald G. Hayes Jr., Apt. 3, 8515 Greenwood Ave., Takoma Park, MD 20912, (301) 589-4190.

FOR SALE: 256K card and Apple 80-column card for Apple IIe. $300 buys both cards. James E. Schwob, 140 Riverview 6W, Great Falls, MT 59404, (406) 761-0092.

WANTED: Micromint Z8 computer system controllers BCC11 and/or peripherals and accessories. Reply with condition and price. Alan, POB 501, Planetarium Station, New York, NY 10024.

FOR SALE: Two TEAC SS/DD 5¼-inch disk drives, perfect condition. $100 each or $150 for both. Boris H. Traven, D.O., 109 Country Club Place, Cherry Hill, NJ 08003, (215) 750-3113 or (609) 428-8624.

FOR SALE: VT-100 terminal upgrade kit. Turns VT-100 into VT-125 with bit-mapped graphics and RGB color outputs for external monitors. Includes hardware, installation instructions, and VT-125 user guide. $600. Todd Hawk, 159 North Oller Ave., Waynesboro, PA 17268, (717) 762-8406.

FOR SALE: Data System Design 480 dual DS/DD floppy-disk drives for DEC equipment. Good condition, hardly used; interface card and cable included. Make offer. Scott Russell, POB 1125, Metairie, LA 70004, (504) 834-3341.

FOR SALE: Heathkit ET-6800 Microprocessor Trainer with hexadecimal keypad, LED, 6808, power supply, expansion capabilities, and programming manuals, plus *Using the 6800 Microprocessor*. $50 or best offer. Gary M. McComas, Route #1, Box 454, West Hamlin, WV 25571, (304) 825-5664.

FOR SALE: Letter-quality printers. NEC 7515 (RS-232 and Diablo-compatible), 55 cps. Almost new. $1475. Datamarc 2000 envelope feeder: $950. Marc 3000 sheet/envelope feeder: $650. Greg Kelley, 203 South Summit, Arkansas City, KS 67005, (316) 442-6344.

FOR SALE: Back issues of *onComputing* (complete set), *Popular Computing* (vol. 1, no. 1 to vol. 2, no. 12), *Interface Age* (vol. 1, no. 1 to vol. 9, no. 4), *Creative Computing* (vol. 1, no. 1 to vol. 9, no. 1 and vol. 9, no. 7), *Dr. Dobb's Journal* (vol. 1, no. 1 to no. 12), and *Compute!*, (vol. 1, no. 1 to vol. 6, no. 12). Make offer. Walter Quatannens, Melkwezerstraat 39, B-3350 Linter, Belgium, West Europe.

FOR SALE: Sinclair ZX-81, 16K RAM, Mindware plain-paper printer, cables, and books: $95. Timex Sinclair 1000, 16K RAM, cables, and books. A. Fred Anderson, Box 112, RFD #2, Antrim, NH 03440, (603) 588-2276.

FOR SALE: Atari 800, disk drive, printer, tape drive, books, documentation, and more. Like new. $699. Ted Larson, RFD #2, Box 210, Milo, ME 04463, (207) 965-8092.

WANTED: German students wish to correspond about computers with American students. Michael Stal, Avenstr. 34, 800 München 5, West Germany.

FOR SALE: HP 67: $175. HP 82162A HP-IL thermal printer: $450. Also, two 82106A single memory modules: $15 each. M. Dorian Gregory, RR #1, North Rd., Gibsons, British Columbia V0N 1V0, Canada.

WANTED: High school student seeks correspondence and information on computer simulation of immiscible fluid systems. Stephen Mercer, 2019 Clinton St., Rockford, IL 61103, (815) 963-4493.

FOR SALE: Apple II+ computer and drive, 64K, parallel and serial ports, and more. $995 or best offer. Walt Heenan, Route 5, Box 309X, Vernon, NY 13476.

FOR SALE: Two HP 85 tape-drive computers. Very good condition. $2000 for both. James Wells, Route 3, Box 335, Petersburg, VA 23803, (804) 733-4472.

WANTED: Radio amateurs with Sinclair or Timex computers to exchange public-domain programs through QZX. Send SASE for sample newsletter. Alex. F. Burr, K5XY, 2025 O'Donnell Dr., Las Cruces, NM 88001.

FOR SALE: Toshiba P1340 dot-matrix letter-quality printer. Excellent condition. $800. Viktoria Stockmal, 424 Long Hill Ave., Shelton, CT 06484, (203) 735-4851.

B·O·M·B

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A COOPERATIVE EFFORT

The tally from the August BOMB shows five coauthors will divvy up the $100 bonus: Trevor G. Marshall, George Scolaro, David L. Rand, Tom King, and Vincent P. Williams. Their article "The DSI-32 Coprocessor Board, Part 1: The Hardware" placed first after "The Amiga Personal Computer" by staffers Gregg Williams, Jon Edwards, and Phillip Robinson. But it is Susan Eisenbach and Chris Sadler, authors of "Declarative Languages: An Overview," who each win $25 of the $50 allotted for second place. The columns by Steve Ciarcia and Jerry Pournelle continue to receive their usual high rating in the BOMB.

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