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Data General/One
C Compilers for Macintosh

KERNEL:

Pournelle Webster

NOVEMBER 1985 VOL. 10, NO. 12
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SECTION ART BY FRANK LEVY

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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.

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IDEA CREDIT: Ann Garner Riddle of Winston-Salem, N.C.
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 Ile. 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-tpl 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 Soricim'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 Ile 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
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

Alsyl 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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Access also lets you compose, send and receive letters through electronic mail services.

The Kyocera 1200 bps modem with Microsoft Access is available in stand alone or...
direct card. The bundled package contains all necessary accessories, including an RS-232C cable (for IBM-PC, XT* and compatibles). And because it’s bundled, you’ll save a bundle.

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 Michael sen, 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?

---

Robert Michael sen 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.)

---

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. 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.
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ONLINE BUSINESS NEWS

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 $X_0$, $Y_0$, and $Z_0$ are galactic coordinates, they may be calculated by:

$$X_0 = -0.0672 \cdot X - 0.8727 \cdot Y - 0.4835 \cdot Z$$
$$Y_0 = 0.4927 \cdot X - 0.4504 \cdot Y + 0.7445 \cdot Z$$
$$Z_0 = -0.8676 \cdot X - 0.1884 \cdot Y + 0.4602 \cdot Z$$

with $X$, $Y$, and $Z$ as used by Webster. The galactic plane is then the $X_0 - Y_0$ plane, and the galactic center is 10 kiloparsecs along the positive $X_0$ 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 collated, 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
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Low cost hardware and software 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/1, but the problems I wanted to work on were heavily computational, and FORTRAN provided easy links to assembly-
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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.
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.

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 LISP 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' 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>PUN:

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>PUN:

and then recalling the terminal program.
quiet operation, and Hex dump diagnostics. Plus the 3320 comes standard with Diablo® 630 and IBM® PC Graphics protocols and works with most major PC software packages such as Lotus®, Wordstar 2000® and Multimate®.

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

We do what we can to maximize utility (and make do!), don't we?

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 those 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)
A few smart reasons to buy our smart modem:

<table>
<thead>
<tr>
<th>Features</th>
<th>Ven-Tel 1200 PLUS</th>
<th>Hayes</th>
</tr>
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<tbody>
<tr>
<td>1200 and 300 baud, auto-dial, auto-answer</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Compatible with &quot;AT&quot; command set</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can be used with CROSSTALK-XVI or Smartcom II software</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Regulated DC power pack for cool, reliable operation</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Eight indicator lights to display modem status</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Speaker to monitor call progress</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Attractive, compact aluminum case</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Two built-in phone connectors</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Compatible with The Source and Dow Jones News Retrieval</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Unattended remote test capability</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Phone cable included</td>
<td>Now</td>
<td>Yes</td>
</tr>
</tbody>
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*Patent Pending

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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 Ex-
pessions" by Jonathan Amsterdam
(August, page 138) was clear and infor-
mative. 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 nec-
essarily limited to numbers not exceeding
MAXINT (32767 on most machines). This
create problems since, in some
Pascals, entering a larger number will
result in getNum producing either a nega-
tive value (because of two's complement-
ing) or even a nonsense result. What is
ever 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 in-
ocent 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 avail-
able on a disk from the Boston Computer
Society's PC User Group. Unfortunately, it
too contains a Getlnteger function that
has the same limitations as Mr. Amster-
dam'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 pro-
grammer, but I am relatively sure that it
would have been 90 percent incompre-
hensible 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 devel-
oped..." type of message. I guarantee
you that the real meaning of error #10
would not be very enlightening to most
users—it is "Emulator" trap, also known
as D3LineFErr. 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.

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<th>Product</th>
<th>Price</th>
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<td>Word Processing</td>
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<td>Spreadsheets</td>
<td>Lotus 1-2-3</td>
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<td>Databases</td>
<td>dBase IV Plus</td>
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<td>Graphics</td>
<td>MacPaint</td>
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<td>Network</td>
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**Complete Technical Specifications**

- **CPU**: Apple IIe, IIc, IIci, IIgs, Macintosh Classic, Macintosh Plus
- **RAM**: 128K-1MB
- **Hard Drive**: Winchester, 10MB-20MB
- **Graphics**: Hercules, CGA, RGB, EGA, VESA, VideoRAM
- **Sound**: Internal, External
- **Expansion**: 68000, 68020, 68030

- **Interface**: UART, JTAG, SPI, PS/2
- **Other**: Keyboard, Mouse, Printer, Scanner

**Memory Chips**

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<td>Baseline Educational Software</td>
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**Hardware for Your Apple II & Macintosh**

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<tr>
<th>Qty.</th>
<th>Manufacturer</th>
<th>Code</th>
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<td>Other</td>
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Complete this section to order merchandise featured in this month’s Advertisement:

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<th>Qty.</th>
<th>Description</th>
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<th>Shipping &amp; Handling</th>
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See other side of order form for more products

Be sure to add and TOTAL all shipping and handling charges. ($2.50 Min. per order)

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Please provide the following information to insure compatibility with your system (check all boxes that apply):

- IBM PC (be sure to indicate version of PC below)
- 64K System board
- 256K System Board
- XT
- AT

- Number of drives: __________
- Amount of memory: __________
- Monochrome or Color monitor (check one)
- Bill my credit card: 
  - VISA
  - MasterCard
  - American Express
  - Exp. Date __________
  - Account Number: __________

Name: ____________________________
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Signature: ____________________________
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PRICING MADNESS

Once again, as Federal Express picks up our ad at the very last millisecond before this issue's advertising deadline, here we sit with dozens of price reductions and new product announcements which have arrived too late for us to let you know.

Why, our ad manager asks, do we always go through a last minute price update frenzy, just seconds before our ad is due at the publisher, when we know that despite our heroic effort, many of these products will cost even less by the time you read this ad?

How, she asks, can we get a crystal ball to forecast what fantastic promotions and specials our suppliers are going to offer from now to the date this ad gets to the newsstand over two months from today?

Well, we decided that she has a good point. While we'll still keep getting our grey hairs and ulcers from last minute revisions, we will start publishing this notice and ask our readers to make a simple check. Look at any four back issues of this magazine (yes we're in every one) and track the prices on the most popular products. You will see that many drop with every issue. Most of these price changes were instituted well before the issue was printed and our members always pay the lower price. This should prove that this notice is much more than hype.

Given the current madness in the PC industry with its spur of the moment pricing and instant product introductions, you will find it always pays to call for our latest prices. You will be glad you did.
How do you suppose most manufacturers of personal computer products get started? They go to the Orient... taking either their designs or simply their ideas to one or more of the major electronics manufacturing concerns, getting bids for making these devices under contract to the creators. Multifunction Cards, Video Cards, Disk Controllers, Modems and I/O Boards all begin their life in this way.

This relationship between the manufacturing capabilities of the East and the design and marketing talents of the US, has resulted in the incredible selection of enhancement products for the IBM and Apple computer markets.

Well, with 100,000 members and growing strong, The Network sent its buyers east to visit some of these manufacturing concerns to check out the feasibility of directly importing these products in the necessary volumes to save our members money! What they came back with was astounding.

Now, we always figured that there were some pretty substantial markups as these boards came into the country and got fancy boxes and marketing promotions under any one of a number of well known brand names in the peripheral add-on markets but we had no idea they were so large!

To prove our point, consider what they brought back. Each board is constructed to the same precise specifications, on exactly the same machinery as their name-brand duplicates. The difference? As a Network member, you pay only 8% above our unusually low wholesale price... and you get our full 1 year warranty!

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A Monochrome Graphics Card with Printer Port... 100% compatible with Hercules product...

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100% compatible with the IBM offering. The wholesale price?

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The “9” Pack Plus
Multifunction like the AST “6” Pack... up to 384Kb of expansion memory, 1 serial, 1 parallel, and 1 game port, a clock/calender and 3 software packages standard.

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512 K Memory
The least expensive way to add memory to your current system. With 0 K installed.

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Multifunction like the AST “6” Pack... up to 384Kb of expansion memory, 1 serial, 1 parallel, and 1 game port, a clock/calender and 3 software packages standard.

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512 K Memory
The least expensive way to add memory to your current system. With 0 K installed.

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**PC NETWORK Members pay just 8% above this wholesale price, plus shipping. All prices reflect a 3% cash discount. Minimum shipping is $2.50 per order. International orders call for shipping & handling charges. Personal checks please allow 10 working days to clear.

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GET THE NETWORK ADVANTAGE!!!
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.

Beck-Tech Company is headquartered at 41 Tunnel Rd., Berkeley, CA 94705. (415) 548-4054. We apologize for the error.

Writing for BYTE Available

Interested in writing for BYTE but don't know how? The answers to your questions lie in Writing for BYTE, a free four-page brochure that addresses the questions most often asked by potential BYTE authors.

Writing for BYTE explains the kinds of articles that are most applauded by BYTE readers, and it tells you what you need to know about acceptance and publication fees. The brochure has tips on what to expect from the editing process, and your rights as an author are spelled out.


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, MinTel, 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 Thorlumy, 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.
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.

Today, IOMEGA has taken another giant step. With the addition of the compact 20-megabyte-per-cartridge Bernoulli Boxes, in single- and dual-drive versions, the Data Independence family gets simultaneously bigger and smaller. The new Bernoulli Boxes double on-line capacity to up to 40 megabytes and cut the space required to carry and store data cartridges. They also boast a footprint that is literally half that of the previous version, freeing just that much more valuable desk space.

But what makes the new Bernoulli Box so exciting are the same features that made it the new standard in data management to begin with.

**TRANSPORTABILITY.**
The Bernoulli Box cartridges are completely interchangeable. You're free to take the cartridge from one and use it in another with complete confidence. Take it across the hall or mail it across the continent.

**EXPANDABILITY.**
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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PERFORMANCE.
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.

SECURITY.
Free your sensitive files, such as payroll and personnel, from unauthorized scrutiny and free yourself from unnecessary anxiety. Put them on a Bernoulli Box cartridge, and put the cartridge where you know it will be safe.

Check out the latest Bernoulli Box family members today. More giant steps towards the complete data independence of businesses using the IBM PC, XT, AT, most compatibles, and the Macintosh. Giant steps with very small footprints.
For the dealer nearest you, call 1-800-556-1234, ext. 215. In California, call 1-800-441-2345, ext. 215.

"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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When it comes to being FIRST with technology-leading products Advanced Digital wears its #1 button with pride. We were FIRST to introduce an 8-Bit, single board S-100 computer... We were FIRST to introduce a 6MHz, 128KByte single board computer... We were FIRST to introduce a 6MHz, 128KByte Slave Processor board. Our record of FIRSTS continues with...

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- The introduction of our new SUPER 186 — the FIRST 16-Bit, single board S-100 computer that performs at twice the speed of older technologies. Loaded with features such as on-board floppy disk controller and up to 1MByte of RAM, the SUPER 186 is designed to function as a bus Slave or Master. Advanced Digital's SUPER 186 permits you to take advantage of vast libraries of sophisticated applications software.

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- The introduction of PC-SLAVE, an IBM PC Multiuser card with 8088 (8MHz) CPU and 256-768K RAM on board.

When it comes to selecting your S-100 boards, go with Advanced Digital — the recognized industry leader. See your local computer dealer or contact Advanced Digital today for more information on the new PC-SLAVE, and the complete line of S-100 single board computers and multiuser systems.

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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 alphabetical 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.


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)
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) 328-9593.

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 25501. (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 compatible. 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.


Inquiry 604.

(continued)
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.

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

8:00 am. You get 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> (or whatever)/P<ENTER> R<ENTER> SALES<ENTER> <PgUp> 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 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.” And he also said, “How did you get all that done so quickly?” And you said, “I’ve got a couple new gizmos 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 $159.90 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. (If you can still buy SuperKey and SideKick separately, SuperKey $89.95. SideKick $84.95. Not copy-protected.)

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.

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<tr>
<th>Product</th>
<th>Quality</th>
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<tr>
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$15 cash-back rebate upon receipt of signed license agreement and cash-back coupon.

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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 (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.

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 filling 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 312K-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 4-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.
IT EXPECTS YOU TO GROW.

INTRODUCING THE NCR PC6.

If you don't want your business to stay small, why get a computer that does? No personal computer gives you more growing room than the new NCR PC6.

The PC6 is upgradable to 40 megabytes—room for 7,575 pages of charts, inventory lists or business letters.

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When you're ready for multitasking, more memory, and new applications, so is the PC6.

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).

Expand your staff and the PC6 extends your authority. It's the perfect nucleus for a computer network.

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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.

For the nearest NCR dealer, call toll-free 1-800-544-3333*

A BETTER PERSONAL COMPUTER. IT'S EXACTLY WHAT YOU'D EXPECT FROM NCR.
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.

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.


EPROM Emulator

GP Industrial Electronics’ XM512 EPROM Emulator.

Fast 20-megabyte Backup Tape

Genoa Systems Corpora­tion is offering the Galaxy Models 3120 (internal) and 3220 (external) 20-megabyte, half-height, streaming-cartridge 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 timel 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.
The VERSABUSINESS™ Series

Each VERSABUSINESS module can be purchased and used independently, or can be linked in any combination to form a complete, coordinated business system.

VERSARECEIVABLES™ $99.95
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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 Nicta and Ronald Petruska (Golden Lee, 1984). It includes sections on all the popular microcomputers, microprocessors, and operating systems.


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 programs 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?

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?

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the consumer is lost in this sea of information.

GLENN DAILE
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 $100” 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

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(continued)
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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 direction.

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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 I28 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

20 X = LEN(B$)
30 REM Get a line of text
40 REM Find out how many characters
50 A$ = RIGHT$(B$, 1)
60 IF A$ = CHR$(13) GOTO 80
70 C$ = C$ + A$
80 B$ = LEFT$(B$, LEN(B$) - 1)
90 NEXT J
100 FOR J = 1 TO X
110 REM Add to end of new string
120 CS = CS + A$
130 REM Remove character from old string
140 BS = LEFT$(BS, LEN(BS) - 1)
150 RE M... and do it again
160 NEXT J
170 THE line can then be right-justified by adding spaces to the front of the string.

—Steve J

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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
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Luis Castro, Jay Hanson,
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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 comp-
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**BOOK REVIEWS**

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)
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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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BOOK REVIEWS

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,
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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.

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16-BIT MODERN MICROCOMPUTERS: THE INTEL 8086 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 8086 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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The rapid intake of breath. or possibly the clearing of a throat, will signal your next move. Make another keystroke to instantly put you into MS/DOS, where you casually do a directory listing. Start to work on a spreadsheet, other entertainers should be on top. His four-hour return. May return their dinner with $25.

Tend to be interrupt-driven. Sit down to write, and Springsteen is 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). Who needs Symphony? Recommended.

Pourouelle 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.

Pourouelle 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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WP and spreads can't afford to share back-ground-processing cycles. WordStar can barely keep up with the cursor now. And when you hit your spreadsheet's "calc" key, you want answers, not a blinking thinking-indicator.

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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.

Yes, there are other switcher programs. But, they lack the compactness and the reliability of Multiple Choice. Their authors haven't "paid the price." Good luck. goodbye competition.

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Multiple Choice takes less than 10K of resident memory (one-seventeenth that of Top View and a fraction of that taken by full-blow SideKick). It's not copy protected, because Jason isn't paranoid (Multiple Choice will even run, speaking about paranoid copy protection. Framework and 1-2-3). And you may return it for any reason within 30 days for a full refund.

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Jerry Pourouelle discusses Multiple Choice in his Byte column: "I've got it here at Chaos Manor (I'm blinking thinking-indicalnr. 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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BOOK REVIEWS

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
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**BOOK REVIEWS**

**16-Bit Modern Microcomputers**

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.

**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
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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 18086. 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..."
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BOOK REVIEWS

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 Eglin 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. Dobbs' Journal. He has published work on atmospheric turbulence and diffusion.
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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 VCS flies above the ordinary mouse, leaving more space on your desktop. Now you have room for books, papers and your favorite coffee cup. If you want, connect both your mouse and your VCS to the Mac and use them interchangeably.

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The VCS uses a proprietary ultrasonic technology to measure subtle changes in the rotation and angle of your head.* These changes are then translated into electrical signals just like those produced by the Mouse. The amount of cursor motion produced by a given amount of head motion depends on the rate your head moves. By monitoring this rate, the VCS can tell whether you are scanning across the screen or zeroing in on a small target. Then, it automatically adjusts to give you the right amount of head-to-cursor translation. Zip from corner to corner, or point to a tiny target with ease, even an individual pixel!

*Patent Pending.
IBM PC and Apple II versions available soon.
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
The chip is called a MOSART (modem synchronous/asynchronous receiver/transmitter) and is shown in Figure 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 2½- by 1- by ¼-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.

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

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 XEI203 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 XEI203 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.

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 Os 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 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 phone line.

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.]

**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 create a speech synthesizer. The MOSANSWR program allows you to talk into the microphone and have it played back through a speaker. The program allows you to record your voice and play it back at any time. The program also allows you to play back music from an audio tape or CD.

---

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

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

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

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

<table>
<thead>
<tr>
<th>ASCII Code (hexadecimal)</th>
<th>Character</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>A</td>
<td>Answer incoming call.</td>
</tr>
<tr>
<td>01</td>
<td>Control-A</td>
<td>Controlled answer. This function can be aborted by the caller by pressing &quot;1&quot; on a Touch-Tone dial or speaking. The MOSART will return a 1 or a v, respectively.</td>
</tr>
<tr>
<td>4D</td>
<td>M</td>
<td>Monitor the line and return status. MOSART returns R (ring back), D (dial tone), B (busy), V (voice), and others as appropriate.</td>
</tr>
<tr>
<td>4F</td>
<td>O</td>
<td>MOSART modem enters the originate mode.</td>
</tr>
<tr>
<td>52</td>
<td>R</td>
<td>Rotary dial.</td>
</tr>
<tr>
<td>54</td>
<td>T</td>
<td>Touch-Tone dial.</td>
</tr>
<tr>
<td>0F</td>
<td>Control-O</td>
<td>Set data-transmission rate to 110 bps.</td>
</tr>
<tr>
<td>14</td>
<td>Control-T</td>
<td>Set data-transmission rate to 300 bps.</td>
</tr>
<tr>
<td>08</td>
<td>Control-H</td>
<td>Set data-transmission rate to 1200 bps.</td>
</tr>
<tr>
<td>16</td>
<td>Control-V</td>
<td>Enable voice to phone-line connection. Returns an I (inappropriate) if a modem connection exists.</td>
</tr>
<tr>
<td>56</td>
<td>V</td>
<td>Enable voice locally. The synthesizer and audio input are connected to the audio output.</td>
</tr>
<tr>
<td>76</td>
<td>v</td>
<td>Disable voice.</td>
</tr>
<tr>
<td>58</td>
<td>X</td>
<td>Enable audio-output connection to the phone line (enables you to listen to the phone line).</td>
</tr>
<tr>
<td>78</td>
<td>x</td>
<td>Disable audio-output connection to the phone line.</td>
</tr>
<tr>
<td>5A</td>
<td>Z</td>
<td>Coupler on. The modulator is connected to audio-out, and the demodulator listens to audio-in.</td>
</tr>
<tr>
<td>7A</td>
<td>z</td>
<td>Coupler off.</td>
</tr>
<tr>
<td>3D</td>
<td>=</td>
<td>Parity checking/generation off.</td>
</tr>
<tr>
<td>3E</td>
<td>&gt;</td>
<td>Even parity checking/generation.</td>
</tr>
<tr>
<td>3C</td>
<td>&lt;</td>
<td>Odd parity checking/generation.</td>
</tr>
<tr>
<td>13</td>
<td>Control-S</td>
<td>Seven-bit character length.</td>
</tr>
<tr>
<td>05</td>
<td>Control-E</td>
<td>Eight-bit character length.</td>
</tr>
<tr>
<td>44</td>
<td>D</td>
<td>DTMF receive mode. The MOSART recognizes keys entered from a Touch-Tone phone and returns their associated ASCII codes.</td>
</tr>
<tr>
<td>48</td>
<td>H</td>
<td>Performs a logical disconnect of the modem but leaves the line in hold status.</td>
</tr>
<tr>
<td>49</td>
<td>I</td>
<td>Identify. Returns a letter corresponding to the version of the MOSART.</td>
</tr>
<tr>
<td>0D</td>
<td>Control-M</td>
<td>Detailed monitor. Every 0.05 second the MOSART returns a data byte indicating the line frequency in tens of hertz.</td>
</tr>
<tr>
<td>6D</td>
<td>m</td>
<td>Same as M.</td>
</tr>
<tr>
<td>70</td>
<td>p</td>
<td>Pause for 2 seconds.</td>
</tr>
<tr>
<td>50</td>
<td>P</td>
<td>Pause for 5 seconds.</td>
</tr>
<tr>
<td>57</td>
<td>W</td>
<td>Wait for dial tone.</td>
</tr>
</tbody>
</table>
Figure 9: Flowchart for the MOSTERM program (see listing 1).
Listing 1: Source code for the MOSTERM program.

CIRCUIT CELLAR

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 AS : 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 ctrl and output character
680 AS$ = CHR$(INP(&H2F8))
690 IF L = 0 THEN PRINT AS$ : 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 "supress 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...
1110 PRINT "enter filename for config file (drive spec and 8 digits max)"
1120 INPUT FS$,
1130 PRINT "you entered " ; FS$ ; " - "
1140 INPUT "enter 0 to redo, 1 to accept " ; P
1150 IF P = 1 THEN 1170

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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$<>""THEN GOTO 2160
2070 REM TEST EVENT
2080 GOSUB 9000
2090 REM CHECK FOR RING
2100 IF (INP(&H2F9) AND &H40)<>&H40 THEN 2050
2110 REM CHECK MODE AND DO IT
2125 PRINT "RING DETECTED"
2127 PRINT "ANSWERING PHONE"
2130 CS="HxDV"
2135 SP=0
2140 ON MO GOSUB 7000,8000
2150 GOTO 2000
2160 RETURN
3000 REM SYSTEM INITIALIZATION
3010 PRINT "SYSTEM INITIALIZATION STARTING"
3020 REM CHECK DATE AND TIME
3030 GOSUB 10000
3040 REM INITIALIZE THF MOSART
3050 GOSUB 6000
3060 REM GET SYSTEM MODE, DATE/TIME, AND CALL-FORWARD FLAGS
3070 GOSUB 11000
3080 PRINT "SYSTEM INITIALIZATION COMPLETE"
3090 RETURN
4000 REM EVENTS SETUP
4005 DIM ES$(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=O
5020 X= PEEK(&H510) + (256 * PEEK(&H511))
5030 X=X+ &H1000
5040 DEF SEG = X
5050 PRINT " STORING SPEECH ROUTINE ",
5060 BLOAD " SPEECH.BIN ", O
5160 PRINT "LOAD OF SPEECH TABLES COMPLETE"
5170 OPEN " SPEECH.TBL " FOR INPUT AS # 1
5180 FOR X = 1 TO 145
5190 INPUT #1 ,W$ ,TB0/o(X ,1) ,TB0/o (X ,2)
5200 NEXT X
5290 PRINT " SPEECH AND DRIVER LOAD COMPLETE ",
5295 CLOSE #1
5297 CLOSE #2
5300 RETURN

6000 REM MOSART INITIALIZATION
6010 PRINT " RESETIING 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=O
6070 X=X+ 1 :1F X >3000 THEN PRINT " MOSART HU NG 
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 RECORD A CALL 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 El= O 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(MIDS(D1$,1,2))
9070 D1 = D1 + (VAL(MIDS(D1$,1,2))*100)
9080 D1 = D1 + (VAL(MIDS(D1$,1,2))*100)
9090 REM T1 = SECS AFTER MIDNIGHT, D1 = DATE NUMERIC CODE
9100 REM CHECK OUT EVENTS TABLE FOR EVENT TO DO
9110 REM EI POINTS TO NEXT CHRONOLOGICAL EVENT
9120 REM BUILD COMPARISON NUMBERS
9130 REM BUILD CURRENT TIME VARIABLES
9140 D1$ = DATE$
9150 T1 = TIMER
9160 D1 = VAL(MIDS(D1$,1,2))
9170 D1 = D1 + (VAL(MIDS(D1$,1,2))*100)
9180 D1 = D1 + (VAL(MIDS(D1$,1,2))*100)
9190 T1 = VAL(MIDS(T1$,1,2))
9200 T1 = T1 + (VAL(MIDS(T1$,1,2))*60)
9210 T1 = T1 + (VAL(MIDS(T1$.1,2))*3600)
9220 IF D2<D1 THEN GOTO 9270
9230 IF D2>D1 THEN GOTO 9250
9240 IF T2>T1 THEN GOTO 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$= " " THEN GOTO 10110
10090 TIMES= "T1$
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 OT= 1 :RETURN
11240 DT = O:RETURN
11250 CF=O :RETURN
11260 CF=1
11270 PRINT "ENTER CALL-FORWARDING NUMBER 
"
11280 PRINT "NO SPECIAL PUNCTUATION EXCEPT FOR 
- ()I 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$(X,1)= "E":E$(X,2) = D1$
12070 GOSUB 12080
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$)< >8 THEN GOTO 12090
12105 ES(X,2)=ES(X,2) + T1$
12110 PRINT "ENTER 1 TO ANNOUNCE ONLY, 2 TO 
ANNOUNCE AND RECORD 
"
12120 INPUT T$:IF T$< >"1" AND T$< >"2" THEN 
GOTO 12110
12130 ES(X,3) = T$
12140 PRINT "ENTER 1 TO GIVE OUT DATE/TIME, 0 NOT 
TO SAY 
"
12150 INPUT T$:IF T$< >"0" AND T$< >"1" THEN 
GOTO 12140
12160 ES(X,3)=ES(X,3) + T$
12170 PRINT "ENTER 1 TO GIVE OUT FORWARDING
13420 PRINT MID$(E$(X,2),1,10);"":";MID$(E$(X,1),11,8);"":";
13430 PRINT MID$(E$(X,3),1,3);";MIO$(E$(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 CHAR 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$(X,3)
14090 NEXT X
14100 PRINT "TABLE LOADED";CLOSE #1
14110 REM BUILD INDEX POINTER
14120 GOSUB 32000
14130 RETURN
14500 REM SAVE EVENTS TABLE
14510 PRINT:PRINT "ENTER NAME OF TABLE TO BE SAVED (8 CHAR MAX)"
14520 INPUT " OR PRESS ENTER TO ABORT :"; T$
14530 IF T$= "" THEN GOTO 15130
14540 IF LEN(T$)>8 AND MID$(T$,2,1)< > ":" THEN GOTO 14510
14550 T$= T$+ "EVT"
14560 OPEN T$ FOR OUTPUT AS #1
14570 FOR X=1 TO 30
14580 PRINT #1,E$(X,1)
14590 PRINT #1,E$(X,2)
14600 PRINT #1,E$(X,3)
14610 NEXT X
14620 PRINT " TABLE SAVED";CLOSE #1
14630 REM SPECIAL ACCESS
14640 GOSUB 32000
14650 RETURN
15000 REM CANNED ANNOUNCEMENT
15010 REM DATA FOR CANNED PHRASE BUILD
15020 PRINT:PRINT "ENTER NAME OF TABLE TO BE LOADED (8 CHAR MAX)"
15030 IF T$= "" THEN GOTO 15130
15040 IF LEN(T$)>8 AND MID$(T$,2,1)< > ":" THEN GOTO 15010
15050 T$= T$+ "EVT"
15060 OPEN T$ FOR INPUT AS #1
15070 FOR X=1 TO 30
15080 PRINT E$(X,1),E$(X,2),E$(X,3)
15090 NEXT X
15100 PRINT " TABLE LOADED";CLOSE #1
15110 REM DO CANNED MESSAGE FOR RECORD
15120 PRINT "ENTER NAME OF TABLE TO BE LOADED (8 CHAR MAX)"
15130 IF T$= "" THEN GOTO 15130
15140 IF LEN(T$)>8 AND MID$(T$,2,1)< > ":" THEN GOTO 15110
15150 T$= T$+ "EVT"
15160 OPEN T$ FOR OUTPUT AS #1
15170 FOR X=1 TO 30
15180 PRINT #1,E$(X,1)
15190 PRINT #1,E$(X,2)
15200 PRINT #1,E$(X,3)
15210 NEXT X
15220 PRINT " TABLE SAVED";CLOSE #1
15230 REM DO RECORD MESSAGE (INCLUDES SUPER/SPECIAL TEST)
15240 REM DO CANNED MESSAGE FOR RECORD
15250 PRINT "ENTER NAME OF TABLE TO BE LOADED (8 CHAR MAX)"
15260 IF T$= "" THEN GOTO 15260
15270 IF LEN(T$)>8 AND MID$(T$,2,1)< > ":" THEN GOTO 15250
15280 T$= T$+ "EVT"
15290 OPEN T$ FOR OUTPUT AS #1
15300 FOR X=1 TO 30
15310 PRINT #1,E$(X,1)
15320 PRINT #1,E$(X,2)
15330 PRINT #1,E$(X,3)
15340 NEXT X
15350 PRINT " TABLE SAVED";CLOSE #1
15360 REM DO RECORD MESSAGE AND BEEP TONE
15370 PRINT "ENTER NAME OF TABLE TO BE LOADED (8 CHAR MAX)"
15380 IF T$= "" THEN GOTO 15380
15390 IF LEN(T$)>8 AND MID$(T$,2,1)< > ":" THEN GOTO 15370
15400 T$= T$+ "EVT"
15410 OPEN T$ FOR OUTPUT AS #1
15420 FOR X=1 TO 30
15430 PRINT #1,E$(X,1)
15440 PRINT #1,E$(X,2)
15450 PRINT #1,E$(X,3)
15460 NEXT X
15470 PRINT " TABLE SAVED";CLOSE #1
15480 REM DO RECORD MESSAGE AND BEEP TONE
15490 PRINT "ENTER NAME OF TABLE TO BE LOADED (8 CHAR MAX)"
15500 IF T$= "" THEN GOTO 15500
15510 IF LEN(T$)>8 AND MID$(T$,2,1)< > ":" THEN GOTO 15490
15520 T$= T$+ "EVT"
15530 OPEN T$ FOR OUTPUT AS #1
15540 FOR X=1 TO 30
15550 PRINT #1,E$(X,1)
15560 PRINT #1,E$(X,2)
15570 PRINT #1,E$(X,3)
15580 NEXT X
15590 PRINT " TABLE SAVED";CLOSE #1
15600 REM RECORD MODE
15610 REM DO CANNED MESSAGE FOR RECORD
15620 PRINT "ENTER NAME OF TABLE TO BE LOADED (8 CHAR MAX)"
15630 IF T$= "" THEN GOTO 15630
15640 IF LEN(T$)>8 AND MID$(T$,2,1)< > ":" THEN GOTO 15620
15650 T$= T$+ "EVT"
15660 OPEN T$ FOR OUTPUT AS #1
15670 FOR X=1 TO 30
15680 PRINT #1,E$(X,1)
15690 PRINT #1,E$(X,2)
15700 PRINT #1,E$(X,3)
15710 NEXT X
15720 PRINT " TABLE SAVED";CLOSE #1
15730 REM DO RECORD MESSAGE AND BEEP TONE
15740 PRINT "ENTER NAME OF TABLE TO BE LOADED (8 CHAR MAX)"
15750 IF T$= "" THEN GOTO 15750
15760 IF LEN(T$)>8 AND MID$(T$,2,1)< > ":" THEN GOTO 15740
15770 T$= T$+ "EVT"
15780 OPEN T$ FOR OUTPUT AS #1
15790 FOR X=1 TO 30
15800 PRINT #1,E$(X,1)
15810 PRINT #1,E$(X,2)
15820 PRINT #1,E$(X,3)
15830 NEXT X
15840 PRINT " TABLE SAVED";CLOSE #1
15850 REM DO RECORD MESSAGE AND BEEP TONE
19410 S=D1  
19420 GOSUB 36000  
19430 D1 = VAL(MID$(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$9,1))  
19480 S = 18 + D1: IF S = 0 THEN S = 28  
19490 GOSUB 36000  
19500 D1 = VAL(MID$(D1$9,2))  
19510 IF D1 < 2 THEN GOTO 19530  
19520 GOSUB 36000  
19530 RETURN  
20000 REM GIVE CALL-FORWARDING NUMBER  
20010 DATA 4,66,90,45,93  
20020 RESTORE 2001  
20030 READ P  
20040 FOR P1 = 1 TO P  
20050 READS  
20060 GOSUB 36000  
20070 NEXT P1  
20080 FOR Z = 1 TO LEN(CN$)  
20090 T$ = MID$(CN$,Z,1)  
20100 IF T$ = " - " OR T$ = "/" OR T$ = " " OR T$ = "(" OR T$ = ")" THEN S = 95: GOTO 2130  
20110 T$ = VAL(T$)  
20120 S = T$: 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 READS  
25080 GOSUB 36000  
25090 NEXT P1  
25100 RETURN  
26000 REM RECORD A CALL  
26010 REM FIRST SET UP MOSART AND START RECORDER  
26020 CS = "XD"  
26030 GOSUB 29000  
26040 MOTOR 1  
26045 GOSUB 35000  
26050 IF GP < 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 CS = "M": GOSUB 29000  
26132 IF CHR$(INP$(&H2F8)) = "T" THEN GOTO 26140  
26135 GOTO 26090  
26140 MOTOR 0  
26150 RETURN  
29000 REM PROCESS MOSART COMMANDS  
29010 REM CS = COMMAND STRING  
29020 FOR X = 1 TO LEN(CS)  
29025 OUT &H2F9, 8H  
29030 Y = 0  
29040 Y = Y + 1: IF Y > 5000 THEN PRINT "MOSART LOCKED UP:" STOP  
29050 IF INP$(&H2F9) AND 5 = 5 THEN 29060 ELSE 29040  
29060 CS = MID$(CS,X,1)  
29070 OUT &H2F8,ASC(T$)  
29080 IF INP$(&H2F9) AND 2 = 2 THEN 29100  
29090 IF INP$(&H2F9) AND 7 = 7 THEN 29110 ELSE 29080  
29100 PRINT: PRINT "INFO BYTE FROM COMMAND ";T$;" WAS ";CHR$(INP$(&H2FS))  
29110 NEXT X  
29120 NEXT Y  
29130 RETURN  
30000 REM DO EVENT  
30005 PRINT "EVENT IN PROGRESS ";D$(X),T$(X)  
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 = 99999999: T1 = 99999999  
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$(D2$,2,1,2)) * 10000)  
32110 T2 = D2 + (VAL(MID$(T2$,2,9,2)) * 10000)  
32120 T2 = VAL(MID$(T2$,9,2))  
32130 T2 = T2 + (VAL(MID$(T2$,2,4,2)) * 60)  
32140 T2 = T2 + (VAL(MID$(T2$,2,4,2)) * 3600)  
32150 IF D2 > D1 THEN GOTO 32180  
32160 IF D2 < D1 THEN D1 = D2: T1 = T2: EI = X: GOTO 26140 (continued)
32180 IF T2<T1 THEN D1=D2:T1=T2:EI=X
32190 NEXT X
32190 RETURN
33000 REM ANNOUNCEMENT ONLY
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
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 CS="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 CS="X":CHR$(22)
36040 GOSUB 29000
36050 OUT &H2F9,&H27
36060 REM WRITE OUT SPEECH DATA
36070 SYNTH%:SP=0
36080 START%=TB%(S,1):COUNT%=TB%(S,2)
36090 CALL SYNTH%(START%,COUNT%)
36100 OUT &H2F9,&HFA
36110 CS="V"
36120 GOSUB 29000
36130 RETURN
37000 REM RECORD ANNOUNCE #2
37010 REM DATA FOR CANNED PHRASE BUILD
37020 OUT &H2F9,&H27
37030 DATA 7,39,67,88,93,77,77,94,96
37040 OUT &H2F9,&H40
37050 OUT &H2F9,&H7
37060 REM SPEAK STUFF
37070 FOR X=1 TO 500
37080 READ P
37090 READ S
37100 REM WAIT A BIT AND CHECK SPECIAL/SUPER
37110 OUT &H2F9,&HFA
37120 CS="V"
37130 GOSUB 29000
37140 PRINT "SPECIAL ACCESS REQUESTED"
37150 RETURN
38000 GOSUB 36000
38010 NEXT P1
38100 RETURN
40000 REM SUPERVISING AND SPECIAL FUNCTIONS
40010 REM NOT YET IMPLEMENTED
40020 DATA 10,57,93,115,52,117,53,58,63,93,93
40030 RESTORE 40020
40040 IF INP(&H2F9) AND &H40 < &H40 THEN 240
40050 IF INP(&H2F9) AND &H40 < > 0 THEN 250
40060 FOR X=1 TO 500
40070 READ P
40080 READ S
40090 GOSUB 36000
40100 GOSUB 36000
40110 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 "RESETING MOSART"
110 OUT &H2F9,0
120 OUT &H2F9,0
130 OUT &H2F9,0
140 OUT &H2F9,0
150 OUT &H2F9,0
160 OUT &H2F9,0
170 CS="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"
280 REM RECORDS... etc.
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 21,92,49,81,17,18,61,52,91,81,1,28,22,5,42,73,92,83,94,72
540 RESTORE 530
550 GOSUB 950
560 REM TEST TIME-OUT
570 IF TIME-OUT = 0 THEN GOTO 630
580 GOTO 670
590 REM TEST END CODE AND THEN TEST GOOD-NUMBER RANGE
600 S = VAL(CODE$)
610 IF S = -1 THEN GOTO 90
620 IF S > 0 AND S <= 145 THEN GOTO 710
630 REM BAD ROUTINE
640 BAD = BAD + 1
650 IF BAD > 3 THEN GOTO 90
660 GOTO 510
670 REM PRINT "SAYING PHRASE NUMBER ";S
680 OUT &H2F9, &H27
690 REM SPEAK STUFF
700 READ P
710 FOR P1 = 1 TO P
720 READS
730 GOSUB 1200
740 NEXT P1
750 OUT &H2F9, &H7
760 RETURN
770 REM PROCESS MOSART COMMANDS
780 REM C$ = COMMAND STRING
790 FOR X = 1 TO LEN(C$)
800 OUT &H2F9, &H7
810 Y = 0
820 Y = Y + 1: IF Y > 5000 THEN PRINT "MOSART LOCKED UP": STOP
830 IF (INP(&H2F9) AND &H2) = 2 THEN X = X + 1: NEXT X
840 OUT &H2F9, &H7
850 IF (INP(&H2F9) AND &H2) = 2 THEN X = X + 1: NEXT X
860 PRINT "INFO BYTE FROM COMMAND "; T$; " WAS "; CHR$(INP(&H2F8))
870 NEXT X
880 RETURN
890 REM SPEECH OUTPUT
900 REM S = POINTER TO PHRASE IN TABLE TB(X,Y)
910 REM ASSUMES CONNECT IS ESTABLISHED ALREADY
920 C$ = "x " + CHR$(22)
930 GOSUB 1250
940 OUT &H2F9, &H7
950 REM WRITE OUT SPEECH DATA
960 OUT &H2F9, &H7
970 OUT &H2F9, &H7
980 OUT &H2F9, &H7
990 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 pacemaker and all others will strive to be compatible with it.
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**LINE-UP**

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It simply works better.
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—

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A VM2 ASSEMBLER

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.

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
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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 do need to keep the assembled program in memory. Instead of outputting an assembled value, you save it in a table I'll call 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
A VM2 ASSEMBLER

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)
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 \( n+1, n+2, \ldots \) 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.
A VM2 ASSEMBLER

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

\[
\text{BUFSIZE} = 30
\]

at the beginning of your program and then on use the more readable \text{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

\[
\text{NELEMENTS} = 20 \\
\text{ELSIZE} = 2 \\
\text{ARRAYSIZE} = \text{NELEMENTS} \cdot \text{ELSIZE}
\]

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

\[
\text{PUSH} \ A \\
\text{PUSHC} \ 1 \\
\text{ADD} \\
\text{POPC} \ A
\]

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:

\[
\text{.MACRO INC %1} \\
; the % indicates an argument \\
\text{PUSH} \ %1 \\
; argument is substituted here... \\
\text{PUSHC} \ 1 \\
\text{ADD} \\
\text{POPC} \ %1 ; ... and here \\
\text{ENDM} \\
; the "end macro" directive
\]

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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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)
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, INTEGRERS:L:IB, 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 \{SY-\} 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 I0Check, 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 for the parameter list. Also, you might want to use the \{SY-\} 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 I0Check, which I will describe later.

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The routine Error writes its message on the top line. 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 for the parameter list. Also, you might want to use the \{SY-\} 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 I0Check, which I will describe later.

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• Data Classes: auto, static, extern, register
• Struct, Union, Bit Fields
• Typedef, Initialization

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file I/O. To use it, you should turn off I/O error checking for your program with the compiler directive {$1-}. 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:

```pascal
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) anywhere 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.

**INTBERS**

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:

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

would produce this output:

<table>
<thead>
<tr>
<th>x</th>
<th>ISqrt(x)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

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
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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:

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

you'll get the following output:

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:

```pascal
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:

```pascal
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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??-
{ 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 A 1 Addr,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;
beginnfor 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 pass­
ing 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 param­
eter's address and then manipulate it to your heart's con­
tent. (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[O] and Str2[O]) and all the currently
unused bytes in both strings.

The Boolean function Identical overcomes a serious defi­
cency in Turbo Pascal. Turbo Pascal does not let you com­
pare 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 be­
tween 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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Each library is independent of the others, and there are no identifier conflicts.

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:

```pascal
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
    Indx := next element in LoopSet
  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*:

```pascal
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.*
EXTENDING TURBO PASCAL

These must be defined before the {$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.

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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, non-erasably); 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)

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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.

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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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.

**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

![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.](image)

![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.](image)
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- C Benchmarks—done on a Compaq Plus with 512k memory with no 8087. Program “SIEVE” with register variables.

<table>
<thead>
<tr>
<th>Exec Time</th>
<th>Code Size</th>
<th>EXE Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsoft C</td>
<td>9.39</td>
<td>141</td>
</tr>
<tr>
<td>Lattice C</td>
<td>12.24</td>
<td>164</td>
</tr>
</tbody>
</table>

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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 (continued)
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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 read-out. 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 (continued)
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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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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)

Michael Kilian (River St., Unit 3, Hudson, MA 01749) is currently a senior software engineer working on object-based compilers at Digital Corporation’s Eastern Research Labs. He holds a master’s degree from Rensselaer Polytechnic Institute and is the author of Screen Machine, a set of assembly-language routines that interface with Pascal to provide direct screen access, multiple windows on the screen from within the higher-level language, and the ability to get key input directly from the BIOS.
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:

```pascal
procedure set_cursor(row,column: integer); external;
```

```pascal
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:

```assembly
PUSH BP
OLD BP - >
MOV BP,SP
; Save old frame pointer.
; 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:

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

(continued)
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Parameter Passing

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
  POP regn
  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)
PARAMETER PASSING

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:

(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 (3) 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.

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

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 (?)
   DD   ?
   ;    double word.
   DD   ?
   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 i might be:

```
LDS   S[B],VP1_2
MOV   word ptr (S),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, 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 read_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.

FORTAN 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 FORTAN 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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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, \( y = \text{PDL}(x) \), 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 I 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 GCI 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 GCO input, I got a \( y \) of 224 when \( r \) was 100K \( \Omega \) (ohms), resulting in a scale factor of 2.24/K \( \Omega \). With GCI, we got a scale of 2.19/K \( \Omega \). 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-\( \mu \)F (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

\[
t = 1.1 \cdot r \cdot c
\]

where \( r \) is the resistance of the game-

(continued)

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paddle potentiometer in ohms and \( c \) is 0.022 \( \mu F \).

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 \( y = \text{PDL}(x) \) instruction by the formula \( t = 11 \times y \times t_c \), where \( t_c \) is the period of the microcomputer clock.

For the Apple II, \( t_c = 0.9778 \) ms (milliseconds), which corresponds to an \( r \) of 113.3 K\( \Omega \). With the GCO input, I obtained a \( y \) of 255 when \( r \) was between 113K and 114K\( \Omega \). With the GCI input, I obtained a \( y \) of 255 when \( r \) was between 116 and 117K\( \Omega \). Thus, given the precision of the components, the game paddles behave exactly as expected.

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 I 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-\( \mu F \) 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.

---

Listing I: A program to graph the output of \( y = \text{PDL}(x) \) as an input parameter is changed.

```markdown
10 INPUT X
20 KYBD = 49152
30 HGR : HCOLOR = 3
40 HPLLOT 0.0 TO 255.0
50 HPLLOT 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 HPLLOT Y,Z
150 PR# 1 : PRINT R,Y
160 PR# 0 : GOTO 50
```

---

**Figure 1:** The resistance, \( r \), as a function of the quantity \( y = \text{PDL}(x) \) as it is graphed on the high-resolution screen by the program in listing I. The relationship between \( y \) and \( r \) is clearly linear.
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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 Bit 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 υPD7281 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.

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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)
AMIGA'S CUSTOM CHIPS

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

(continued)

Figure 1: A block diagram of the Agnus chip.
# HARDWARE

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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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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 number of clock ticks it takes to decode the instruction—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

Figure 3: A block diagram of the Paula chip.
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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 (continued)

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**Figure 4:** A block diagram of the Amiga's overall architecture.
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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're 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: Why 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)
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AMIGA'S CUSTOM CHIPS

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 biomer'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

(continued)
what shows on the screen. One is to horizontally scroll smoothly 0 to 15 bits within a word. The other is to change the pointer a whole word value. So you can relocate the thing just by changing the pointer. If you come to the edge of the big picture, then you've got to do something in the software—block moves and so on.

**Collison 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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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 component.

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John Bennett, a computer systems architect, is president of Pacific Mountain Research Inc. He is a Ph.D. candidate in computer science at the University of Washington. He can be contacted at Pacific Mountain Research Inc., 8026 35th Ave. NE, Seattle, WA 98115.
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 **continued**

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**Figure 1:** Basic raster display system.

**Figure 2:** Some textured lines.
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bit-blt), 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 Combining Portions of Bit Maps. BitBlt is a general-purpose abstract delivery anywhere.

Examples of typical functions:

- An arbitrarily aligned rectangular region of a source bit map is replaced on a pixel-by-pixel basis with the corresponding pixel from a halftone bit map. The halftone image is typically a 16- by 16-pixel array interpreted as one tile of a pattern covering the entire destination bit map.

RAS TER OPERATIONS

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

(continued)
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- Copy source
- Copy halftone
- Paint halftone (source = “brush” halftone = “paint”)
- 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.

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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.

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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 “Bit chip”). A block diagram of the 96016 is shown in figure 3.

**PMR 96016 Circuit Description**

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hardware) the functions that consume
the most time in a software-only im-
plementation of BitBlt—namely, shift-
ing, masking, and Boolean combina-
tion.

As shown in figure 3, the Blt chip
consists of two Source registers, a
Destination register, a data path, and
five configuration registers that con-
trol the data path. All data-path ele-
ments are 16 bits wide. The three
data-path registers are the most fre-
cently used and therefore are con-
trolled 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 ap-
pear 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 configura-
tion register addressed by A1–A3 to
be loaded from the data bus. Except
where otherwise specified, all con-
figuration 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 posi-
tions, 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 posi-
tions 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 cor-
responding bit of the function unit
output, while a "1" selects the cor-
responding bit of the Destination reg-
ister (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 con-
trolling microprocessor. The BitBlt
algorithm for which the Blt chip de-
sign 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 en-
tire 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 reg-
isters, 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

---

**Figure 4**: PMR 96016 pin-out.
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RASTER OPERATIONS

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 Bit 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 Bit 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 Bit chip configuration registers directly as individual words in its I/O (input/output) address space (that might be memory-mapped). The three types of Bit 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, Bit-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 (Bit-Special Read) and substituting its own data on Write cycles (Bit-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.

Previously, we outlined the sequence of memory and Blt chip cycles that occurs most frequently during a BltBit 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.

A Blt-Special Write cycle is quite different from an ordinary Write cycle. It is orchestrated by a Blt-Special Write

Figure 6: Timing diagram of a Blt-Special Read cycle.

Figure 7: Timing diagram of a Blt-Special Write cycle (Read-Modify-Write).
FEATURES AND SPECIFICATIONS

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  - 640Kb Main Memory
  - ROM Bios
  - Eight I/O expansion slots (six with 62 and 36 pins, two with 62 pins only)
  - CMOS clock/calendar with battery back-up
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  - Seven-channel direct memory access (DMA)
  - 16 level interrupts
  - Three programmable timers
- 192 Watt Power Supply
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  - Color Monitor with adapter
  - Monochrome Monitor with adapter
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 Bit-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 Bit chip resides, and the memory is accessed for reading. When the Read data becomes available, LDDEST- is asserted to load it into the Bit chip Destination register. Finally, the Bit chip OE- pin is asserted and the data path 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 Bit-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 Bit chip. Figure 7 shows the actions of the BSWC during a Bit-Special Write (Read-Modify-Write). Clearly Bit-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...
RASTER OPERATIONS

SKEWMASK = (skew == 0) ? 0 : rightmasks[16 - skew];
starbits = 16 - (destx & 15); /* # of bits in first dest word */
mask1 = rightmasks[starbits];
mask2 = rightmasks[15 - ((destx + width - 1) & 15)];
nwords = ((width - starbits + 15) / 16) + 1;
/* Calculate starting addresses, word increment between lines. */
/* Check if need 2 words of src */
preload = (skew != 0) && skew <= (sourcex & 15);
/* Calc starting addresses */
srcptr = srcbits + BLTSPECIAL + sourcey * srcraster + (sourcex / 16);
dsptr = dstbits + BLTSPECIAL + desty * draster + (destx / 16);
/* Calc scanline offsets */
srcdelta = srcraster - nwords;
dstdelta = draster - nwords;
if (preload) srcdelta -= 1;
/* Copy one row at a time */
BLTFUNC = combrule;
while (height--; > 0) {
    /* copy one row */
    if (htonebits) {
        HALFTONE = htonebits[desty & 15];
desty += 1;
    }
    if (preload)
        junk = *srcptr ++;
        /* preload previous word */
    wordcount = nwords;
    MERGEMASK = mask1;
        /* copy first word */
    *dsptr ++ = *srcptr ++; /* BLTSPECIAL read, BLTSPECIAL rmw*/
    if (--wordcount > 0) {
        MERGEMASK = 0x0000;
        /* copy full words */
        while (--wordcount > 0)
            *dsptr ++ = *srcptr ++; /* BLTSPECIAL read, BLTSPECIAL rmw*/
        MERGEMASK = mask2;
        /* copy last word */
        *dsptr ++ = *srcptr ++; /* BLTSPECIAL read, BLTSPECIAL rmw*/
    }
    srcptr += srcdelta;
        /* calc address of next row */
    dsptr += 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 Bit-Special bit (address bit 23) set cause the Bit 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 Bit-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 Bit chip's Destination register; the new destination word is computed combinatorially by the Bit 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 Bit 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 Bit 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.

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<thead>
<tr>
<th>Automatic Data Transfer From:</th>
<th>R:base 5000</th>
<th>dBASE III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lotus 1-2-3*</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>pfs:file*</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>dBASE II*</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Multiplan* (Sylk)</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Visicalc* (DIF)</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>ASCII (delimited and fixed files)</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

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<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<td>384 RAM Memory, Amiga 20 MHz Monitor P3</td>
<td>7 Expansion Slots</td>
<td>5 Megabyte RAM, 8 Meg with 7 Expansion Drives</td>
<td>IBM PC/AT Compatible</td>
<td>Disk Letter Sweep 8 Mbyte</td>
<td>2 DC 3900 Drive</td>
<td>IBM PC/XT Compatible</td>
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<tr>
<td>Built in IBM Expansion</td>
<td>1 Expansion Slot</td>
<td>CZW-154-4285U</td>
<td>Singe GS/DD 1.2 Meg Disk Drive</td>
<td>2 Standard DS/DD 360K Drives</td>
<td>14.3 Lb, 2900 RAM</td>
<td>IBM PC/XT Compatible</td>
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<tr>
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<td>2,429</td>
<td>512K RAM, Serial Parallel</td>
<td>640 x 330 Graphic</td>
<td>2311-42</td>
<td>IBM Graphic Card</td>
</tr>
<tr>
<td>4 8 Meg Memory</td>
<td>1,850</td>
<td>Four Plus</td>
<td>Amiga 20 MHz Monitor P3</td>
<td>24 x 36 RAM</td>
<td>1,995</td>
<td>Enhanced Keyboard for IBM PC</td>
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<tr>
<td>5 One Plus</td>
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<td>Hard Disk System</td>
<td></td>
<td>128K RAM, 64K with expansion slot</td>
<td>1,299</td>
<td>IBM PC/XT Compatible</td>
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<td>with or without 40 Meg Hard Disk</td>
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<td>IBM PC/XT Compatible</td>
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<td></td>
<td>CZW-154-4285U</td>
<td></td>
<td>CZW-148-4178U</td>
<td></td>
<td>PC Card Slot 19</td>
</tr>
</tbody>
</table>

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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)
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 \((X_{\text{SCREEN}}, Y_{\text{SCREEN}})\). The transformation formulas are:

\[
X_{\text{SCREEN}} = \frac{(AX + BY + CZ + D)}{W} \\
Y_{\text{SCREEN}} = \frac{(EX + FY + GZ + H)}{W} \\
W = IX + JY + KZ + L
\]

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 \((X_{\text{LEFT}}\) and \(X_{\text{RIGHT}}\)). 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 scanline 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.

<table>
<thead>
<tr>
<th>Method Used</th>
<th>Floating-Point Multiplication Time</th>
<th>Floating-Point Addition Time</th>
<th>Floating-Point Division Time</th>
<th>Time to Transform 1 Vertex</th>
<th>Time to Transform 2000 Vertices</th>
<th>Achievable Images per Second</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software Only (8086)</td>
<td>1600 µs</td>
<td>1600 µs</td>
<td>3200 µs</td>
<td>35,200 µs</td>
<td>70,400 ms</td>
<td>0.015</td>
</tr>
<tr>
<td>Floating-Point Coprocessor (8087)</td>
<td>19 µs</td>
<td>17 µs</td>
<td>39 µs</td>
<td>402 µs</td>
<td>804 ms</td>
<td>1.25</td>
</tr>
<tr>
<td>Floating-Point Multiplier Chip</td>
<td>0.2 µs</td>
<td>0.2 µs</td>
<td>0.8 µs</td>
<td>5.2 µs</td>
<td>10.4 ms</td>
<td>96</td>
</tr>
</tbody>
</table>

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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 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

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.

<table>
<thead>
<tr>
<th>Method</th>
<th>Pixels per Memory Cycle</th>
<th>Average Time to Access 1 Pixel</th>
<th>Average Time to Rasterize 10 Million Pixels</th>
<th>Average Time to Rasterize 300 Million Pixels</th>
<th>Achievable Images per Second</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software Only</td>
<td>1</td>
<td>2000 ns</td>
<td>20 sec</td>
<td>600 sec</td>
<td>0.05</td>
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<tr>
<td>Graphics Processor</td>
<td>1</td>
<td>800 ns</td>
<td>8 sec</td>
<td>240 sec</td>
<td>0.125</td>
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<tr>
<td>Software Only, Bit Map (16 pixels/16-bit word)</td>
<td>16</td>
<td>125 ns</td>
<td>1.25 sec</td>
<td>37.5 sec</td>
<td>0.8</td>
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<tr>
<td>Graphics Processor</td>
<td>16</td>
<td>20 ns</td>
<td>0.20 sec</td>
<td>6 sec</td>
<td>5</td>
</tr>
<tr>
<td>Graphics Processor and SLAM Chip</td>
<td>1 to 1024 (typically, 100)</td>
<td>0.2 ns to 200 ns</td>
<td>0.02 sec</td>
<td>0.06 sec</td>
<td>50</td>
</tr>
</tbody>
</table>

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 ms 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 OPDM. 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 OPDM 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

---

**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 OPDM 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.

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 right coordinate and directs the SLAM to read the selected scan line from the memory array. Finally, the fourth command specifies the left coordinate and directs the SLAM to modify all pixels in the range [XLEFT, XRIGHT] 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)
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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.

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 \( X_{\text{LEFT}} \) and \( X_{\text{RIGHT}} \) values and generates a 1 bit for each of the 256 horizontal bit positions that lie in the range \([X_{\text{LEFT}}, X_{\text{RIGHT}}]\) 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 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 \( \mu \)s (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...
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-
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).

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.
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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.

Unfortunately, this is not easily done in BASIC, so we must look elsewhere.

Now let's declare the variables that are to reserve this space:

Var Evenmap, Oddmap: data_type; (continued)

Mark Bridger and Mark Goresky are associate professors of mathematics at Northeastern University. Mark Bridger has a Ph.D. from Brandeis University; Mark Goresky holds a Ph.D. from Brown University. Mark Bridger can be reached at Bridge Software, 31 Champa St., Newton Upper Falls, MA 02164. Mark Goresky can be reached at the Mathematics Dept., Northeastern University, 360 Huntington Ave., Boston, MA 02115.
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 Is represent the dots that you actually want to draw and the Os 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 7 ½ 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 dots high.

---

**Table 1:** This table shows the dot positions on the page. The Is represent dots that you actually want to draw; the Os represent positions you want to skip over.

<table>
<thead>
<tr>
<th>Even</th>
<th>Odd</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>0</td>
</tr>
</tbody>
</table>

**Table 2:** This table shows the distribution of the various print dot positions between even and odd rows.

<table>
<thead>
<tr>
<th>Even</th>
<th>Odd</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1000000000000000</td>
</tr>
<tr>
<td>2</td>
<td>0010000000000000</td>
</tr>
<tr>
<td>4</td>
<td>0001000000000000</td>
</tr>
<tr>
<td>6</td>
<td>0000100000000000</td>
</tr>
<tr>
<td>8</td>
<td>0000010000000000</td>
</tr>
<tr>
<td>10</td>
<td>0000001000000000</td>
</tr>
<tr>
<td>12</td>
<td>0000000100000000</td>
</tr>
<tr>
<td>14</td>
<td>0000000010000000</td>
</tr>
</tbody>
</table>

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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 BYTEnet 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. Line 54 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

---

**Listing 1: Epson FX-80 procedures in disk file Printpak.pas.**

```pascal
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 i := 0 to down 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
  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 i := 0 to 39 do
    begin
      write(Lst, chr(27), 'Z', chr(n_lo), chr(n_hi));  (* Enter graphics mode; give # bytes coming *)
      for j := 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
        begin
          write(Lst, oddmap[i, j]);  (* print odd row *)
          write(Lst, chr(13));  (* carriage return *)
          write(Lst, chr(27), '3', chr(22));  (* start next line 7/5 dots down *)
          write(Lst, chr(10));  (* linefeed *)
        end;
    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: 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 *)
  end;
end;  (* Change *)

(continued)
```
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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:

\[
\text{Old: } = \text{Old OR M[height]}
\]

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:

\[
\text{Old: } = \text{Old AND R[height]}
\]

Here, R[height] is a byte made up of all zeros except for a 1 in bit height. If Old is 01000010 and height is 7, then Old becomes the byte (01000010 AND 0001110000000000) = 01000010.

If you want to insert a 0 into this same byte, you use the mask R[height] together with the logical AND operation:

\[
\text{Old: } = \text{Old AND R[height]}
\]

Here, R[height] is a byte made up of all zeros except for a 1 in bit height. If Old is 01000010 and height is 7, then Old becomes the byte (01000010 AND 0001110000000000) = 01000010.

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 1/2 dot, which results in a theoretical vertical density of 216 dots per inch. The Prowriter allows 1/2-dot linefeeds, or a vertical density of 144 dots per inch. In the examples in this article, we use the Epson 1/2-dot linefeeds as if they were 1/2-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 1/4 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)
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 1/2 dot but rather works in multiples of 1/5 dot. Since even Epson disclaims any great accuracy for such a tiny linefeed, we tried various combinations such as 1/5 and 7/30, 1/5 and 7/30, etc. The best image seemed to result from using 1/5 and 7/30 (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 I = 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 \( y = x^2 \) (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 \( y = 639 - (x - 25)^2 \). For such a tiny linefeed, we tried various combinations such as 1/5 and 7/30, 1/5 and 7/30, etc. The best image seemed to result from using 1/5 and 7/30 (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 I = 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 \( y = x^2 \) (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 \( y = 639 - (x - 25)^2 \). 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 mod 50) and let \( i \) go from 0 to width. The scale factor \( i \) is \( width/50 \) and \( x \) equals \( i/width \) mod 50. Thus, when \( i \) equals 0, \( x \) is 0; when \( i \) equals width, \( x \) is 50. Then you use Pset to graph your points:

\[
Pset(i, trunc(639 - ((i/width - 25) * (i/width - 25)), 1)
\]

Note that you must truncate (trunc) since Pset requires integer parameters.

**Connecting the Dots**

The procedure Plotcurve draws a curve by computing each point separa-

---

**Listing 3: Program to test printing procedures. It draws a parabola: \( y = x^2 \). Note the $1 directive to include the routines in **Printpak.pas** (see listing 1).**

Program Testcurve;
{$1 printpak.pas} {Include printer procedures listed above.}
var ch: char;
Procedure Plotcurve;
var I, width: integer;
scale: real;
begin {Plotcurve}
width := across - (across mod 50);
scale := 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;
TextStyle(BW80)
end. {Testcurve}
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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, deltax: 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;
      deltax:= 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 + deltax
          else {else}
            begin
              y:= y + b;
              d:= d + deltax
            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}
    end {Case: if dx <= dy}
end {Pixel_Line}
```

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HI-RES PRINTER GRAPHICS

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

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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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<tr>
<td>100 items $ .83 each</td>
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<table>
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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).
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 into 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—are "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 non-sequential, 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 OREQ (output request) line. If it can accept the receiving processor signals on its ACK (input acknowledge) line. The input controller uses...
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 (continued)

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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<th>NEW PRICE</th>
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<td>$495</td>
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<td>4 Mbyte disk emulator for CompuPro 10 Plus</td>
<td>$4500</td>
<td>$2100</td>
</tr>
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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 functional table address whose contents in turn call for the token to be output, that

### Table 1: The μPD7281’s instruction set. A single token may include address-generator-and-flow-controller instructions and processing-unit instructions.

<table>
<thead>
<tr>
<th>Address-Generator-and-Flow-Controller Instructions</th>
<th>Processing-Unit Instructions</th>
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<tr>
<td><strong>Mnemonic</strong></td>
<td><strong>Instruction</strong></td>
</tr>
<tr>
<td>QUEUE</td>
<td>queue</td>
</tr>
<tr>
<td>RDCYCS</td>
<td>read cyclic short</td>
</tr>
<tr>
<td>RDCYCL</td>
<td>read cyclic long</td>
</tr>
<tr>
<td>WRCYCS</td>
<td>write cyclic short</td>
</tr>
<tr>
<td>WRCYCL</td>
<td>write cyclic long</td>
</tr>
<tr>
<td>RDWR</td>
<td>read/write data memory</td>
</tr>
<tr>
<td>RDIX</td>
<td>read data memory with index</td>
</tr>
<tr>
<td>PICKUP</td>
<td>pick up data stream</td>
</tr>
<tr>
<td>COUNT</td>
<td>count data stream</td>
</tr>
<tr>
<td>CONVO</td>
<td>convolve</td>
</tr>
<tr>
<td>CNTGE</td>
<td>count generation</td>
</tr>
<tr>
<td>DIVCYC</td>
<td>divide cyclic</td>
</tr>
<tr>
<td>DIV</td>
<td>divide</td>
</tr>
<tr>
<td>DIST</td>
<td>distribute</td>
</tr>
<tr>
<td>SAVE</td>
<td>save ID</td>
</tr>
<tr>
<td>CUT</td>
<td>cut data stream</td>
</tr>
<tr>
<td><strong>Mnemonic</strong></td>
<td><strong>Instruction</strong></td>
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<tr>
<td>OR</td>
<td>logical OR</td>
</tr>
<tr>
<td>AND</td>
<td>logical AND</td>
</tr>
<tr>
<td>XOR</td>
<td>logical EXCLUSIVE-OR</td>
</tr>
<tr>
<td>AND NOT</td>
<td>logical INVERT first operand then AND [A AND B]</td>
</tr>
<tr>
<td>ADD</td>
<td>add</td>
</tr>
<tr>
<td>SUB</td>
<td>subtract</td>
</tr>
<tr>
<td>MUL</td>
<td>multiply</td>
</tr>
<tr>
<td>NOP</td>
<td>no operation</td>
</tr>
<tr>
<td>ADDSC</td>
<td>add, shift, and count</td>
</tr>
<tr>
<td>SUBSC</td>
<td>subtract, shift, and count</td>
</tr>
<tr>
<td>MULSC</td>
<td>multiply, shift, and count</td>
</tr>
<tr>
<td>INC</td>
<td>increment</td>
</tr>
<tr>
<td>DEC</td>
<td>decrement</td>
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<tr>
<td>SHR</td>
<td>shift right</td>
</tr>
<tr>
<td>SHL</td>
<td>shift left</td>
</tr>
<tr>
<td>SHR BV</td>
<td>shift right with bit reverse</td>
</tr>
<tr>
<td>SHL BV</td>
<td>shift left with bit reverse</td>
</tr>
<tr>
<td>CMPNOM</td>
<td>compare and normalize</td>
</tr>
<tr>
<td>CMP</td>
<td>compare</td>
</tr>
<tr>
<td>CMPXCH</td>
<td>compare and exchange</td>
</tr>
<tr>
<td>GET1</td>
<td>get one bit</td>
</tr>
<tr>
<td>SET1</td>
<td>get one bit</td>
</tr>
<tr>
<td>CLR1</td>
<td>clear one bit</td>
</tr>
<tr>
<td>ANDMSK</td>
<td>mask a word with logical AND</td>
</tr>
<tr>
<td>ORMSK</td>
<td>mask a word with logical OR</td>
</tr>
<tr>
<td>CVT2AB</td>
<td>convert two's-complement to sign-magnitude</td>
</tr>
<tr>
<td>CVTAB2</td>
<td>convert sign-magnitude to two's-complement</td>
</tr>
<tr>
<td>ADJ</td>
<td>adjust long (for double-precision numbers)</td>
</tr>
<tr>
<td>ACC</td>
<td>accumulate</td>
</tr>
<tr>
<td>COPC</td>
<td>copy control bit</td>
</tr>
<tr>
<td><strong>Generate Instructions</strong></td>
<td><strong>Instruction</strong></td>
</tr>
<tr>
<td>COPYBK</td>
<td>copy block</td>
</tr>
<tr>
<td>COPYM</td>
<td>copy multiple</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUT1</td>
<td>output 1 token</td>
</tr>
<tr>
<td>OUT2</td>
<td>output 2 tokens</td>
</tr>
</tbody>
</table>

**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;

... (continued)

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 through ODB18 to IDB through IDB18). 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 an OMA (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 multiprocessor Transputer. The µPD7281 assembler, however, is really quite simple.

The assembler is based on the flowgraph 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 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-
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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-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.
$699 Computer Breakthrough

IBM compatible computer with 128K memory and two disk drives is more than a bargain.

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

First, it is a tremendous bargain. At $699 nothing even comes near. Secondly, it's powerful. You get 128K memory that's expandable to 512K. And finally, it's totally IBM compatible. It will even run the Flight Simulator program and Lotus Symphony. But there's more.

The unit can be used as a stand-alone office computer as shown above or it can be packed up and used as a portable—but without all the weight. There's an optional 16-line x 80 character LCD display that pops up to replace the heavy CRT monitor. Unlike the smaller portable computer keyboards, the Commuter keyboard is a full-size replica of the IBM with its own function keys and LCD key pad. And the Commuter uses 5¼" disks so you have full access to all the popular IBM software.

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.

USE IBM PROGRAMS

Even if you have another computer but miss some of the IBM programs, for only $699 and an IBM compatible monitor, you've got a complete MS/DOS system.

It was also made modular so you can select just those components that you need for your particular application. For example, you may not need the 16-line x 80 column LCD display which adds 2 lbs to the unit's weight (a blank lid comes with the unit). Or you may not need a monitor because your other computer may already have one. But you may want more power—256K or 512K—so you order just what you need.

For all you technical people, listen to these specs. There's a 16-bit 8086 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, sup port 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 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, on-line warranty service and a customer hotline to answer any of your teletype questions.

You may have recently heard of Visual Technology Incorporated. They are innovators in the design and manufacture of smart alphanumeric terminals and some of the finest graphic terminals in the country.

The Visual Commuter was scheduled to sell for over $2500 with the LCD display. And even at that price, when compared to the IBM system, it was a good value. But JS&A and Visual (in a joint venture with SGD Holding Corp.) saw the opportunity of having just one system, it was a good value. But JS&A and Visual (in a joint venture with SGD Holding Corp.) saw the opportunity of having just one customer. Together, by selling directly to you, we've eliminated the distributors, dealers and all the sales, administration and advertising costs and have passed the savings on to you. But there are a few catches.

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 no service centers in 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. Consider using 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 a low cost terminal to the Flight Simulator program. I strongly recommend the system.

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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.
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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
The Data General/One

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...
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.
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).

**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 PCTalk, 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...
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 3¼-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)
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. I may not have 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 12 1/4 by 4 1/4 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 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)
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 TOP 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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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. 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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- 10 switches, selectable for Bell or CCITT standard
- Auto dial, auto answer (tone or pulse)
- Auto line disconnected
- Compatible with Hayes commands
- Speaker with volume control
- Self test
- Call progress detection

SmarTEAM 103/212AT $299
- Fully Hayes compatible support all 20 commands and 5 response. Option switches identical to Hayes.
- Auto dial, auto answer (tone or pulse), auto redial between two phone numbers.
- 2 self test modes (analog loop back and remote digital loop back test).
- Automatically switches between tone and pulse.
- Call progress detection (ringing, dial tone, busy).
- Auto speed selection (0-300, 1200 bps).
- 0-300, 1200 bps. Bell 103, 212A standard.
- 8 status indicators

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### RGB WAVELENGTH

![RGB Wavelength Diagram]

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SEE US AT COMDEX BOOTH 116 & 120
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
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)
REVIEW: MBC-775

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.

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 8¾ inches
Keyboard: 19½ by 7¼ by 1¾ inches
Weight: 39 pounds and 13¼ 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 380K-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,

**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 over¬
shadows 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, pro¬grams 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 docu¬ments 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 MSDOS 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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- Electronics Design Technology
- Industrial Electronics
- Satellite Communications Electronics
- Data Communications
- Telephone Servicing
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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
Table 1: A quick comparison of the five C compilers reviewed, highlighting important features.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Softworks C</th>
<th>Mac C</th>
<th>Aztec C</th>
<th>Hippo-C</th>
<th>Megamax C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claims complete access to ROM</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Type of interface to MAC ROM</td>
<td>glue</td>
<td>direct</td>
<td>direct</td>
<td>glue</td>
<td>glue</td>
</tr>
<tr>
<td>Produces stand-alone Mac programs</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Direct support of desk accessories</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Source code for standard library</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Register variables</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Floating-point math</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Produces assembly code</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>In-line assembly</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Assembler included</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Apple MDS assembler required</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Form of user interface</td>
<td>Mac</td>
<td>Mac</td>
<td>UNIX-like shell</td>
<td>HOS (note 1)</td>
<td>Mac</td>
</tr>
<tr>
<td>Assembly-level debugging aids</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Library manager</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Intelligent linker</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Copy-protected</td>
<td>no</td>
<td>yes (note 2)</td>
<td>yes</td>
<td>yes (note 2)</td>
<td>no</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Softworks C</th>
<th>Mac C</th>
<th>Aztec C</th>
<th>Hippo-C</th>
<th>Megamax C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of CHAR</td>
<td>8 bits</td>
<td>8 bits</td>
<td>8 bits</td>
<td>8 bits</td>
<td>8 bits</td>
</tr>
<tr>
<td>Size of SHORT</td>
<td>16 bits</td>
<td>16/16 bits</td>
<td>16 bits</td>
<td>16 bits</td>
<td>8 bits</td>
</tr>
<tr>
<td>Size of INT</td>
<td>32 bits</td>
<td>32 bits</td>
<td>32 bits</td>
<td>32 bits</td>
<td>32 bits</td>
</tr>
<tr>
<td>Size of LONG</td>
<td>32 bits</td>
<td>32 bits</td>
<td>32 bits</td>
<td>32 bits</td>
<td>32 bits</td>
</tr>
<tr>
<td>Size of FLOAT</td>
<td>32 bits</td>
<td>n.a.</td>
<td>32 bits</td>
<td>n.a.</td>
<td>32 bits</td>
</tr>
<tr>
<td>Size of DOUBLE</td>
<td>64 bits</td>
<td>n.a.</td>
<td>64 bits</td>
<td>n.a.</td>
<td>64 bits</td>
</tr>
<tr>
<td>Size of POINTER</td>
<td>32 bits</td>
<td>32 bits</td>
<td>32 bits</td>
<td>32 bits</td>
<td>32 bits</td>
</tr>
<tr>
<td>Bit fields</td>
<td>no *</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Enumerated types</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Automatic variable initialization</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Structure passing</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Structure assignment</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Extra support function (with source)</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

* 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 Quick-sort 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

Table 3: The results of the benchmark tests and the sizes of the execution files produced.

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Softworks C</th>
<th>Mac C</th>
<th>Aztec C</th>
<th>Hippo-C</th>
<th>Megamax C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Execution Times</strong> (in seconds)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FRAME</td>
<td>Normal 0.13</td>
<td>0.13</td>
<td>0.10</td>
<td>0.25</td>
<td>0.10</td>
</tr>
<tr>
<td>Register 0.08</td>
<td>n.a.</td>
<td>0.05</td>
<td>n.a.</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>POINTER</td>
<td>Normal 24.33</td>
<td>26.60</td>
<td>25.50</td>
<td>33.23</td>
<td>30.02</td>
</tr>
<tr>
<td>Register 11.15</td>
<td>n.a.</td>
<td>13.15</td>
<td>n.a.</td>
<td>18.93</td>
<td></td>
</tr>
<tr>
<td>INTMATH</td>
<td>Normal 30.05</td>
<td>5.10</td>
<td>5.03</td>
<td>15.93</td>
<td>5.05</td>
</tr>
<tr>
<td>Register 26.73</td>
<td>n.a.</td>
<td>2.70</td>
<td>n.a.</td>
<td>2.76</td>
<td></td>
</tr>
<tr>
<td>SIEVE</td>
<td>Normal 8.83</td>
<td>7.98</td>
<td>6.20</td>
<td>12.65</td>
<td>6.20</td>
</tr>
<tr>
<td>Register 4.73</td>
<td>n.a.</td>
<td>3.88</td>
<td>n.a.</td>
<td>4.17</td>
<td></td>
</tr>
<tr>
<td>QSORT</td>
<td>Normal 157.09</td>
<td>63.92</td>
<td>69.43</td>
<td>test failed</td>
<td>93.38</td>
</tr>
<tr>
<td>Register 93.72</td>
<td>n.a.</td>
<td>50.87</td>
<td>n.a.</td>
<td>70.80</td>
<td></td>
</tr>
<tr>
<td>FLOAT</td>
<td>Normal 332.77</td>
<td>268.22</td>
<td>n.a.</td>
<td>334.32</td>
<td></td>
</tr>
<tr>
<td>POINTER</td>
<td>Normal 28.60</td>
<td>31.67</td>
<td>24.72</td>
<td>47.22</td>
<td>25.97</td>
</tr>
<tr>
<td>INTERFACE</td>
<td>Normal 59.18</td>
<td>71.40</td>
<td>56.22</td>
<td>78.47</td>
<td>72.00</td>
</tr>
</tbody>
</table>

**File Sizes** (in bytes for "normal" [non-register] runs)

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Softworks C</th>
<th>Mac C</th>
<th>Aztec C</th>
<th>Hippo-C</th>
<th>Megamax C</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRAME</td>
<td>32,000</td>
<td>10,496</td>
<td>8537</td>
<td>20,992</td>
<td>6544</td>
</tr>
<tr>
<td>POINTER</td>
<td>32,000</td>
<td>10,496</td>
<td>8571</td>
<td>21,044</td>
<td>6586</td>
</tr>
<tr>
<td>INTMATH</td>
<td>32,512</td>
<td>11,008</td>
<td>9109</td>
<td>21,948</td>
<td>7128</td>
</tr>
<tr>
<td>SIEVE</td>
<td>40,448</td>
<td>10,752</td>
<td>16,897</td>
<td>21,318</td>
<td>6768</td>
</tr>
<tr>
<td>QSORT</td>
<td>36,608</td>
<td>11,008</td>
<td>13,113</td>
<td>test failed</td>
<td>7226</td>
</tr>
<tr>
<td>FLOAT</td>
<td>32,256</td>
<td>n.a.</td>
<td>9205</td>
<td>n.a.</td>
<td>7256</td>
</tr>
<tr>
<td>FIB</td>
<td>32,256</td>
<td>10,496</td>
<td>8751</td>
<td>21,304</td>
<td>6810</td>
</tr>
<tr>
<td>INTERFACE</td>
<td>32,256</td>
<td>10,496</td>
<td>8697</td>
<td>21,230</td>
<td>6700</td>
</tr>
</tbody>
</table>
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 OSORT 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 in-
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)
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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REVIEW: C COMPILERS

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 stand-alone 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

Finally, there's a way to stop the proliferation of software in your word processing environment. It's called WordMARC™—the single full-featured word processor that runs an identical program on some 35 different makes and models of computers.

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In addition to being compatible with all kinds of computers, WordMARC also gets along with all kinds of users.

Its documentation is written specifically for the computer system it will operate on. Its self-teaching
REVIEW: C COMPILERS

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 pages.

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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 Tool times. Also helpful is a section titled "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

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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:

**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.

**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.

**MDS is designed**

- to help developers
- cope with writing
- programs conforming
to the user interface.

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** 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.

**RMAKE:** 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, RMAKE is included in MDS. RMAKE 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 RMAKE 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.

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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**SOFTWARE for Macintosh**

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### Listing 5: The INTERFACE benchmark.

```c
/* interface.c */
#include "stdio.h"
#include "Events.h"
#define COUNT 10000
main ()
{ int i, eMask1, eMask2, 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 Is, 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 program.
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 OSORT 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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REVIEW: C COMPILERS

Listing 6: The INTMATH benchmark.

```c
#include "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;
        for (j = 240; j < COUNT) {
            k = (j * (j / k));
        } 
    } 
    #include "done"
}
```

Listing 7: The QSORT benchmark.

```c
#include "stdio.h"
#include "stdlib.h"
define MAXNUM 1000
#define COUNT 10
#define MODULUS ((long) Ox20000)
define C 13849L
#define A 25173L
long seed = 7L;
long random();
long buffer [MAXNUM] = {0};
main() {
    int i;
    long temp;

    for (i = 0; i < COUNT; ++i) {
        j = 240; k = 15;
        for (j = 240; j < COUNT) {
            k = (j * (j / k));
        } 
    } 
    #include "done"
}
```
Most software companies would call it a stroke of luck if they designed a system so effective, it became the small business favorite. We call it a stroke of genius.
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 compiler/assembler/linker/debugger system. The combination of Mac C and MDS gives you a fully integrated software development 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 appendices. 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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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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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 OSORT 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 OSORT 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.

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It was with those seemingly endless hardware hours still fresh in my mind that I 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 frustrating hours later I had the system running alright and I was fairly happy with it.

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**COMPATIBILITY**

If a program runs on the IBM PC, it will run on the Turbo 640. We use DOS III, Lotus and Microsoft Word daily on our PS Turbo 640. In the turbo mode (selected with a keystroke) the increase in program execution speed is immediately evident. Peer to peer system simulation assigns the PS Turbo 640 a processing speed factor of 1.4 in comparison to an IBM PC. That’s 43% 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, Turbo color graphics or high speed, if 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" TTAM. 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 of a PC type computer can usually be 640K - exactly the amount that comes with Turbo 640’s 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.

The PS Turbo 640 system includes a multi function card that will handle four disk drives, has two serial ports, a parallel port, a game port and a battery backed up RAM disk and DOS Basic on an 8000 watt power supply.

**TECH STUFF**

The PS Turbo 640 uses the 8086 2 processor running at a keyboard selectable 5 to 7 or 5 MHZ. The mother board is an extremely well constructed product of Japan. There are 2 bus expansion points and 6 expansion slots (the IBM basic 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.

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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.

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REVIEW: C COMPILERS

Listing 8: The POINTER benchmark.

```c
#include "stdio.h"
#define COUNT 10000
#define ALLOTED 128

main()
{
    char workarea[ALLOTED], *ptr;
    int i;

    #include "startup"
    for (i = 0; i < COUNT; ++i)
    {
        ptr = workarea + i;
        while (ptr < (workarea + ALLOTED))
        {
            ++ptr;
        }
    }

    #include "done"
}
```

Listing 9: The SIEVE benchmark.

```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 (k = i + prime; k < SIZE; k += prime)
                flags[k] = FALSE;
            count++;
        }
    }

    #include "done"
    printf("Number of 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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<th>Microsoft® Word v.2.0</th>
<th>Word Perfect v.4.0</th>
<th>WORDSTAR® 2000 PLUS v.1.01</th>
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<tr>
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<td>Built-in Telecommunications</td>
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<td>Alphabetic And Numeric Sorting Within Document</td>
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<td>&quot;Macros&quot; For Recalling Often Used Command Sequences</td>
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<td>Supports Over 100 Printers</td>
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<td>Experience With Over 1.3 Million Owners</td>
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</table>

This updates and corrects comparisons with MultiMate which appeared previously.
For a complete comparison chart, write: MicroPro, Dept. 3500, 35 San Pablo Ave., San Rafael, CA 94903. Specifications are for the latest released versions of all products effective July 1985. MultiMate is a trademark of MultiMate Corp.; Microsoft is a registered trademark of Microsoft Corp.; WordStar and MicroPro are trademarks of MicroPro International.
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)
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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?

<table>
<thead>
<tr>
<th>Time Required (in minutes)</th>
<th>Frustration Factor</th>
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<tr>
<td>Softworks C</td>
<td>7:27 high</td>
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<tr>
<td>Mac C</td>
<td>7:47 high</td>
</tr>
<tr>
<td>Aztec C</td>
<td>4:07 low</td>
</tr>
<tr>
<td>With RAM disk</td>
<td>0:40 low</td>
</tr>
<tr>
<td>Hippo-C</td>
<td>5:20 medium</td>
</tr>
<tr>
<td>Megamax C</td>
<td>4:16 medium</td>
</tr>
<tr>
<td>DeSmet C on IBM PC</td>
<td>1:20 low</td>
</tr>
<tr>
<td>With RAM disk</td>
<td>0:18 low</td>
</tr>
</tbody>
</table>

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.

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REVIEW: C COMPILERS

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 rescaning 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.

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.

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REVIEW: C COMPILERS

Listing 11: Register version of the INTMATH benchmark.

```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 = (j * (j / k));
        j = (j * (j / k));
        j = (j + j + j + j + j + j + j + j);
        k = (k - k - k - k - k - k - k - k);
        /* test byte-word combinations */
        j = (j << 4); k = (k << 4);
        j = (j * (j / k));
        j = (j * (j / k));
        j = (j + j + j + j + j + j + j + j);
        k = (k - k - k - k - k - k - k - k);
        /* test word-word combinations */
        j = (j << 4); k = (k << 4);
        j = (j * (j / k));
        j = (j * (j / k));
        j = (j + j + j + j + j + j + j + j);
        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
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REVIEW: C COMPILERS

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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Listing 12: Register version of the OSORT benchmark.

```c
/* OSort.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 = ?L;
long rand();
long buffer [MAXNUM] = {0};
main()
{
    int i,j;
    long temp;
    #include "startup"
    printf("Filling array and sorting O/od times \n",COUNT)
    for (i=0; i<COUNT; + +i)
    {
        for (j=0; j<MAXNUM; + +j)
        {
            temp = rand()%MODULUS);
            if (temp < OL)
                temp = ( - temp);
            buffer[j] = temp;
        }
        printf("Buffer full, iteration O/od \n",i);
        quick(lo,MAXNUM , buffer);
    }
    #include "done"
}
quick(lo,hi, base)
int lo, hi;
long base[];
{
```

Compiler, the Softworks compiler had me
anticipating some pretty spectacular
run times for the standard C bench­
mark 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 incompatibili­
ty 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 provi­
sions for automatically opening and
manipulating text windows for dis­
playing standard printf operations. If
you compile and run a standard C
program using Softworks C, be
prepared to see all text placed direct-

(continued)
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President Ashton-Tate Software, “InfoWorld” July 22, 1985

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REVIEW: C COMPILERS

register int i,j;
long pivot, temp;
if (lo< hi)
{
    for (j = lo, i = 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 random(size)
    long size;
    {
        seed = seed * A + C;
        return(seed % size);
    }

Problem 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 negative

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Listing 13: Register version of the POINTER benchmark.

```c
#include "stdio.h"
#define COUNT 10000
#define ALLOTIED 128
main()
{
  char workarea[ALLOTIED];
  register char ptr;
  register int i;
  #include "startup"
  for (i=0; i< COUNT; i++) {
    ptr = workarea;
    while (ptr < (workarea + ALLOTIED)) {
      *ptr = ' ';
      ++ptr;
    }
  }
  #include "done"
  printf("ALLOTIED = \%d \n", ptr-workarea-1);
}
```

The register version of the POINTER benchmark dramatically affects 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 containing

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Listing 14: Register version of the SIEVE benchmark.

```c
/* 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\nFound %d primes.\n", count);
    getchar();
}
```

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
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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

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This miniature RS232 tester is designed to monitor RS232 lines. This tester is very useful in diagnosing RS232 communication problems. There are 7 different colored LED indicator lights to monitor the following functions: Receive Data (RD), Clear To Send (CTS), Data Terminal Ready (DTR), Request To Transmit Data (TT), Request To Send Data (RTS), Data Set Ready (DSR), and Carrier Detect (CD). Ask for the RS232 Mini Tester at your nearest authorized DATA SPEC® dealer.

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All RS232 25 pin switch boxes are available in these configurations: AB-25, ABC-25 and AB-X-25 (Cross Matrix, allows the use of 2 computers and 2 peripherals). Can be switched with IBM PC parallel port, compatible too! It's about time you benefit from high performance at affordable prices! Ask for the 25 Pin Data Switches at your nearest authorized DATA SPEC® dealer.

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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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Xerox knows, as our customers know, that we have an extensive testing program. Here is what we contribute toward giving you the maximum hard disk performance.

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First, we buy the best drives available. Sounds trite, doesn't it? I mean, a drive's a drive—right? Hardly. You should see some of the junk we get in our labs. Some have such high failure rates that we even questioned our own $10,000 hard disk tester. But when we tested other manufacturers' drives we were assured that our equipment was fine, which just confirmed that the bad hard disks were not only bad—they were real bad.

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 documented, the AT's hard disk develops bad tracks later on.

We do what DOS can't

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, XT's, and AT's. 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.

We even include a program that will give you continuous comments on the status of your hard disk. No more waiting for that catastrophic failure.

Average Access Time

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 the 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 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.

More than 32 Megabytes

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 megabyte (formatted) hard disk into two equal volumes of 32 megabytes each.

Reliability

We offer you a choice between iron oxide and platted media—the stuff that covers the hard disk and gives it its magnetic properties. Iron oxide is magnetic—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. Platted 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.
technology, and quite frankly, manufacturers understand it better. Their better understanding, combined with some of the special head locking mechanisms, gives us peace of mind when we sell you one.

**Power**

Hard disks consume power. Our small, half-high hard disks consume so little power that you can use them with your existing IBM PC power supply. If you plan to use lots of slots, you'll want to increase your power supply to be safe. We offer the same amount of power for your PC that comes in the XT.

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Some folks just never feel comfortable buying mail order. They forget that Sears began as a mail order house or that IBM is now into mail order. But, if it helps, here is a partial list of customers who have felt comfortable to buy from us:

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- AT&T (Bell Labs)
- RCA
- Xerox
- Lockheed
- Sperry

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We offer you a one year warranty on our hard disks—the same as IBM on the AT and 90 days on the tape drives. (It's all the manufacturer gives us.) If anything goes wrong with your tape or disk drive or hard disk, send it back in the box it came in. However, we have found that we can usually solve the problem over the phone. So call first for a return authorization number because we can't accept any returns without it.

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### Complete Hard Disk Kits

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<tr>
<th>MB formatted</th>
<th>Height</th>
<th>Plate Media</th>
<th>Average Access</th>
<th>Transfer Rate</th>
<th>PC or PC XT</th>
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<tr>
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<td>1/2</td>
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**Removable Hard Disk**

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<td>26 Mbytes Floppy Tape Subsystem</td>
<td>31</td>
<td>595</td>
<td>$595</td>
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All of our hard disk and tape controllers are available separately: Please call for prices.

### Subsystem Chassis

Any of our disk or tape units are available in an external subsystem for an additional $250.00. You can mix & match any of our 1/4 high hard disks or tape drives together or add any single full height hard disk.

### Tape Cartridges

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### Power Supply

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<tr>
<td>150 Watt Power supply</td>
<td>$125.00</td>
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* Color Boxed GQTY. 100

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**REVIEW: C COMPILERS**

The ROM Toolbox routines using character strings expect the strings to be in Pascal format.

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 each 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 to 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 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 MOS 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.
I realize that what you are about to read may seem incredible. I can understand. But occasionally there are indeed bargains and opportunities that only come once in a lifetime. I'm convinced that this is one of them.

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. A similar printer might be found at some discount computer dealers for as low as $1000. And at that price it is indeed a bargain.

**AUTOMATIC FEATURES**

If we offered it to you at $499—a unit that we could be selling for $1795 and that would be a bargain at $1000—you'd probably think that there was a catch. But guess again. As unusual a bargain as this may appear, and despite all its quality features, this printer can be yours for the incredible low price of only $499—below wholesale, below dealer cost and without question, the lowest priced high-speed letter-quality printer sold today.

JS&A bought out an entire warehouse full of these printers, promised that we would not display the name on the unit, in our phone, 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 own now. 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, 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 continuously until you stop. And the system uses standard Diablo daisy wheels and ribbons which you can get from JS&A or any computer store.

With the Pica pitch, you can print up to 136 columns and with the Elite pitch, up to 163. The 15.5" carriage will take a print area of 13.6 inches. It measures 6 x 16 x 24", comes with a 10-pitch daisy wheel, one ribbon and complete instructions. The unit has provisions for a tractor feed and a sheet feeder which can be purchased locally or at a discount from JS&A.

You can select either 10, 12 or 15 for the print pitch or even use the 10-pitch daisy wheel supplied with the unit at the 12-pitch setting for large and bold letter spacing. There are dip switches which let you customize each printer to any computer with a parallel printer interface. Setting recommendations are supplied for IBM, Apple and other popular computers.

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Magic/L

 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

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)
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 runtime 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-repeat cycle, 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 runtime 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)
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REVIEW: MAGIC/L

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 I 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:

```magic
mgl > INTEGER A B C ; ; LONG D E
```

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: == <> \( \leq \) \( \geq \) \( =0 \) \( <>0 \) \( \geq0 \) \( \leq0 \)
- Assignment operators: := += -= INCREMENT DECREMENT CLEAR SET

Control Structures
- IF ( <condition> ) . . . . ENDIF
- DO <low value> . <high value > LOOP [( <increment>)]
- ITER <count> . . . . LOOP [(<increment>)]

Listing 1: An example of a DEFINE . . . END sequence.

```magic
DEFINE SQUAREIT INTEGER
INTEGER NUMBER ;<input argument declarations>
SOUAREIT : = NUMBER • NUMBER ;<executable code>
END
```

(continued)
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You do not explicitly declare string variables. You store string data in subscripted CHAR arrays:

\texttt{mgl > CHAR CLIENT (10)}

Having declared the variables A and CLIENT, you can now assign values to them:

\texttt{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:

\texttt{mgl > INTEGER A}
\texttt{mgl > A := SQUAREIT (8)}
\texttt{mgl > PRINT A}
\texttt{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

**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.

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BINCOM &lt;file&gt; &gt;</td>
<td>a binary comparison of two files</td>
</tr>
<tr>
<td>COPY &lt;sourcefile&gt;&gt;&lt;destfile&gt;</td>
<td>equivalent of PIP &lt;dest&gt; = &lt;source&gt; directory, same as CP/M CCP</td>
</tr>
<tr>
<td>DIR &lt;filespec&gt;</td>
<td>displays space on current disk dumps file to console in hexadecimal</td>
</tr>
<tr>
<td>DISK</td>
<td>erase, same as CP/M CCP</td>
</tr>
<tr>
<td>DUMP &lt;filespec&gt;</td>
<td>equivalent of PIP currentdr:file = file</td>
</tr>
<tr>
<td>ERA &lt;filespec&gt;</td>
<td>equivalent of PIP file = current dr:file</td>
</tr>
<tr>
<td>GET &lt;file&gt;</td>
<td>equivalent of PIP current:file = file</td>
</tr>
<tr>
<td>MOVE &lt;file&gt;</td>
<td>type, same as CP/M CCP</td>
</tr>
<tr>
<td>REN &lt;oldname&gt; &lt;newname&gt;</td>
<td>displays current I/O byte assignments and possibilities</td>
</tr>
<tr>
<td>TY &lt;file&gt;</td>
<td>used with argument to set I/O bytes</td>
</tr>
<tr>
<td>DEV</td>
<td>used to create new drive selection commands (e.g., MAKE &quot;E:&quot; $SELECT 5)</td>
</tr>
<tr>
<td>LST, PUN, RDR, CON</td>
<td>for a fifth drive</td>
</tr>
</tbody>
</table>

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REVIEW: MAGIC/L

Magic/L comes with a basic dictionary that includes many functions, subroutines, system variables, and other words already defined.

Magic/Ls 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 run-time 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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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-

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"
caroff
; 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
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.

<table>
<thead>
<tr>
<th>2-MHz Z80</th>
<th>6-MHz Z80</th>
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<tr>
<td>FIG-FORTH</td>
<td>16.4 seconds</td>
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<tr>
<td>Magic/L</td>
<td>22.7 seconds</td>
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<tr>
<td>MBASIC</td>
<td>6 minutes 5.2 seconds</td>
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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)
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REVIEW: MAGIC/L

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:

```
    ; REAL FIX FOR MG/L
    DEFINE FIXREAL
    if ( dup ( literal ($tbuf) ) )
    exec ( rvl 2315x )
    endif
```

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 subvocabularys, 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

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 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 I 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.

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**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 AECADD 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 2: The same palette of 256 colors displayed using the Tecmar Graphics Master.

Photo 3: The same palette of 256 colors displayed using the IBM Professional Graphics System.

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 5: The same architectural drawing displayed using the Tecmar Graphics Master board with 16 simultaneous colors at 640- by 480-pixel resolution.

Photo 6: The same architectural drawing displayed using the IBM Professional Graphics System with 256 simultaneous colors at 640- by 480-pixel resolution.
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.

<table>
<thead>
<tr>
<th>Listing A: The primitive commands that should have filled the ellipse with red.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HX</td>
</tr>
<tr>
<td>RESETF</td>
</tr>
<tr>
<td>WINDOW 0,639,0,479</td>
</tr>
<tr>
<td>LUTINT 0</td>
</tr>
<tr>
<td>COLOR 24</td>
</tr>
<tr>
<td>MOVE 320,240</td>
</tr>
<tr>
<td>ELLIPSE 200,100</td>
</tr>
<tr>
<td>AREA</td>
</tr>
</tbody>
</table>

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 LUTNT 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.

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.

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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 cagged 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 Hyflute II ribbon cartridges but will not accept the 1/4-inch taller Hyflute 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 snaps 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)
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. The Juki 6300 printer is the pitch used by Juki for determining its speed specifications. 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.

The primary factors in determining 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

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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 As. Bench 7 consists of 10 spaces followed by 60 As. 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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THE TANDY 1000

The S999 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 print 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.

—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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QUERY 313
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 ARPA-NET 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-168. He bought the HD model, which has a 3½-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.
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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) 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 ARPA NET 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 ARPNET 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 exploring...
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. 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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CHAOUS MANOR

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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Inquiry 148
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 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—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, 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 (continued)
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. 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 280 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 286/280 board. Moreover, 8/16 systems give you a larger workspace and have much faster disk operations. I have a CompuPro 286/SPUZ, a Macrotech 286/280, 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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CHAOE MANOR

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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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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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 keymacro 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 PC-Compatible 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
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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 (continued)

---

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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/SPU2 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 PC-compatible software, and so far I've found none that he won't run. Cross-talk 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 spotty 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, and it's perfectly possible 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. (continued)
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always had an ambiguous attitude to staying away. NCC has companies 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 floppy. 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. Statically 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

(continued)
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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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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 fighters is probably not of much concern.

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 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 ("Computer 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 ran 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 FO0 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 FO0 = BARF, you have to load BARF and store it in FO0." 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 "gooddammit" 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 for program developed at Project MAC."

W. D. Maurer
Washington, DC

Fascinating. Thanks—Jerry

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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 if 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...
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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 onto 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 Leveco 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 (continued)
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According to Webster

loaded applications (with a minimum of application RAM),
you can quickly get to the desktop and back for file dele­
tions, 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 reseting, 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, per­
formance was still pretty mediocre. I won't mention any
names until I've verified it myself, but look for some pos­
sible balloon-popping in future columns.

Incidentally, the Monster Mac runs cooler than a regular
512K-byte Mac. That's because Levco installs a piezo­
electric "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 elec­
tric current is passed through them. The fan is quiet and
apparently never wears out. An interesting note: The firm
that makes the fans to Levco that they had been ap­
proached by Apple many months earlier. Apple was ap­
parently ready to order large quantities of the fan, presum­
ably 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 oper­
ing 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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- Apple Macintosh, 128K RAM, one or more disk drives, printer optional
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 reading 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 300/2400-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 “firms” 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)
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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.

In the case of 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 use what you do need. The Finder could keep track of in memory.

"too much" mass storage—look at all the to-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.

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...
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$1,000) 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 machine 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.
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While the optical-disk technology is fascinating, there are some serious implications, especially in telling an original from a copy. 

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, with metal threads woven into it. Similar or related techniques may be needed for other important documents to ensure against undetectable 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 ARPA/NET/ucup addresses that you've given just don't work, and my replies don't get through. If you've sent me some mail via ARPA/NET/ucup (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 limit 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.

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Well, actually, spelling correctly is as easy as S. You see, after you've completed your document, you need only press S, and Final Draft will check your spelling with its 80,000-word dictionary. Typos need never again become an international incident.

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United
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 compiler). 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)
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)
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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 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 presented with a new menu (see figure 1), 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 your file." 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.

<table>
<thead>
<tr>
<th>C Continue</th>
<th>V Variable</th>
<th>Q Quit execution</th>
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<tr>
<td>S Single step</td>
<td>A Alter data</td>
<td>X Exit Living C</td>
</tr>
<tr>
<td>Z Zoom</td>
<td>T Trace speed</td>
<td>F Function level</td>
</tr>
</tbody>
</table>

The Variable and Alter data options permit inspection or alteration of the

---

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.

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:

\[
\begin{align*}
  a &= b + c; \\
  g &= b + c; \\
  a &= b + c; \\
  a &= b + c; \\
  a &= b + c;
\end{align*}
\]

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.

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Since the monitor and I/O windows are separate, debugging information is clearly distinguished from normal program output.

The 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)
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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:

- `! < 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 pseudo-code 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

...
**NOVEMBER SPECIALS**

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**MODEMS**

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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

SOFTWARE MENTIONED

Information on Living C-Personal can be obtained from:

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(800) 826-2612
Price: $99

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. ■
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Repeating Decimals

Early in our educational career, we all discovered that $\frac{1}{3} = 0.3333\ldots$ (abbreviated to $0.\overline{3}$ in this column) and that $\frac{2}{3} = 0.6$. Some of us went even further and found that $\frac{1}{7} = 0.142857$ and $\frac{1}{11} = 0.09$. While some fractions have terminating decimals ($\frac{1}{16} = 0.0625$), 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 $\pi$ 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 $p_1p_2\ldots p_k$, where the $p_i$ 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 $\frac{1}{7}$ has a 6-digit cycle. If we divide out $\frac{1}{17}$, we find a 16-digit cycle: $0.0588235294117647$. Similarly, we see that $\frac{1}{19}$ has an 18-digit cycle: $0.052631578947368421$. Boldly, then, we conjecture that for any prime $p$, the decimal of $\frac{1}{p}$ will have $p-1$ digits in its cycle. But we are wrong—we overlooked two earlier examples: $\frac{1}{3} = 0.\overline{3}$ and $\frac{1}{11} = 0.\overline{09}$.

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 ($\frac{1}{88} = 0.011364. \frac{1}{75} = 0.013$). These decimals are called late repeaters. If we express these denominators as $2^a5^b\ldots p_k\ldots$, the length of the delay will equal either $a$ or $b$, whichever is larger (sound familiar?). For example, $\frac{1}{88} = 2^2\times5^1\times11$, so the cycling portion begins after the first three digits. Further, in the simple case where the denominator can be expressed as $2^a5^b\ldots p_k\ldots$, the length of the delay will equal the length of the cycle of $\frac{1}{p}$ (for example, $\frac{1}{88}$'s cycle length equals the cycle length of $\frac{1}{11}$).

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 $\frac{1}{13}$, 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, 4, 5, 6, 7, 8, 9, 10, 11, 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. (continued)
Table 1: The first four steps in turning 1/13 into a decimal number.

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<td>0.076</td>
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Listing 1: A program to calculate the cycle for repeating decimals.

```plaintext
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 'DIGIT' KEEPS TRACK OF THE DECIMAL PLACE OF THE TERM.
170 DIGIT=0
180 REM 'DIVIDEND' HOLDS THE VALUE OF EACH REMAINDER TIMES
190 DIVIDEND=TERM(DIGIT)*DENOMINATOR
200 REM 'NEW.REMAINDER$' WILL BE SET TO 'NO.'
210 REM WHEN WE'VE SEEN A REMAINDER BEFORE, NEW.REMAINDER$=
220 REM '= "YES"
230 REM 'DIGIT' KEEPS TRACK OF THE DECIMAL PLACE OF THE TERM.
240 REM 'DIVIDEND' HOLDS THE VALUE OF EACH REMAINDER TIMES
250 REM 'TERM' HOLDS THE VALUE OF EACH DIGIT IN THE DECIMAL.
(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 I (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 \(\text{TERM}\), 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 \(\text{REMAINDER}\), 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, \(\text{REMAINDER}(1)\) will be set equal to 1. Remainder 10 was used to calculate the second term, so \(\text{REMAINDER}(10)\) = 2, etc. When the remainder finally equals one we have had before, as indicated by the relevant \(\text{REMAINDER}\) element being nonzero, the contents of the \(\text{TERM}\) array are printed out and the beginning of the cycle (the term denoted by the contents of \(\text{REMAINDER}(\text{REMAINDER})\) 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 \(\text{REMAINDER}\) 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.
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---

**DECIMAL CYCLES**

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 ";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 (0.002457). 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 = 0.076923, 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.
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DECIMAL CYCLES

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 $42 = 7^2 \times 6$ and $294 = 7^2 \times 6$. Similarly, $1/11$ has a 2-digit cycle; its square, $1/121$, has an 11-digit cycle; and its cube, $1/1331$, has a 242-digit cycle ($242 = 11^2 \times 2$); and its fourth power, $1/14641$, has a 2662-digit cycle ($2662 = 11^3 \times 2$). 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

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.

<table>
<thead>
<tr>
<th>0.01</th>
<th>0.011235955056... = 1/89</th>
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</table>

Table 3a: The algebraic method of converting repeating decimals to the corresponding fraction, demonstrated for 0.123.

1. Let $x =$ the repeating decimal $x = 0.123123123...$
2. Multiply 1. by 1000 (this time) $1000x = 123123123...$
3. Subtract 1. from 2. $999x = 123$
4. Solve for $x$ and reduce $x = 123/999 = 41/333$

Table 3b: The method of table 3a applied to the late-repeating decimal 0.1327. 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 $x = 0.13272727...$
2. Multiply 1. by 100 (this time) $100x = 13.272727...$
3. Subtract 1. from 2. $99x = 13.14$
4. Solve for $x$ and reduce $x = 13.14/99 = 1314/9900 = 73/550$
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a few suggestions. First, a decimal with a long cycle, like 1/1861, may be a convenient source of pseudo-random 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 numbers in the Fibonacci sequence, can we exploit this information to retrieve the nth term 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 0.123 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-cycle power (in the example, the cycle length is 3, so multiply both sides of the equation by 10³ 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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The C Programming Guide (Purdum, Que Corp.). $20.00

This best seller walks you through the C language in an easy-to-read manner. All aspects of the language are covered with plenty of examples. Many of the error messages issued by the Eco-C88 compiler have page numbers that reference this book making the compiler and book perfect for the beginning C programmer.

The C Self-Study Guide (Purdum, Que Corp.). $17.00

This new book is designed for the individual that is learning C on their own. The book is filled with questions-answers and many examples about C and illustrates many of the tips, traps, and techniques in C that may take years to learn otherwise. Although written to complement the Guide, it can be used with any introductory C text.

The C Programmer's Library
(Purdum, Leslie, Stegemoller, Que Corp.). $20.00

This best seller is an intermediate text designed to teach you how to write functions in a generalized fashion. The book contains many useful library additions, including a complete ISAM file handler, plus sections on several advanced C topics.

CED Program Editor. $29.95

You're gonna love CED (pronounced "said"). It was written specifically for use with the Eco-C88 compiler. (CED creates a programming environment similar to that of Turbo Pascal.) You create the source file with CED, compile the program and, if there are any errors, CED automatically reloads the source file and places the cursor on the offending section of code. CED also has windows for editing multiple files, macro capability, and is configurable to suit your needs. CED is fast and has many features found only in editors costing up to ten times as much. Perfect for use with Eco-C88.
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 CPMSYS. 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)
the keyboard, screen, and other peripheral chores. But for some reason, the FM-16B 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-16B, 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-16B 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 just for less than $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 10-megabyte hard-drive disk that replaces the hottest 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-16B 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 of 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-16B 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)
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 any-
how. 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 caved 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.

DETERMINE 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 DNA/RNA 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 writings 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 through a small dictionary of dozens of domain 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 textbases, and by that blithering swill they named Al and palindrome.

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.

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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 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 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.
Store this in your memory: buy two packs of Xerox Floppy Diskettes and get one pack free.

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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:

Glitchs?

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

DESPERATELY SEEKING SWITCH

Dear Steve,

In "Understanding Linear Power Supplies" in the January BYTE, you mention using a thermostat 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

Dig-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,

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 KLEINBERG
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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NUMBER SMASHER ™ The World’s Fastest Accelerator Card for the IBM PC, XT, and Compatibles! Increases the clock speed of the 80287 from 4 to 8 mhz. Our NUMBER SMASHER ™ includes 512K ram. It will run the IBM PC at clock speeds up to 10 mhz and achieves a throughput of 1 megaflops with 87BASIC/INLINE, Intel Fortran, or Microsoft Fortran. Software reviewers consider MicroWay software as the best in the industry! Our customers frequently write to thank us for recommending the correct software and hardware to meet their specific needs. They also thank us for our same day shipping! In addition to our own products which support the 807, and 80287, we stock the largest supply of specialized software anywhere. For information call us at 617-746-7341

FASTBREAK ™. MicroWay’s software turns on your 8087 during 1-2-3™ execution. Recalculations run up to 36 times faster. When used with the NUMBER SMASHER ™ it can provide a total increase in 1-2-3™ execution speed of up to 79 to 1. FASTBREAK™ provides you with the unique capability for running other programs on top of 1-2-3™. These programs can be written in BASIC, PASCAL, Fortran C and can access the current values in your 1-2-3™ worksheet...

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256K CMOS RAM Set...
$39
128K RAM Set PC AT...
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AST Advantage...
$439
JRAM-2 ™ (9K)
$169
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For IBM Assembler guidelines and compatibility with various operating systems, please contact your nearest MicroWay representative or MicroWay’s toll-free number.

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Dasher/One from Data General

Data General's Dasher/One workstation provides an MS-DOS environment for the company's CEO (Comprehensive Electronic Office) products. MS-DOS support lets the machine run applications software written for the IBM PC.

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 3 1/2-inch floppy-disk drive with an optional second floppy disk or a 3 1/2-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.

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 3 1/2-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 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.


(continued)
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Innovation in microcomputer products
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 512 K 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 13¾ 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 OSX 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's ID-4801 EPROM programmer kit.

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.

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. You can set 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.


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 set 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 VT102; 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)
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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.

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 FOCI 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 FOCI 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 FOCI plug-in card costs $249. The FOCI-K kit, available for $750, contains two FOCI 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
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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 $279.5. 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 633.

**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 Ile 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 Ile 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 Ile line. It lets you create pictures, graphs, and charts in 16 colors and 30 patterns.

The Color Enhancer with Dazzle Draw for the Apple Ile is $179.95; the same package for the IIC is $129.95. The Ile 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-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 predefined 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)
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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.

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 VHSCC 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 636.

Thai/English Word Processor

Duanglan 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.

Duanglan is $197.50 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 637.

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.
WHAT'S NEW

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 exponential 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 1167, 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

S tats 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 SoftWare Tools, POB 8751, Boise, ID 83707, (208) 343-1437.

Inquiry 645.

(continued)
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-, NSC80-, 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, MPM, 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: Tbase, a database manager; TWriter, a text formatter. The chip plugs into the Tandy 100 and 200 and the NEC PC-8201.

Tbase lets you design relational databases and set up screen files. The program performs math computations and can borrow information from fields in other databases.

TWriter 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 TMerge 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. Inquiry 649.
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HOT NEW PRINTERFACER 1™ - Print buffer I/O Board. Up to 1 Meg, RAM on board. Looks as/works with Interfacer 3/4. Single or Multiluser/Interrupt driven or polled. Super-slick design handles one serial, one parallel, BOARD software switchable. Also for Zenith and Alpha. Intro Price — $349.

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<td>CPU 68K - $359</td>
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<td>Super Sale - M-Drive/H - $229</td>
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<td>FD-100 Reflash - $249</td>
<td>Interfacer 3 - $429</td>
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<td>Enclosure 2 Desk - $369+</td>
<td>Interfacer 4 - $299</td>
<td>System Support 1 - $299</td>
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<td>Concurrent DOS 8-16 (CCT/MX) - $309</td>
<td>CP/M 80 (CCT/MX) - $125</td>
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<td>CPU 80/16 - (CCT/MX) - $199</td>
<td>CP/M 68K (CCT/MX) - $279</td>
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<td>16 Bit Upgrade Kit: CPU/M 86, RAM 23, Support 1 Cable $649</td>
<td>CP/M 86-16 Kit - $673</td>
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CCT-1 ENTRY LEVEL S-100 BUSINESS SYSTEM

| Enclosure 2-Desk-21 Slot Mainframe | $3,150 |
| CPU-2 - 2.6 Mhz Z-80 CPU Board | |
| Disk 1A - DMA Floppy Disk Controller | |
| RAM 23 - 64K Static RAM - 12Mhz | |
| Interfacer 4-3 Serial/2 Parallel I/O | |
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NOVEMBER 1985 • BYTE 469
Introuducing 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 "suck." Just saying that quality control was poor would be charitable.

So much was wrong that DISK WORLD wouldn't sell them.

That was yesterday.

Keeney-National Inc., a $200-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.

Here's what you get.

Wabash Pinnacle diskettes are:

- certified 100% Error-Free
- are covered by a LIFETIME WARRANTY
- meet or exceed all industry specifications (by quite some distance)
- 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.

But I took a box and, 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 Rostenthal 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 mett) ... and then formatted, booted and ran on his Apple.

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 than anyone else in the world.

If, as President of the corporation, won't tolerate a product with a failure rate of more than 1/10000 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 a 1-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 "supposedly" selling 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

The 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" image, while 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. "Discarrier 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 1/10000 of 1% reject/return rate. Next to garbage, this is the source of most diskettes advertised at a dollar or less.

2. The people who buy "cosmos"... stuff from major manufacturers that usually hits that 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 1/10000 of 1% reject/return rate. Next to garbage, this is the source of most diskettes advertised at a dollar or less.

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 buy 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.
When choosing a POWER SUPPLY for your PC, XT, AT or Compatibles please consider this...

"All look-alike supplies come with some type of warranty, only Fortron's power supplies come with a guarantee backed by a full U.L. rating. Your PC represents a substantial investment, so warranty, only Fortron's power supplies come with a guarantee backed by a full U.L. rating. Your PC represents a substantial investment, so when for a few dollars more you can have the confidence of Fortron quality, it makes sense to risk costly downtime due to bargain power supplies, when for a few dollars more you can have the confidence of Fortron quality."

Trust in Fortron quality without compromise.

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<table>
<thead>
<tr>
<th>IBM PC, 256K, One Half Height 320K Disk Drive DS/DD, Persyst Color Card With Printer Port, Taxan Green Monitor, DOS 2.1, PLUS a 10MB Hard Disk Sub System All For:</th>
<th><strong>$2599.</strong></th>
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<tr>
<td>IBM PC, 256K, Two Half Height Drives DS/DD, Persyst Color Card With Printer Port, Taxan Green Monitor, DOS 2.1, 130 Watt Power Supply PLUS a 10MB Hard Disk Sub System All For:</td>
<td><strong>$2899.</strong></td>
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<tr>
<td>IBM PC, 256K, Two Half Height Drives DS/DD, Persyst Color Card With Printer Port, Taxan Green Monitor, DOS 2.1, 130 Watt Power Supply, 10MB Hard Disk Sub System, PLUS 10MB Tape Back Up System All For:</td>
<td><strong>$3499.</strong></td>
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<tr>
<td>IBM PC, 256K, Two Half Height Drives DS/DD, Persyst Color Card With Printer Port, Taxan Green Monitor, DOS 2.1, 130 Watt Power Supply, 20MB Hard Disk Sub System All For:</td>
<td><strong>$3299.</strong></td>
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**PRINTER ADAPTERS**

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<td>NEC PINWRTWR 80 COL</td>
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**MONITORS**

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<td>AMDEK 310 Amber W/TTL Plug</td>
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<td>PGS MX-12</td>
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<td>PGS SR-12</td>
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<td>TAXAN #440 COLOR MONITOR</td>
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<tr>
<td>IBM MONOCHROME DISPLAY</td>
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<td>IBM COLOR DISPLAY</td>
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**CONQUEST PC TURBO 256K Two Half Height Drives, Floppy Disk Controller 135 Watt Power Supply, Serial Port, Parallel Port (IBM Standard), Enhanced Keyboard, Monochrome or Color Adapter with Green or Amber Monitor All for:**

- **Above System With 10MB Internal Hard Disk:** **$1545.**
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- **With 40MB Internal Hard Disk:** **$2840.**

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**SPECIAL 13" RGB MONITOR**

| COMREX 6600 | **$169.00** |

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**HARD DISKS**

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We warehouse 60,000 items at American Design Components — expensive, often hard-to-find components for sale at a fraction of their original cost! You'll find every part you need — either brand new, or removed from equipment (RFE) in excellent condition. But quantities are limited. Order from this ad, or visit our retail showroom and find exactly what you need from the thousands of items on display.

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Originally designed for use in Atari coin-operated games. Contains a 19" (UP22) 3-gun color tube, focus and brightness controls. Has electromagnetic deflection and solid state circuitry with three "Z" amp inputs (red, green, blue). Ideal for arcade replacement or, with the addition of external circuitry, for color television. Takes standard 8 1/2" x 11" paper.

DIMENSIONS: 5"W x 31/4"H x 4" deep

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Precision steppers with increments as low as 500 steps.

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<th>Step</th>
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<td>1 Mitsubishi</td>
<td>$14.95</td>
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COMPUTER & GAME CONTROLLERS (Set of 4)

- 12-digit keyboard and joystick, originally used in computer and games, includes all original components with 9-pin connector.
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Super Disk Diskettes

NOW...Diskettes you can purchase without the hassle of ordering!

Super Disk Inc. offers you diskettes directly from their manufacturing plant. With our efficient warehouse facilities, your order is processed within hours! Now you can buy Super Disk brand diskettes from Communications Electronics Inc., a name brand producer at super computer prices.

NOW...NAME BRAND QUALITY AT SUPER LOW PRICES

Super Disk diskettes are packed 10 disks to a carton and 10 cartons to a case. The economy bulk pack is packaged 100 disks to a case without envelopes or labels. For best value, you should order in increments of 100 diskettes. All diskettes are immediately available from Super Disk. With our efficient warehouse facilities, your order is normally shipped in less than a day.

39¢ per disk Quantity One

Our diskettes are packed 10 disks to a carton and 10 cartons to a case. The economy bulk pack is packaged 100 disks to a case without envelopes or labels. For best value, you should order in increments of 100 diskettes. All diskettes are immediately available from Super Disk. With our efficient warehouse facilities, your order is normally shipped in less than a day.

Super Disk diskettes are 100% surface tested. At Super Disk, we have the lowest possible diskette error rate to make sure you get a reliable diskette every time you use one.

How They Made the Best Diskettes Even Better

The management of Super Disk diskettes then hired all the top brains in the diskette industry to make the Super Disk diskette. Then these top bananas (sometimes called floppies from their rounded shape) stand out in the quality and dependability. Super Disk is a name you can trust because they've hired the remaining "magnetic media moguls" from competitors around the world. They are all world class, top-dollar engineers, physicists, research scientists and production experts. Super Disk is a name you can trust because they've hired the remaining "magnetic media moguls" from competitors around the world. They are all world class, top-dollar engineers, physicists, research scientists and production experts (if they've missed you, send your resume to Super Disk) were given one directive...to pool all the manufacturing know-how and create a new, better diskette.

How Super Disk Diskettes are Manufactured

The Super Disk crew then assembled the newest, totally quality monitored, automated production line in the industry. Since the manufacturing equipment at Super Disk is new, it's easy for Super Disk to consistently make better diskettes. You can always be assured of ultra-tight tolerances and super dependability when you use Super Disk diskettes. If you're looking for a new, better diskette, this is the one you want.

Super Disk diskettes will:

1. TOTAL SURFACE TESTING - For maximum reliability, and to lessen the likelihood of disk errors, all diskettes are tested completely at Super Disk. Then, when you purchase a diskette, you're guaranteed to receive a reliable diskette.

2. COMPLETE LINE OF PRODUCTS - For diskettes that are easy to use, our company has designed a line of diskettes specifically for your computer. Super Disk has an entire line of diskettes that are compatible with your computer.

3. SPECIAL LUBRICATED DISK - Super Disk uses a special oxide lubricant which is designed to provide the optimum performance of your diskette. This gives you a better diskette, more reliability and longer diskette life.

4. HIGH TEMPERATURE/LOW-MARRING JACKET - A unique high temperature and low-marring vinyl jacket allows you to operate this equipment. Since most manufacturers use high temperature and low-marring vinyl jackets, they are compatible with all industry standards for reliability.

5. REINFORCED HUB RINGS - Standard on all Super Disk mini-diskettes, to strengthen the center hub of the diskette. This increases the life of the diskette by reducing wear and tear.

6. DISK DURABILITY - Super Disk diskettes are constructed with industry standards for reliability. They are built to last longer. Now you can buy diskettes that will last you more than 75% of the original signal amplitude remaining even after an average (Weibull-B of 50) of 30 million passes. They are compatible with all industry specifications as established by ANSI, ECMA, ISO, IBM and JIS.

7. SINGLE SIZED PACKAGING - Super Disk diskettes are packaged 10 disks to a carton and 10 cartons to a case. The economy bulk pack is packaged 100 disks to a case without envelopes or labels.

8. LIFETIME WARRANTY - If all else fails, remember, all diskettes sold by Super Disk Inc. have a lifetime warranty. If any Super Disk diskette fails to meet factory specifications, Super Disk Inc. will replace them under the terms of the warranty.

9. SUPERS DURABILITY - With Super Disk's automated production line, high-quality, error-free diskettes are yours without the high cost.

Order toll free 800-USA-DISK

NOW...NAME BRAND QUALITY AT SUPER LOW PRICES

Now you can buy Super Disk brand diskettes directly from Communications Electronics at prices less than "unbranded" generic diskettes. Your data is valuable, so why take chances using a diskette that could be so unreliable that the manufacturer refuses to put their name on it? To them, you are just one more dollar. You can buy Super Disk diskette product where all diskettes are packaged in the same box without envelopes or labels. Since we save packaging costs, these savings are passed on to you. Diskette envelopes are also available from us. These superstrong and tear resistant envelopes are only 8¢ each. Use order # EV-5 and specify the quantity of 5" diskette envelopes that you want.

SAVE ON SUPER DISK™ DISKETTES

Product Description Part # Regular Price per disc Price per disc

- Super Disk™ 49¢
- Super Disk™ 99¢
- Super Disk™ 1.99

SAVE ON SUPER DISK™ DISKETTES

Product Description Part # Regular Price per disc Price per disc

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To get the fastest delivery of your diskettes, phone your order directly to us. If you're interested in ordering, we'll charge it to your credit card. Written purchase orders are accepted from approved government agencies and most well rated firms at a 10% surcharge for net 10 billing. For maximum savings, your order should be prepaid. All sales are subject to availability, acceptance and verification. All sales are final. All prices are in U.S. dollars. Prices, terms and specifications are subject to change without notice. Out of stock items may be placed on backorder or substituted for equivalent product unless we are instructed differently. A $5.00 additional handling fee will be charged for all orders with a minimum order total under $50.00. All shipments are F.O.B. Communications Electronics Inc., Ann Arbor, Michigan. COD terms are available, in U.S. UPS areas for $5.00 extra, and are payable with cash or certified check. Michigan residents add 4% sales tax.

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Mail orders to: Communications Electronics Inc., Box 1045, Ann Arbor, Michigan 48106-1045 U.S.A. If you have a Visa or Master Card, you may call and place a credit card order. Order toll-free in the U.S. Dial 800-USA-DISK. In Canada, order toll-free by calling 800-CA1-DISK. If you are outside the U.S. or in Michigan dial 313-973-8888. Telex anytime 810-223-2422. Order your Super Disk diskettes now.

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Fully assembled and tested Mega Board with 256 K RAM. Mega board is 100% hardware compatible and the capacity for a full Mega Byte on Board.

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Complete Users Manual—fully illustrated

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130 Watt/ Switching

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- $4.00

**Monitor Stand TILT & SWIVAL** $13.44

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  - **97¢ ea.**
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These are poly-bagged diskettes packed with Tyvek sleeves, reinforced hubs, user identification labels and write-protect tabs. Nashua Corporation is a half-billion dollar corporation and a recognized leader in magnetic media.

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$1.36 ea. — 5.25” SSDD with FREE Flip ‘n File 15
5.25” DSDD with FREE Flip ‘n File 15...

**100% LIFETIME WARRANTY!**

This is a Super Special Promotion. It was supposed to end May 31, 1985.

But we decided to buy more than 1,000,000 3M diskettes packed in the FREE Flip ’n File 15... and give you the benefits of this terrific value.

One word of warning: this offer is limited only to supplies on hand. Once this inventory is gone, that’s it. The prices stay the same... but there’s no FREE Flip ‘n File.

The last time we ran an offer like this, everything sold out in about six weeks.

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## PRINTERS

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<th>Brand</th>
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## PRINTER ACCESSORIES

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## DISPLAY MONITORS

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## COMPUTER ACCESSORIES

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<td>$425</td>
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</table>

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VOLTAGE REGULATORS

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We will try to BEAT
All Competitor's Prices
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DISC CONTROLLERS

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CRT CONTROLLERS

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UV ERASERS

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51/4" Diskettes

NO LABEL: (25 per package)

- 2-YEAR WARRANTY ON ALL BULK DISSERTES.

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The incredible savings offered by Priority One settles the issue of who gives the best value for your diskette dollar.

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### 5¼" Double Density 48 TPI

<table>
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<th>Part Number</th>
<th>Description</th>
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<th>100 or More</th>
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<td>$13</td>
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In the course of selling more than a million diskettes every month, we've learned something: higher prices don't necessarily mean higher quality.

In fact, we've found that a good diskette manufacturer simply manufactures a good diskette... no matter what the price is! (By way of example, consider that none of the brands that we carry has a return rate of greater than 1/1,000th of 1 percent!)

In other words, when people buy a more expensive diskette, they aren't necessarily buying higher quality. The extra money might be going toward flashy advertising, snazier packaging or simply higher profits. But the extra money in a higher price isn't buying better quality. All of the good manufacturers put out a good diskette. Period.

How to cut diskette prices... without cutting quality.

Now this discovery posed a dilemma: how to cut the price of diskettes without lowering the quality. There are about 85 companies claiming to be "diskette" manufacturers. Trouble is, most of them aren't manufacturers. Rather they are fabricators or marketers, taking other company's components, possibly doing one or more steps of the processing themselves and pasting their labels on the finished product.

The new Eastman Kodak diskettes, for example, are one of these. So are IBM 5½" diskettes. Same for Dysan, Polaroid and many, many other familiar diskette brand names. Each of these diskettes is manufactured in whole or in part by another company!

So, we decided to act just like the big guys. That's how we would cut diskette prices... without lowering the quality.

We'd go out and find smaller companies to manufacture a diskette to our specifications... specifications which are higher than most... and simply create our own "name brand" diskette. Name brand diskettes that offered high quality at low prices.

Super Star Diskettes. You already know how good they are. Now you can buy them... cheap.

Well, that's the story. Super Star diskettes don't roll off the boat from Pago-Pago or emerge from a basement plant just east of nowhere.

Super Star diskettes have been around for years... and you've used them for years as copy-protected software originals. Sometimes, depending on what computer you own, the system master may have been on a Super Star diskette. And maybe more than once, you've bought a box or two of Super Star diskettes without knowing it. They just had some "big" company's name on them.

Super Star Diskettes are good. So good that a lot of major software publishers, computer manufacturers and other diskette marketers buy them in the tens or hundreds of thousands.

We buy them in the millions. And than we sell to you. Cheap.

When every little bit counts, it's Super Star Diskettes.

You've used them a hundred times... under different names.

Now, you can buy the real McCoy, the same diskette that major software publishers, computer manufacturers and diskette marketers buy... and call their own.

We simply charge less.

Super Special!

Order 50 Super Star Diskettes and we'll be happy to sell you an Amray Media-Mate 50 for only $8.75, shipping included... a lot less than the suggested retail price of $15.95.

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The Super Star LIFETIME WARRANTY!

Super Star Diskettes are unconditionally warranted against defects in original material and workmanship so long as owned by the original purchaser. Returns are simple: just send the defective diskettes with proof of purchase, postage-paid by you with a short explanation of the problem and we'll replace them. (Incidentally, coffee stained diskettes and diskettes with staples driven through them don't qualify as "defective").

WE WILL MEET OR BEAT ANY NATIONALLY ADVERTISED PRICE ON THE SAME PRODUCTS AND QUANTITIES SUBJECT TO THE SAME TERMS AND CONDITIONS.

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  - Portable (2) Drive 256K: $1875
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    - Max 12E: $160
    - HX-9: $429
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    - SR-12 w/Doubler Card: $789
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    - Color Monitor: New Monochrome Monitor: $Call

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  - Mitsubishi 4851: $84
  - Tandon TM 100-2: $84
  - CDC 9409: $84
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  - Promodem 1200A: $309
  - Promodem 1200B: $275
- **Anchor**
  - Mark 12: $218
  - Express: $299

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- **Micromax**
  - Viewmax, 80 Column: $135
  - Viewmax 80E, 80 Column w/ 64K, IEE: $119
- **Orange Micro**
  - Grappler: $85
  - Grappler + Buffered w/ 64K: $155
- **Micro SCI**
  - 80 Column Card 64K: $89

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LETTER QUALITY
F-10 DAISY WHEEL PRINTER

$199

The TEC F-10 Daisy Wheel printer is the perfect answer to a reasonably priced 40 character word processing printer. While this printer is "extremely" similar to a Linotype 10/40 Starwriter printer. Legal firms for the C-Linth Company have advised us that we should refrain from referring to the TEC printer as a Starwriter. This 40 character per second printer is a word processor that can be used in word processing functions that allow ease adaptability and reduced software complexity. Industry standard Centronics interface provides instant compatibility with all computers equipped with a parallel 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 arrangement 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.

FREE PROBE

California Digital is offering this S-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 instantaneous logic level indications. To receive your FREE Logic Probe your order must be placed by MAIL before...

DUAL SHUGART SUBSYSTEM

$239

The dual Shugart subsystem features two SA686 (98 sp) 5 ½ double sided disk drives. Also supplied within the subsystem is 50 watt power supply and a shielded signal cable.

TEAC 55B 48 TPI

One Two Ten

Five Inch Double Sided Drives

TEAC FD55B half height
98 95 89
TEAC FD55B 95 TPI, half height
119 115 109
CONTROL DATA 9409 PC
169 159 155
SHUGART SA455 Half Height
99 95 89
SHUGART SA455 465 ½ HT, 96TP
95 95 89
TANDON 100-2 full height
129 125 119
TANDON 101-4 96TPI full height
199 195 189
MITSUBISHI 485 ½ HT, 96 TPI
139 135 129
MITSUBISHI 485 465 TPI, half height
152 149 141
MITSUBISHI 48548 96 elec.
295 285 275
QUITE 142 half height
110 105 99

Eight Inch Single Sided Drives

SHUGART 801R
119 115 109
SIEMENS FDD 100-8
239 235 231
TANDON 846-1 Half Height
369 359 349

Eight Inch Double Sided Drives

SHUGART SAB51R
495 485 475
QUITE 842 "QUITE TRACK" 8
319 315 313
TANDON 846-2 Half Height
459 447 435
REXÈF RFD-4000
219 215 209
MITSUBISHI 82896-63 ½ HT.
459 449 439

PRINTERS

MATRIX PRINTERS

Saw Gemma 2201 100 characters
259 255 251
Saw Gemma 2201 100 chars, 11 ½ in.
289 285 281
Saw Gemma 2250 120 Char/sec
299 295 291
Codito 5448 3300 TPI, 11 ½ in.
299 295 291
Orchid 1250 series, single platen, 11 ½ in.
359 355 351
Orchid 1254 series, single platen, 11 ½ in.
379 375 371
Epson LX-800, 240 TPI, single platen, 9 in.
399 395 391
Epson LX-800, 330 TPI, single platen, 11 ½ in.
409 405 401
Epson LX-800, 480 TPI, single platen, 11 ½ in.
419 415 411
Epson LX-800, 600 TPI, single platen, 11 ½ in.
429 425 421
Epson LX-800, 960 TPI, single platen, 11 ½ in.
439 435 431
Epson LX-800, 1200 TPI, single platen, 11 ½ in.
449 445 441
Compo 6400 3000 char/sec, 12 in.
469 465 461
Compo 6500 6000 char/sec, 12 in.
499 495 491

WORD PROCESSING PRINTERS

Spectra PrintMaster 600
499 495 491
Spectra PrintMaster 1200
529 525 521
Spectra PrintMaster 1200, double platen
559 555 551
Spectra PrintMaster 1600, double platen
589 585 581
Spectra PrintMaster 2000, double platen
619 615 611
Spectra PrintMaster 2400, double platen
649 645 641
Spectra PrintMaster 3000, double platen
739 735 731
Spectra PrintMaster 3200, double platen
769 765 761
Spectra PrintMaster 4000, double platen
829 825 821
Spectra PrintMaster 5000, double platen
899 895 891
Spectra PrintMaster 6000, double platen
959 955 951
Spectra PrintMaster 7000, double platen
1019 1015 1011
Spectra PrintMaster 8000, double platen
1079 1075 1071
Spectra PrintMaster 9000, double platen
1139 1135 1131
Spectra PrintMaster 10000, double platen
1279 1275 1271
Spectra PrintMaster 11000, double platen
1339 1335 1331
Spectra PrintMaster 12000, double platen
1399 1395 1391
Spectra PrintMaster 13000, double platen
1459 1455 1451
Spectra PrintMaster 14000, double platen
1519 1515 1511
Spectra PrintMaster 15000, double platen
1579 1575 1571
Spectra PrintMaster 16000, double platen
1639 1635 1631
Spectra PrintMaster 17000, double platen
1699 1695 1691
Spectra PrintMaster 18000, double platen
1759 1755 1751
Spectra PrintMaster 19000, double platen
1819 1815 1811
Spectra PrintMaster 20000, double platen
1879 1875 1871
Spectra PrintMaster 21000, double platen
1939 1935 1931
Spectra PrintMaster 22000, double platen
Spectra PrintMaster 23000, double platen
2059 2055 2051
Spectra PrintMaster 24000, double platen
2119 2115 2111
Spectra PrintMaster 25000, double platen
2179 2175 2171
Spectra PrintMaster 26000, double platen
2239 2235 2231
Spectra PrintMaster 27000, double platen
2299 2295 2291
Spectra PrintMaster 28000, double platen
2359 2355 2351
Spectra PrintMaster 29000, double platen
2419 2415 2411
Spectra PrintMaster 30000, double platen
2479 2475 2471

TERMINALS

Eight Inch Single Side

SHUGART 801 R
119 115 109
SIEMENS FDD 100-8
239 235 231
TANDON 846-1 Half Height
369 359 349

Eight Inch Double Side

SHUGART SAB51R
495 485 475
QUITE 842 "QUITE TRACK" 8
319 315 313
TANDON 846-2 Half Height
459 447 435
REXÈF RFD-4000
219 215 209
MITSUBISHI 82896-63 ½ HT.
459 449 409

Planning: First five pounds $3.00, each additional pound $.50. Foreign orders: 10% shipping, excess will be refunded. California residents add 6.5% sales tax. COD discouraged. Open accounts extended to state supported educational institutions and companies with a strong "Dun & Bradstreet" rating.
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 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 a recorder for dictating messages. An optional dual floppy disk drive module, pictured above, is available for only $219. 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.

The Team 212A offers all the features of the Hayes Smart Modem 1200 baud modem at a fraction of the price. Note 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.

The UltraLink is a Hayes compatible 300/1200 modem designed for the IBM/PC market place. The UltraLink adds a voice/data demarcation to your PC. The Team 212A modem is NOT Hayes compatible.

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.

Includes:
- 14" Color Monitor
- Mouse & Software
- 10 Meg. Winchester
- 256K RAM Memory

Complete with 90 day warranty.

This 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 a 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 5 1/4" disk format and over 5000 CP/M programs available in public domain.

Includes:
- 14" Color Monitor
- Mouse & Software
- 10 Meg. Winchester
- 256K RAM Memory

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10 Mb Hard Disk

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- Professional Molded Packaging and Design
- High Quality 100 Watt Switching Supply
- Complete Integrated System
- Professional Molded Packaging and Design
- Microsoft Compatible Mouse Function

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:

- (1) 360K DD/DS Floppy Disk Drive
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- 256K Memory Expandable to 640K on the Motherboard
- Deluxe Keyboard with LEDs
- Serial Port and Parallel Port
- Color or Monochrome Controller
- 4.77MHz, 8086 CPU
- 100 Watt Switching Supply w/Fan
- Three Expansion Slots
- Optional 8 Slot Expansion Chassis with Power Supply (add $399)

Base System A (as above) $995.00

System Configuration

<table>
<thead>
<tr>
<th>SYSTEM CONFIGURATION</th>
<th>IBM List Price</th>
<th>Year Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSTEM A</td>
<td>Base System (see left) PC with 360K Floppy, Keyboard &amp; Mouse</td>
<td>$2100.00</td>
</tr>
<tr>
<td>SYSTEM B</td>
<td>Base System (see left) plus Add'1 360K Floppy Drive</td>
<td>$2265.00</td>
</tr>
<tr>
<td>SYSTEM C</td>
<td>Base System plus 12&quot; Green Monitor with Detachable Til/Swivel Base</td>
<td>$2575.00</td>
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<tr>
<td>SYSTEM D</td>
<td>Base System plus 12&quot; Color Monitor with Detachable Til/Swivel Base</td>
<td>$2995.00</td>
</tr>
<tr>
<td>SYSTEM E</td>
<td>Base System plus CRT Monitor, 10Mb Hard Disk and Boot Diagnostics</td>
<td>$3000.00</td>
</tr>
<tr>
<td>SYSTEM F</td>
<td>Base System plus 80 Col. x 25 Line LCD Screen</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Base System A (as above)** $995.00

**Assumes required add-on boards to provide same capacity**

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- All items have manufacturer's warranty. Some warranties up to 5 years.
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- ACP Retail Store pricing may vary.
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The price of each Byte Limited Edition Classic is $55; if two or more prints are ordered, the price of each is only $45.

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Address: ________________________
City: __________________________
State: __________ Zip: __________

Mail this coupon to:
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Baton Rouge, Louisiana 70815

Call 1-504-272-7266

Byte Limited Edition Classics are shipped flat, and are guaranteed to arrive undamaged or be immediately replaced. In fact, if for any reason you are not satisfied with your order, you may return it within 30 days for a no questions asked refund. Your prints will be shipped UPS Blue Label (two day delivery), and will usually be shipped within one week of receipt of order.

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To order your Byte Limited Edition Classic(s), just clip out and mail the coupon below. If you prefer, you may call in a MasterCard or Visa order to Robert Tinney Graphics, 1-(504)272-7266.

Visa or MasterCard orders
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WANTED: Nonprofit organization 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; provider generates forms and relies on volunteers to help. Receipt available: will pay shipping. Church of Jesus Christ of Latter Day Saints, Carrollton Branch, c/o R. A. Forsyth, 600 N. 11th Street, Carrollton, GA 30117, (404) 834-0904.


UNCLASSIFIED ADS MUST BE noncommercial, from readers who have computer equipment to buy, sell, or trade on a nonet network. 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. Ad must be typeset double spaced, contain 50 words or less, and include full name and address. This is a free service for space permit. BYTE reserves the right to reject any unclassified ad that does not meet these criteria. When you submit your ad, send a self-addressed, stamped envelope with 90-cent stamp for a reply.


FOR SALE: TRS-80 computer with 16K RAM, monitor, keyboard, CRT-80 cassette recorder for storing programs, drives, books, and more. $100 or best offer. Dan or Nancy O'Connell, 63 Maple St., Wenham, MA 01984, (617) 774-5047.


WANTED: Any kind of technical manuals of printers, disk drives, and computers. Also, I would like to correspond with anyone using Z80 systems. Larry Mulcahey, 2000 Akron Ave., Lima, OH 45803, (614) 595-6494.

FOR SALE: Key 11" on-line keyboard. power supply. IBM monitor. $200. Condition unknown. 1000 Massachusetts Ave., Cambridge, MA 02138, (617) 876-3296.

WANTED: NRI course in microcomputers and microprocessors. Also, NRI master course in TV, video cassette recorders, and other course. C. E. Heaths, etc. Incomplete or older courses acceptable. Reasonable. Joseph Wegner Jr., POB 252, Glenendale, CA 91201.


FOR SALE: Apple IIe -2000. $750. Also, various programs. Also, two 82106A single memory boards, one 82105A single memory board, and one 82105C single memory board. 1215) 757-8359.


WANTED: FX80 computer for use with IBM or Fortune-type micro. Excellent condition. M. B. Motwani, 2741 Brinton Lane, Westwood, MA 02090.


WANTED: Exchange of information with anyone owning a Netronics Explorer 88 in IBM-compatible version (737 ROM), or am I all alone? Lawrence Wall, 1806 N. 39th St. Santa Rosa, CA 95404, (707) 573-8407.

WANTED: IBM 800 users to form group Jim Stone, 2116 MacArthur St., Wash. DC 20011, (111) 711-7838.


FOR SALE: MPX16 single-board computer system (floss cassette card) with interface adapter, Key Tronic keyboard, power supply. IBM monochrome adapter, documentation, and more. Perfect working condition. $900 or best offer. Tom Lobeslein, 2053 Gencore Way. 101) 784-3703.


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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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Inquiry 324

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