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BYTE
MODULA-2
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BYTE

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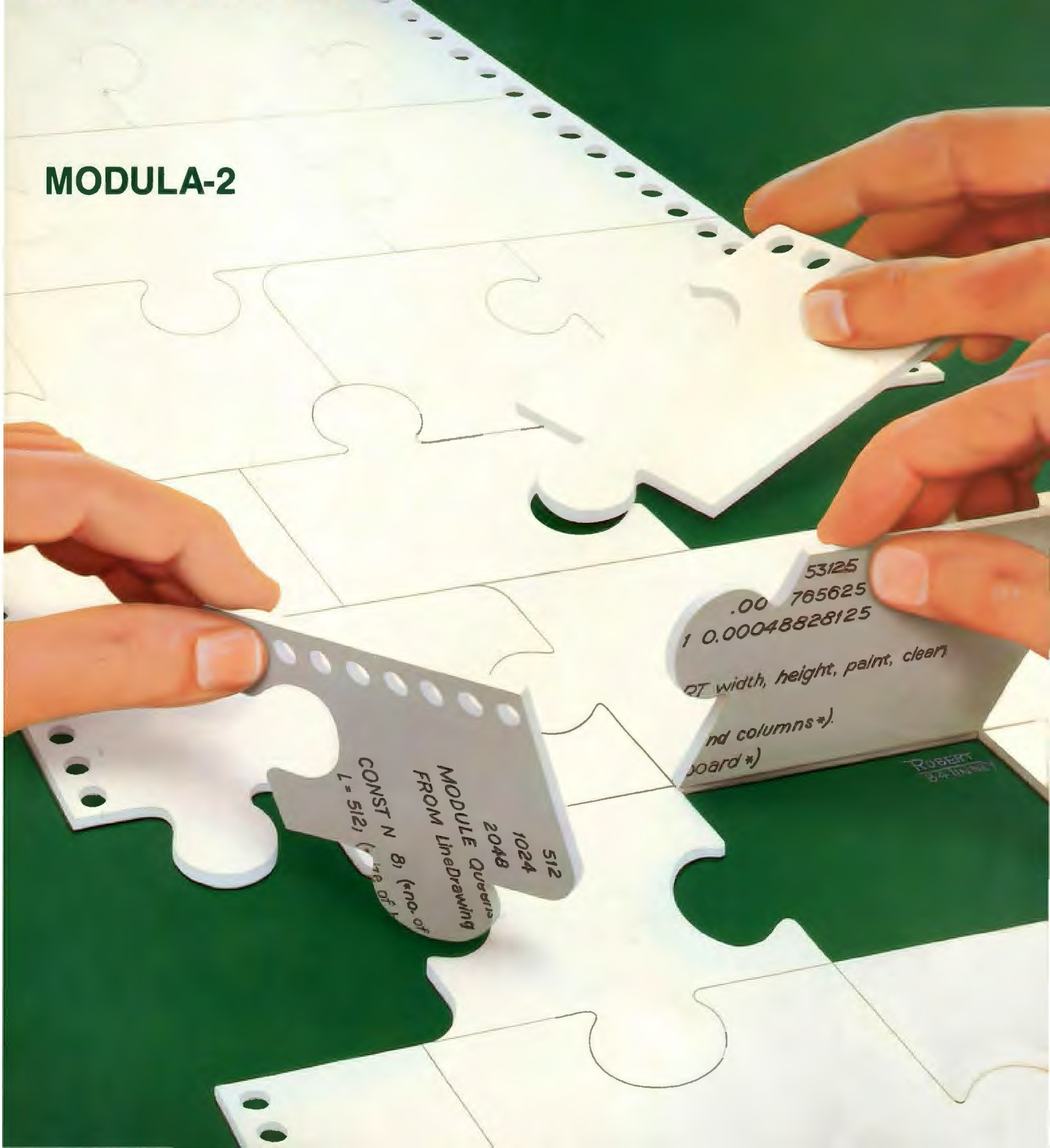

Announcing a small im

It's 12″ x 11¼″ x 2¼.″
It weighs less than 8 pounds.*
And costs less than $1,300.**
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The IIc has a full-size keyboard.

Because it's inherited all the talents of the eminently talented Apple IIe:

The versatility to run over 10,000 different software programs.

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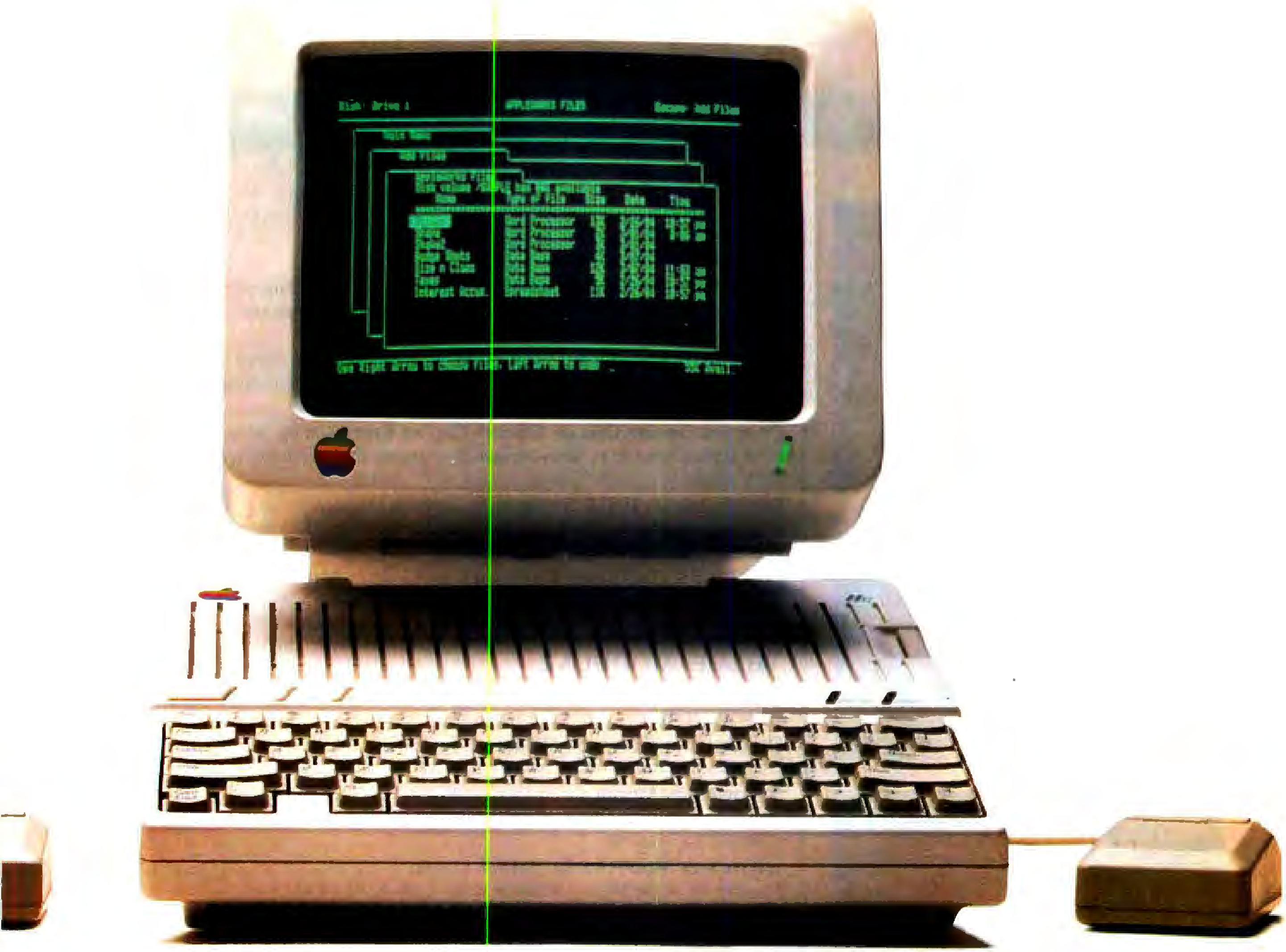

ovement on the Apple IIe.

Including the new Apple Scribe—Apple's first full-color print-on-anything printer for under $300, it can handle anything from business graphics to term papers.

The IIc's father, of course, is the granddaddy of the whole personal computer industry, the Apple IIe. Which, lest we forget, has quite a few improvements of its own this year.

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** Don't asterisks make you suspicious as all get-out? Well, all this one means is that the IIc CPU alone weighs 7.5 pounds. The power pack, monitor, an extra disk drive, a printer and several bricks will make the IIc weigh more. Our lawyers were concerned that you might not be able to figure this one out for yourself.* *** The FTC is concerned about price-fixing. So this is only a Suggested Retail Price. You can pay more if you really want to. Or less.*
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FEATURES

THEME: MODULA-2

REVIEWS

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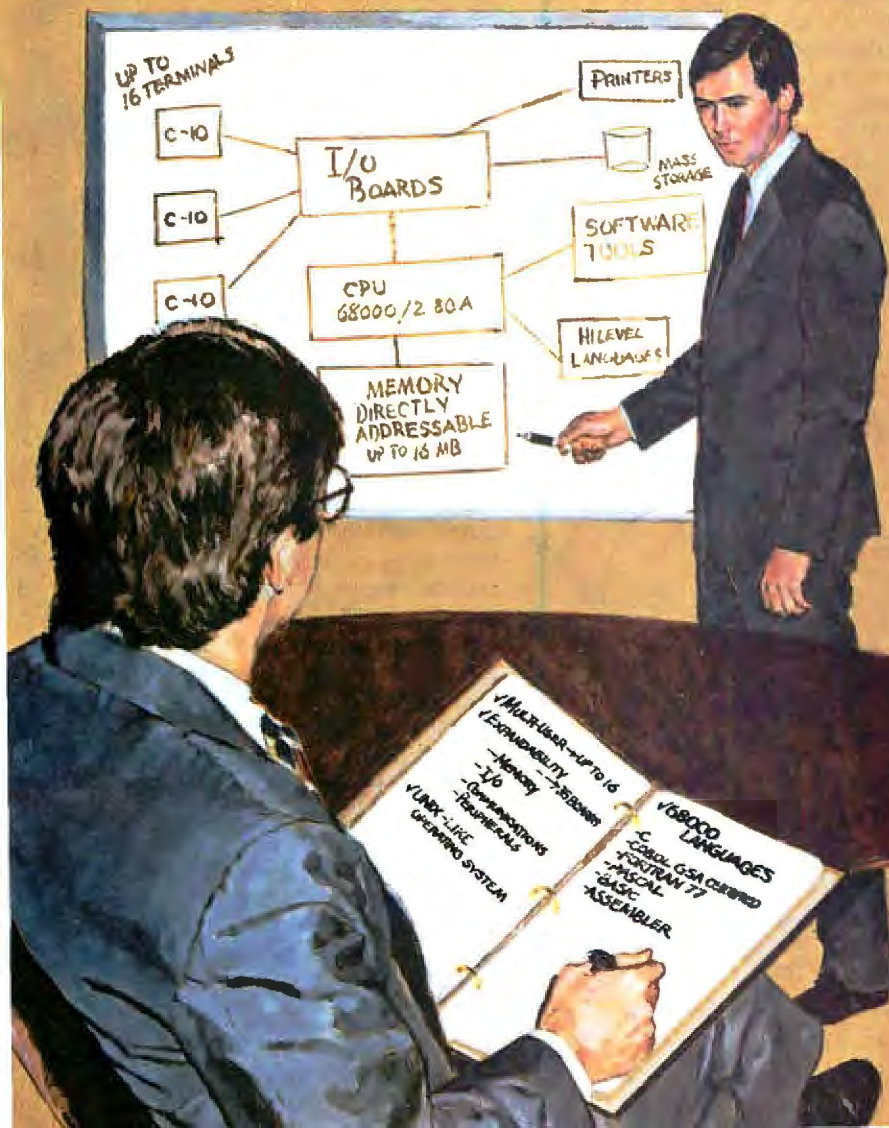

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E·D·I·T·O·R·I·A·L

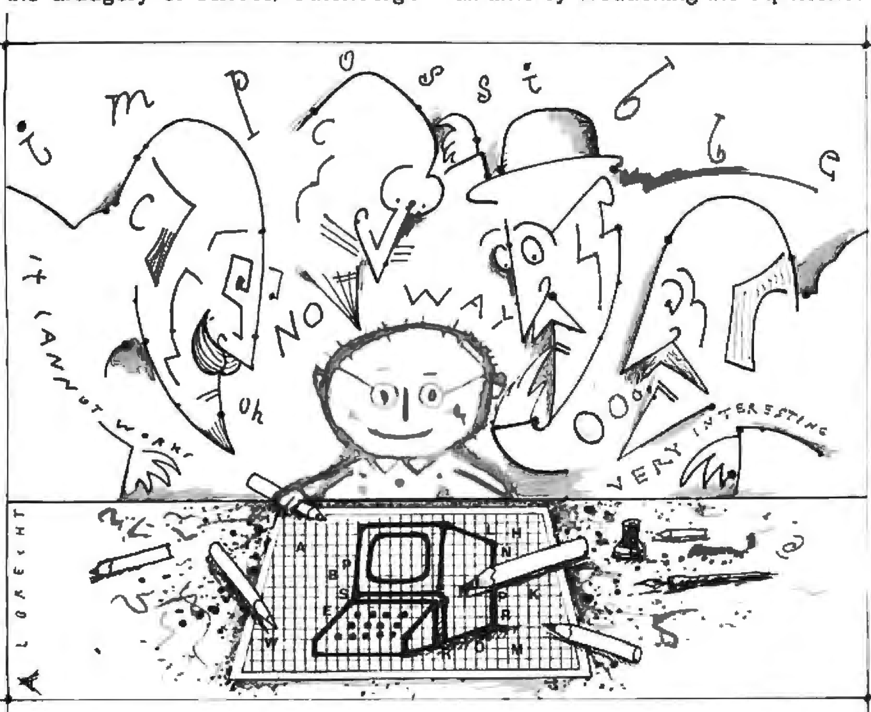
What Makes Personal Computers Special?

People sometimes ask me why there's so much fuss about personal computers. Now that there are millions of them in the hands of ordinary people, personal computers are, in a sense, commonplace. Even enthusiasts may forget that personal computers are very special indeed. We would enjoy them even if they lacked practical applications and never overcame the digital indifference so often characterized as unfriendliness. To put personal computers in perspective, we should compare them with such earlier cultural watersheds as the printing press, the industrial Revolution, and the automobile.

Because it made the production of books far more efficient, the printing press made it possible for more people to learn more than ever before. But while the printing press gave creative work a wider audience and eliminated the drudgery of scribes, Gutenberg's technology did not directly enhance the creativity of the people who wrote books.

The Industrial Revolution made the production of goods far more efficient than ever before. The efficiencies of mass production made possible the accumulation of great wealth. Unfortunately, mass production also brought about cultural impoverishment of many workers. The assembly line deprived workers of the creativity that belonged to craftsmen—the stamp of individuality that went with good handwork. The *Encyclopaedia Britannica* puts it this way: "...the discipline of the factory (a discipline often imposed by strangers), the remorseless monotony of many of the tasks, and the physical hazard and discomfort of some of the new processes took a heavy toll." Few would deny that the Industrial Revolution was, on balance, a good thing. But it did exact a great human price.

The automobile changed society for all time by broadening the experience of millions of people. The ability to travel quickly and widely enabled people to see more of the world and to judge it for themselves. The automobile's influence resembled that of the printing press; while widespread book publishing extended knowledge, the mass production of automobiles extended experience. With broadened experience came wider choice in place and type of work. But the automobile did not directly enhance creativity; furthermore, the automobile was produced by the dehumanizing assembly-line methods introduced by the Industrial Revolution.



The personal computer disseminates knowledge, as the printing press did; increases productivity, as the Industrial Revolution did; and broadens experience, as the automobile did. In many applications, personal computers also reduce drudgery such as needless retyping and recalculation.

What sets personal computers apart, however, is their ability to enhance the creativity of the individual. They have justly been called "mind appliances" and "thought amplifiers." They can help us manipulate information and ideas with remarkable freedom. Rather than forcing us all to work alike under the supervision of strangers, personal computers will let us develop our own unique ways of working. Rather than requiring personal sacrifices to achieve greater social goals, personal computers will contribute to the achievement of social goals by enriching the lives of individual persons. Programs like Bill Budge's Pinball Construction Set, Bill Atkinson's MacPaint, and Warren Robinett's Rocky's Boots offer glimpses of things to come.

Will personal computers make us all geniuses or saints? No. But they *will* help us make the most of ourselves. That is ample reason for regarding personal computers as far more than just another major consumer item.

—Phil Lemmons, Editor in Chief

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M·I·C·R·O·B·Y·T·E·S

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

AT&T Unveils Microcomputer

AT&T Information Systems introduced its long-expected IBM-compatible microcomputer in late June. The AT&T PC 6300, made by Olivetti, includes an 8-MHz 8086 processor, 640 by 400 color graphics, 128K bytes of RAM, serial and parallel ports, two 360K-byte floppy-disk drives, a clock/calendar, MS-DOS 2.11, and seven additional expansion slots for $2810. A 10-megabyte hard-disk version is $4985. AT&T also announced that its 3B2 and 3B5 series of UNIX computers would be available through retail channels and introduced many programs that run on the machines under UNIX System V. The AT&T PC does not use UNIX. AT&T also announced dot-matrix and daisy-wheel printers.

AT&T also introduced the Information Systems Network, a local-area network designed to link from 200 to 1920 computers. ISN uses standard twisted-pair wiring and transfers information at a speed of 8.64 megabits per second, using a proprietary "perfect scheduling" system. It costs from $400 to $500 per node. AT&T said it will announce a smaller network later this year.

Morrow and Visual Add UNIX-Based Multiuser Systems

Morrow, which last month introduced an IBM PC-compatible portable computer, has now unveiled Tricep, a 68000-based multiuser S-100 bus computer that uses the UNIX System V operating system. Morrow's new machine includes 512K bytes of RAM, a 16-megabyte hard-disk drive, one floppy-disk drive, and a four-user capacity for a base price of $9000. The system can be expanded to include up to 2 megabytes of RAM, four 34-megabyte hard disks, four floppy disks, and eight users.

Visual Technology Inc. was expected to unveil an 80286-based multiuser system that uses the XENIX operating system. With 512K bytes of RAM, a 19-megabyte hard-disk drive, a streaming tape drive, and ports for six users (expandable to 16), the system will be priced in the $10,000 to $15,000 range. Visual hopes to sell the system both through retail channels and to other manufacturers.

Polebrook Computer Systems, Peterborough, England, says it has completed development of a 68000-based UNIX system that it says will retail for about $2750 with a 10-megabyte hard-disk drive and 256K bytes of RAM. Polebrook is seeking a company to market the system both in the U.K. and the U.S.

IBM Speculation

IBM attended the June meeting of Committee SC-156 of the Radio Technical Commission for Aeronautics, which is studying potential hazards to airplanes by portable computers. This has fueled speculation that a battery-powered IBM portable may be in the works. SC-156 will meet again September 18-19.

Epson Brings PX-8 Notebook Computer to U.S.

Epson America Inc., Torrance, CA, announced the Geneva PX-8, the notebook computer its parent company showed at the Hannover Fair in West Germany earlier this year. The PX-8 includes an 8-line by 80-character LCD, microcassette tape drive, a Z80-compatible microprocessor, and the CP/M 2.2 operating system. MicroPro's ROM-based Portable WordStar, Portable Calc, and Portable Scheduler are bundled with the PX-8, which will retail for $995. An optional battery-powered 3½-inch disk drive will be available for $599. Epson will also offer a 300-bps modem, a printer, and 64K- and 128K-byte memory-expansion units.

Tektronix Announces Color Ink-jet Printer

Tektronix introduced the 4692 Color Graphics Copier, a color ink-jet printer with a resolution of 154 dots per inch. The 4692 can be used with Tektronix color-display terminals or with the 4510 Color Graphics Rasterizer, which uses an RS-232C interface to link to other computers. The 4692 Copier will be available in October for $5995; the 4510 Rasterizer will be priced from $4495 to $9995, depending on memory.

(continued)

Uniform Software to Run PC-DOS Software Under UNIX

Uniform Software Systems Inc., Santa Barbara, CA, has announced the Connector, a program that allows any MS-DOS or PC-DOS software to run under UNIX. Initially, the Connector will be available for PC/IX, the UNIX version sold by IBM, but may be translated for other versions of UNIX. The program will be available in September for less than $300.

Two New Telephone-Management Systems

Natural Microsystems, Needham, MA, was expected to announce Watson, a $1000 telephone-management system for the IBM PC, in late July. Watson includes a 300/1200-bps modem and software to digitize voice messages so the system can be used as a telephone-answering machine. Terminal emulation and calendar software are also included.

Liberty Electronics, San Francisco, CA, announced a voice/data terminal, the Freedom 212. The $1295 terminal includes an auto-dial 300/1200-bps modem and a built-in 25-line telephone directory.

NANOBYTES

Assimilation Process, Los Gatos, CA, has announced the Mac-Daisywheel Connection. This $99 program allows Apple's Macintosh computer to print text using a standard daisy-wheel printer; an interface cable is included. . . . **Leading Edge Products** said it will sell a line of "Peanut" IBM PC-compatible computers beginning in late fall. . . . **AST Research** is developing a PCnet expansion card for the IBM PCjr. . . . **Teknowledge**, Palo Alto, CA, has introduced M.1, an expert-system generator for the IBM PC, priced at $12,500. . . . **Gigabit Logic**, Newbury Park, CA, has begun shipping 12 logic and counter chips that use gallium arsenide (GaAs) instead of silicon. GaAs parts are much faster and more expensive than their silicon counterparts. . . . **Faxtel**, Toronto, Ontario, is developing software that will allow the Macintosh to be used as a NAPLPS decoder terminal. . . . **Solutions Inc.** has developed Straight Talk, terminal software for the Macintosh, to be sold by **Dow Jones** for $79. **Apple** was expected to introduce MacTerminal in July. . . . **Advanced Storage Technology Inc.**, San Jose, CA, has announced 61- and 103-megabyte half-height 5¼-inch hard-disk drives. In large quantities, the 103-megabyte drive sells for $1950. . . . **NEC Information Systems** announced a 55-cps daisy-wheel printer, the 8850, for $2500, and three floppy-disk drives, including a 1.6-megabyte 5¼-inch and two 3½-inch models. NEC is also developing a $3500 6-page-per-minute thermal-transfer printer and a $700 HP-compatible four-color plotter. . . . **Intel** says it is shipping CMOS 256K-byte RAMs. **Motorola** will begin full production late this year. . . . The **Computer Satellite Network** hopes to offer cable programming for computer enthusiasts by late fall. . . . **Practical Peripherals**, Westlake, CA, planned to unveil an encryption device at NCC. The Data Encryption System (D.E.S.) 2000, priced at less than $500, will attach to the computer's serial port. . . . **Xetec Inc.**, Salina, KS, will begin shipping a dual 3¼-inch disk-drive system for IBM's PCjr entry model. The $800 unit includes a disk controller and can add a third 3¼-inch or a 5¼-inch drive. . . . **Kamerman Labs**, Beaverton, OR, is selling a 10-megabyte hard-disk subsystem for the IBM PC for $895. . . . **Motorola** formally introduced the 68020, a 32-bit version of the 68000 microprocessor. The CMOS chip includes an on-board cache and a coprocessor interface and can run at 16 MHz. . . . **Wang** has announced a $595 expansion card that it says makes its Wang Professional Computer fully compatible with the IBM PC. . . . **Xerox** will sell a $795 expansion card linking the IBM PC to Ethernet. . . . **Sony** will reportedly begin private showings of a compact laser-disk read-only memory device late this summer. The drive will use the same technology as Sony's audio laser disks. . . . Keyboard maker **Key Tronic** will manufacture a version of **Display Interface Corporation's** HiFi Mouse, which uses sound to detect motion and direction. It will sell for $65 in very large quantities. . . . **Volition Systems**, Del Mar, CA, has added a CP/M-68K version of its Modula-2 compiler. The $495 compiler will be available next month. . . . **Telos Software Products**, Santa Monica, CA, announced FileVision, a $195 visual database manager for Apple's Macintosh. . . . **Ricoh** introduced the LP4120, a $14,000, 12-page-per-minute laser printer. . . . **Delphax Systems**, Mississauga, Ontario, introduced a laser printer designed to print up to 1.5 million copies per month. The $70,000 S 6000 can print 60 pages per minute.

"Dare to

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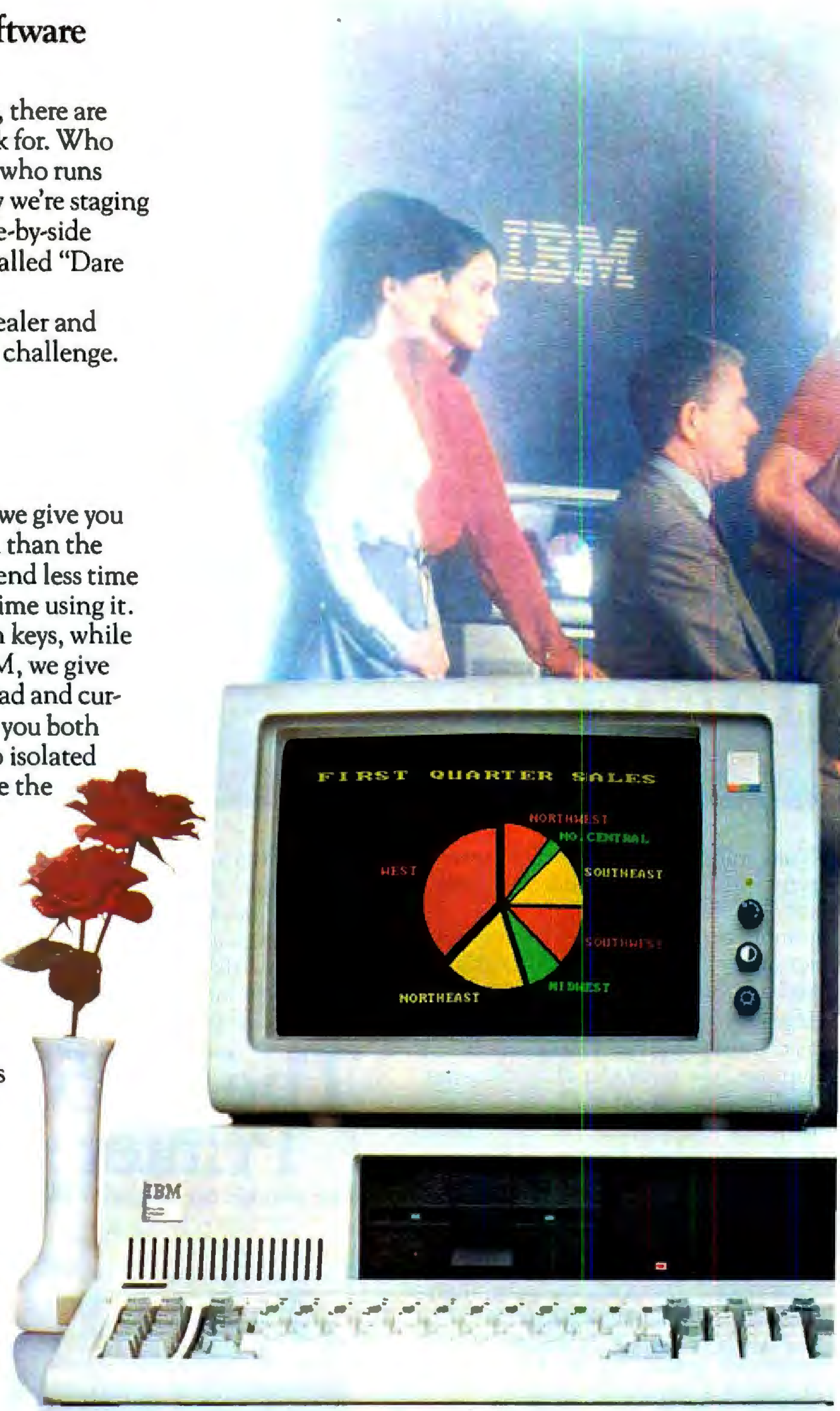
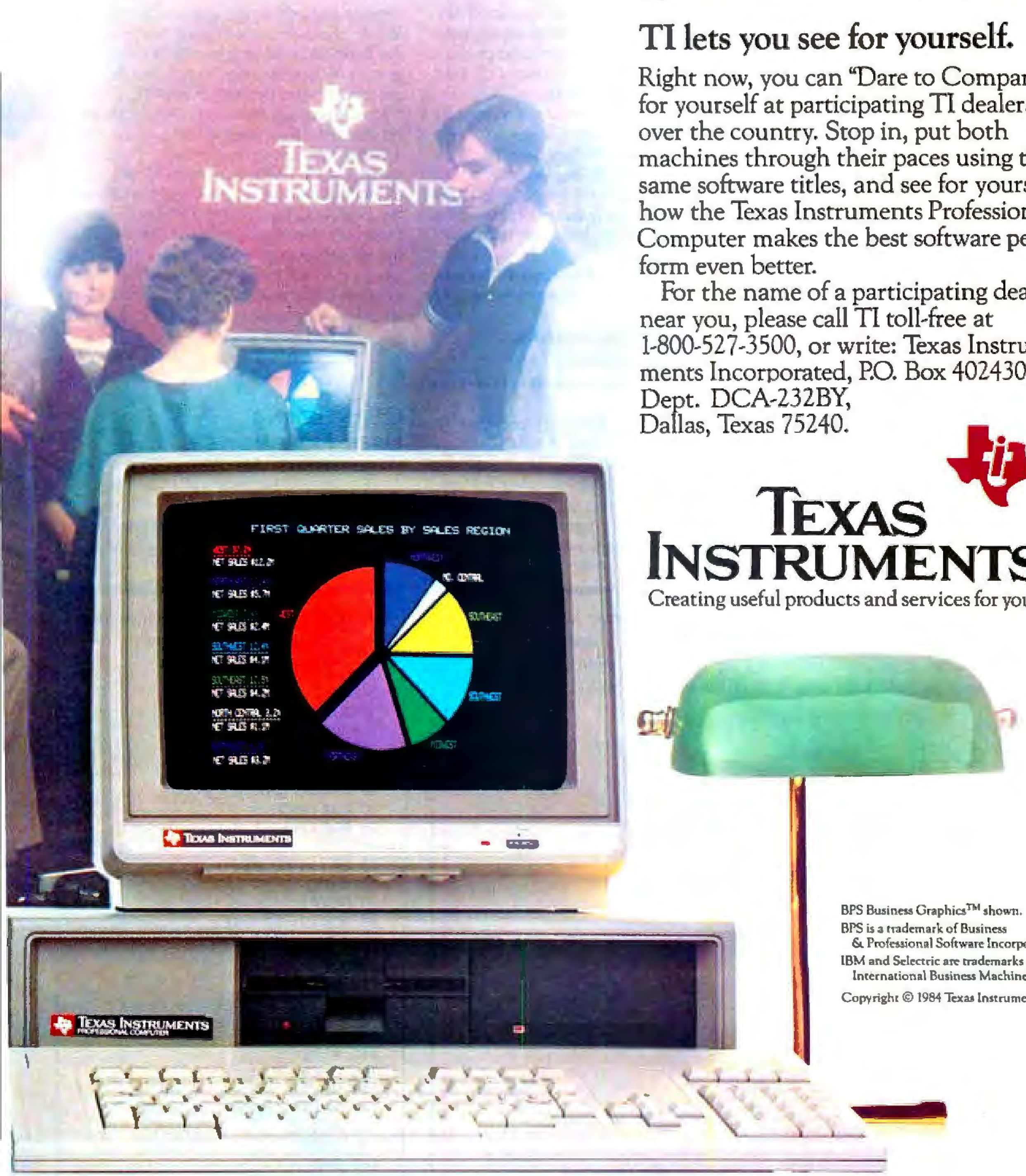


IBM Personal Computer

Compare”



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In Praise of APL

I read G. T. Hunter's article "Calculating Overhead Costs by Computer" (February, page 416) with great interest. It was well written, with a good blend of history. It would seem that progress is rather slow. The article did tease the reader a bit with the statement on page 423 "In APL, the procedure is even simpler. . . ." Indeed, that is true. It is unfortunate that Dr. Hunter did not demonstrate this. Consequently, I have picked up the challenge. I am enclosing the APL function that generates the same numeric data that the listed BASIC program or the iterative-spreadsheet approach does.

The first step of the closed-form solution is to recognize that the set of four equations on page 418 is a set of four equations in four unknowns. Simple algebra will put them into standard form. Thus, if you place a −1 on the main diagonal of the matrix of distribution factors, it becomes the matrix of coefficients for the set of linear equations. Negating the initial values makes them the constants for the set of linear equations. Thus, in APL, the expression that produces the answer is simply:

```
(−INITIAL VALUES)  ⌹  DISTFACTORS
```

Listing 1 (presented here) is an annotated APL function that will accept the initial approximate vector and the distribution matrix and produce the data in the form of table 3 (page 422). I did this on my IBM PC using IBM's PC APL.

It is unfortunate that more of the computing community is not aware of this powerful general-purpose programming language. There are at least five different full implementations of APL on the IBM PC. I believe that APL is the most powerful general-purpose programming language currently available on microcomputers.

Raymond P. Polivka
Poughkeepsie, NY

The Sieve Benchmark on a Heath H-89

After reading "STSC APL*PLUS and IBM PC APL: Two APLs for the IBM PC" (March, page 246), I decided to put my machine to the test and run the Sieve program in listing 2. I used a Heath H-89 with CP/M 2.23 and Microsoft BASIC. I modified the program slightly to provide indications of start and completion, and to automatically recycle the program. Running my version (see listing 2, presented here) I was able to obtain results averaging 284.56 seconds per iteration of the program. Note that my program is looped 10 times to be consistent with the benchmarks presented in BYTE.

Needless to say, I was surprised to obtain the results I did. I have been thinking about adding a 4-MHz upgrade to my processor board (I am using a stock 2-MHz machine). If I were to do so, my lowly 8-bit machine would out-loop even the mighty Big Blue and its 16-bit powerhouse. I had considered purchasing an IBM PC to handle my computing needs, but now I believe *I'll* hang on to what I've got. Thank you for the enlightening article and also for renewing my already strong faith in the Z80, CP/M, Microsoft BASIC, and Heath.

Peter M. Hermsen
Burlington, NC

Quantifying User Friendliness

Thank you for William J. Raduchel's article "A Professional's Perspective on User-Friendliness" (May, page 101). His equation for quantifying

(continued)

Listing 1: An APL *adaptation of a* BASIC *program for determining how indirect costs are distributed among the four departments of a hypothetical company. This function accepts the initial approximate vector and the distribution matrix to produce data in the form shown in table 3 on page 422 of the February* BYTE.

```
      ∇BURDEN[0]∇
     ∇ Z←INT BURDEN DF;T;S
[1]  ⍝INT:INITIAL DEPT. COST EST.
[2]  ⍝DF: DISTRIBUTION FACTORS AS A MATRIX
[3]  ⍝    COLN =FROM , ROW=TO
[4]  ⍝Z: MATRIX WITH
[5]  ⍝    1st ROW−TOTAL EXPENSE /DEPT
[6]  ⍝    LAST ROW−NET EXPENSES/DEPT
[7]  ⍝  REST OF THE ROW ARE THE DISTRIBUTED EXPENSES
[8]  ⍝  OF EACH DEPT(COL) TO EACH OTHER DEPT(ROW)
[9]  ⍝ LAST COLN −INITIAL DEPT COST EST I.E. INT
[10] ⍝ ──────────────────────────────────────────
[11] ⍝ PUTTING −1 ON MAIN DIAGONAL OF DF
[12]   T←DF+(ρ−1↑ρDF)ρ0
[13] ⍝ TOTAL EXPENSE/DEPT
[14]   Z←(−INT)⌹T
[15] ⍝ GET INDIVIDUAL DISTRIBUTIONS
[16]   T←DF×(ρDF)ρZ
[17] ⍝ BUILD OUTPUT MATRIX
[18]   S←Z,[1]T
[19]   S←S,[1](Z−+/[1]T
[20]   Z←S,(+/Z),INT,+/INT
     ∇
```

Listing 2: A *modified version of the Sieve of Eratosthenes program.*

```
1 FOR X=5 TO 0 STEP −1
2 FOR Y=1 TO 650
3 NEXT Y
4 PRINT " ";X          ("^G")
5 NEXT X
10 DEFINT A−Z
20 OPTION BASE 1
30 DIM F(8191)
35 FOR Q=1 TO 10
40 C=0
50 OR I=1 TO 8191
60 F(I)=1
70 NEXT I
80 FOR I=1 TO 8191
90 IF F(I)=0 THEN 170
100 P=I+I+1
110 K=I+P
120 WHILE K<=8191
130 F(K)=0
140 K=K+P
150 WEND
160 C=C+1
170 NEXT I
180 PRINT C;"primes"^G
182 NEXT Q                ^G
185 PRINT "                    ^G"
190 END
OK
```

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user friendliness is a noble attempt to take an advertising slogan and make it a tool for better program design.

However, I would like to point out that in his example (Standard PC versus Script versus Lisa) he uses Script to imply a command that will correctly do exactly what a user wants with no additional decisions by the user. Essentially, this means that any variation in the task performed would require that an entirely new Script be produced or the user would be required to resort to the underlying command structure. Neither of these would be acceptable with Mr. Raduchel's assumption that $P_0 = 1.0$ (that the user will always pick the right action). Therefore the Script case is the theoretical maximum—that one command is all the user needs to consider. Mr. Raduchel's results do indicate an approachable goal, though—to make frequently used sequences available as a single command.

The inclusion of Script (or macros) into another command (either Standard PC or Lisa cases) seems to be logical. Before looking too closely, I would like to define the cases. Standard PC is used to indicate a system where the user initiates all information transfer. If the user wants to move a file but does not remember the name or how much room is on the disk, he or she must ask for a directory. The Lisa approach implies that the system will supply the user with the necessary information at the time and location it is needed. Although this definition is simplified, it describes the fundamental difference between Script and Lisa. Windows and icons are used in a Lisa-type approach because of the large volume of different information displayed at the same time. In essence, windows are simply organized groups of information, displayed together and manipulated as a unit. And if a picture is worth a thousand words, an icon must be worth a dozen or so.

But both Lisa and Script approaches can support macros. Neither approach has any inherent limitation to prevent it from taking advantage of macros. In fact, UNIX assumes that a shell (in effect, macros) will be used in an application environment. I also agree with Mr. Raduchel that the Lisa approach, if properly supported with hardware and consistent throughout all applications, will produce higher user friendliness than the Standard PC approach. Therefore, it would seem logical to conclude that a shell, similar in concept to a UNIX shell and optimized for each type of application, coupled with a Lisa-like environment, would produce the most user-friendly programs.

J. L. MAHOWALD
Overland Park, KS

COMPUTERS AND LAWYERS

I am a subscriber to, and regular reader of, your excellent magazine. I would like to comment on Robert P. Wilkins's article "How Lawyers Can Use Microcomputers" (May, page 160).

I am a practicing attorney who is knowledgeable about office-automation issues and the computer marketplace. I know Mr. Wilkins's works well. He is an acknowledged authority and leader in the automation area of the legal industry.

However, we differ philosophically in a key area. In his first paragraph, Mr. Wilkins states that lawyers do not need to know terms such as RAM, bps, ". . .and other foreign, often unnessary technical terms. All lawyers need to know is how computers can improve the efficiency of a legal practice."

To the contrary, the road to efficient and proper use of computers in law offices must start with lawyers and staff members having a good understanding of the new buzzwords. How else can a lawyer feel confident when walking into a computer store? You must know if 64K bytes of memory is enough, what disk drives are for, whether a hard disk is necessary, what programs are for and what they do, etc. There is no substitute for this basic education.

Lawyers are intimidated by this new world and knowledge of these words will get things going. Mr. Wilkins discussed database-managment systems for lawyers, including dBASE II. I am told dBASE II is complex and requires a great deal of expertise to use. How can a lawyer use this product without knowing terms such as bits, bytes, etc.? Even using search techniques on databases is easier if you understand what a database is, how it is compiled and stored, and what the rationale is for the search methods.

Electronic mail also has its tricks and problems. The American Bar Association has gotten off to a slow start with its electronic mail network. I believe the reason is that lawyers are intimidated because they don't understand this new technology. Further, to use electronic mail, you'd better know what a modem is and how to use it.

It wouldn't be a bad idea for lawyers to subscribe to BYTE for its technical tutorials and educational materials. Lawyers must know something of computer technology and terminology.

There is another reason lawyers must learn about this new technology. Our clients are involved with computers at every level. How are we to serve our clients if we do not understand what they do or what they are telling us? How can we discuss a source-code escrow if we don't know what source code is, why it's important, and how it differs from object code?

Mr. Wilkins and I do agree 100 percent on one issue. Computers are indeed the most significant change in the way the law is practiced since the invention of the telephone and the typewriter.

PAUL BERNSTEIN
Chicago, IL

COMPUTERS AND DOCTORS

I found George Zucconi's article "A Computer in the Doctor's Waiting Room" (May, page 108) very interesting. Programs such as his are useful for providing patients with information that they might otherwise not "bother the doctor with."

However, it cannot be overemphasized that such a computer program is not a substitute for consultation with a physician. In particular,

(continued)

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drugs for diabetes, hypertension, and acne, as well as related medications, are not covered in Dr. Zucconi's program, Drugs in Pregnancy.

SAMUEL NEFF, M.D.
Narberth, PA

PROGRAM COMMENTS

I enjoyed the article "Using Comments to Aid Program Maintenance" by Richard A. Thomas (May, page 415), and I think that an article that attempts to demonstrate some good (and bad) commenting techniques would also be useful. I have found that the usual reason for bad comments is that the programmer doesn't know how to do it any better. My company has developed fairly rigid standards regarding code and documentation, and we avoid some of the problems stated in the article by stressing that you can't move on to a new project if no one else can maintain your old one.

We consider the most useful comments to be the program and subroutine headers. Our program headers contain the name of the program, the system it belongs to, the name of the programmer, a complete revision history, and a brief description of the program's function. Our subroutine header contains the name of the subroutine, a description of the subroutine's function, and the input and output parameter details. These headers seem to be the biggest help to a maintenance programmer and we insist that they be kept up to date at all times.

D. P. KERKHOFF
Orlando, FL

DEAR THIEVES

Judging by the letters and articles in microcomputer publications, the controversy over software piracy seems to have died down recently. However, from my own experience I feel that it is as much a problem as ever and is merely reaching the level of general acceptance. Lest it arrive at that point and doom us forever to the curse of sophisticated and costly protection schemes, I submit the following:

An open letter to software pirates:

I am constantly amazed at a practice so prevalent among microcomputer owners that a person who does not participate in it is almost considered a freak. I refer of course to the practice commonly referred to as software piracy. I prefer, however, to call it by its correct name—software THEFT. I am not referring only to those who copy software for profit or underground distribution, but to anyone who copies copyrighted software they did not purchase. The law is clear on this point. You have the legal right to copy software you have purchased for your own use. Any other copying, even if you give, not sell, the copies to friends, school, users groups, or anyone else, is *illegal*. In spite of this, I know people who would not think of violating the 55-miles-per-hour speed limit but freely and frequently copy copyrighted software from

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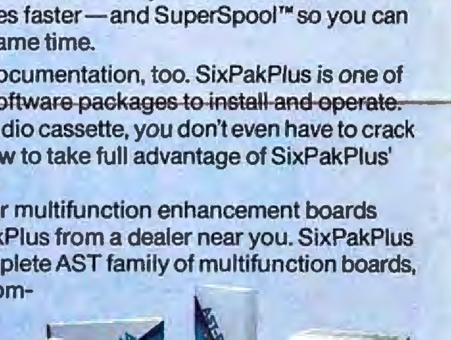

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others or to give to others.

I have heard and read more rationalizations for this practice than I could possibly list. They are just that—rationalizations of those who must make excuses for their actions. One of the most common I hear is "software is overpriced." To that I say, if you absolutely cannot live without a piece of software then, whatever its price, it is worth it to you to pay it. Otherwise, don't buy it, don't copy it, and don't use it. If it truly is overpriced and people do not buy it or use it, the price will come down or it will disappear from the market. We should encourage and support such software publishers as A.P.P.L.E., Penguin, Beagle Bros., and others who have chosen to reduce their costs and their prices by not copy-protecting their software. These publishers sell top-quality software for reasonable prices. I encourage you to buy and use their products, but please do not rip them off by stealing their software.

For those of you whose only ethical standard is "it's OK if I don't get caught," I don't expect to make much of an impression on you. You are right about one thing: if you don't sell bootlegged software you probably won't get caught. But I am writing this to those of you who hold to some form of ethics or morality that says it is wrong to steal, whether or not you might get caught. Consider what you are doing when you accept or give copies of copyrighted software: consider the example you are setting for your children and friends. You are stealing, regardless of your rationalizations to the contrary.

Just because software piracy does not receive the press attention it once did does not mean that it is no longer a problem. In reality, it is bigger than ever as more and more people buy computers. I don't expect that this letter will make much of a difference in the overall problem, but if a few who may be unwittingly copying software accept the reality of what they are doing and refuse to continue the practice, then it is worth it.

WILLIAM G. WRIGHT
Oceanside, CA

RECONFIGURING PERFECT WRITER COMMANDS

Recently, I bought a Kaypro 2 computer to use primarily for word processing. After looking through the manuals, I decided to use the Config program provided to program the number keys to replace many of the Control-X commands in Perfect Writer. I thought it would be nice to replace three- or four-keystroke commands with one-keystroke commands. I quickly found two problems. First, the documentation is terrible. No instructions are given to explain how to use the Config program with Control or Escape sequences. Second, once I found the necessary information in the Perfect Writer manual (which is also terrible), it turned out that the hexadecimal codes for these commands are all three characters long, which will not work with the Config program.

I finally worked out a way of doing everything I wanted. Perhaps it is not the easiest way but it does work, and I thought many of your readers who own Kaypro 2s would be interested. The process follows:

1. Copy the following files onto a blank formatted disk from the Perfect Writer Installation disk: PWBIND.COM, FUNCTS.TXT, PW.SYM. Copy the following files onto the same disk from the Perfect Writer Edit disk: PW.COM, PW.SWP, PW.HLP.
2. Edit the FUNCTS.TXT file by typing PW FUNCTS.TXT at the A> prompt. Then, pick out any 14-line section of FUNCTS.TXT that consists of all unknown commands *and* whose hexadecimal codes are two characters long. Numbers 161–174 are ideal since the corresponding hexadecimal codes are A1, A2, A3, . . . , AD. Find in the Perfect Writer manual the printout of FUNCTS.TXT and the commands you want. Then replace just the items in the third and fourth columns of each line (161–174) with the commands you want. When done, save the edited version with Control-X, Control-S, then exit with Control-X, Control-C.
3. Call up PWBIND.COM by simply typing "PWBIND" at the A prompt. PWBIND will do the rest.
4. Next, copy PW.COM, PW.SWP, and PW.HLP back to the Perfect Writer Edit disk. The commands corresponding to the lines you edited will now work. (If you use Perfect Speller, it will be necessary to copy these to the Perfect Speller disk, too.)
5. Next, put the new PW Edit disk into drive B, and the CP/M disk into drive A. Then, at the A> prompt, type CONFIG. Choose number 4 from the menu (change the number pad) and then number 2 to actually change them. Then enter the new hexadecimal codes into the chart (if you used 161–174 then the next hexadecimal codes will be A1–AD) in accord with your wishes (a hand-drawn chart comes in handy). Then press Esc twice, then answer Y when asked if you want to keep the changes made.
6. Finally, put the reconfigured Edit disk in drive A, and then push the reset button. After this, the number pad will be reconfigured the way you want it.

Although there are a number of steps involved here, this procedure is not difficult. It is unfortunate that both Kaypro and Perfect Software chose to make this all sound so difficult in their manuals. However, once it is done, life with Perfect Writer is much nicer.

I find it convenient to have a STAT file on the same disk as my word-processing software. This is no problem on WordStar because there is plenty of room left on the disk. However, on the Perfect Writer disk there is all of 1K byte left. The PW.HLP file is exactly the same length as STAT.COM, though, and, since I never use the on-screen help feature, I erased it from the *Edit* disk (I did save it on the PW LESSONS disk) and copied STAT.COM to Perfect Writer. This allows me to know the remaining space on a disk without changing to the CP/M disk.

BARRY D. SMITH
Carbondale, IL

A Call for QX-10 Support

I am the owner of an Epson QX-10 with an MX-80 FT as well a Comrex CR-11. I purchased this primarily for business use and am happy with it except for one thing. There is virtually no one putting out any educational software to use under the CP/M-80 operating system. I realize that the QX-10 is relatively new but CP/M isn't. Why don't the good educational-program writers who work for Atari and Apple understand that CP/M system users have children who could benefit from such software?

And what about all those ingenious add-on board builders? Why hasn't someone made one that will run Apple and IBM PC programs on the QX-10?

David M. Boyd
Tampa, FL

Supermicros

I would like to suggest that technology has advanced enough to warrant a shift of focus for "the small systems journal."

Many of the articles in BYTE seem to be pitched to the level of systems with a 6502, 8088, or 8086 central processing unit. But there are a number of "small systems" on the market using 68000s and calling themselves supermicros. I have been following the product announcements of Cadmus, Pixel, Callan, and Wicat for a while, hoping that I might win the state lottery so I could buy one. Actually, given another year or two, I might be able to afford a supermicro without the lottery. But now my interest has been aroused by the appearance of 32-bit "supermicros."

DEC has announced its Microvax, and now AT&T is about to market its 3B2/300. Both of these are true 32-bit machines and yet they are being promoted as small systems, i.e., not quite minicomputers. At this point, all I know is that I would like to own one of these machines, without knowing what they could offer me. One of the things I'm looking for is the capability of doing graphics more on the level of computer-aided design than pie charts, but AT&T tells me that the 3B2 doesn't support graphics as yet.

So now I want to suggest that BYTE extend its coverage of slightly more sophisticated machines. Before you object that none of your readers can afford these machines unless they have a healthy business going, let me mention that I am an individual without such a business who will probably buy a 68000-based system running UNIX, and who is very interested in reading about and learning more on the generation of 32-bit microcomputers.

Jay Steinbrunn, Ph.D.
South Hadley, MA

Request for Help

I recently bought a Radio Shack Model 4 and now I need help with some conversions from my old Model I.

First I would like to know if anyone knows what patches must be applied to Microsoft's muMATH for the Model I to make it run on a Model 4 (either in Model III or Model 4 mode).

I would also like to know where I can buy a disk-controller board so that an 8-inch disk drive from my old Model I will run on the Model 4. I want to use the 8-inch drive with three 5¼-inch drives under DOSPLUS 3.5, DOSPLUS IV, NEWDOS/80 (Model III mode), Montezuma MICRO CP/M version 2.2, and Radio Shack CP/M version 3.0.

James R. Primm
Paris, MO

A Subscriber Complains

I look forward to the delivery of my BYTE each month because I enjoy it and it is a method of keeping up with my peers who also subscribe to BYTE. My complaint is in regard to my perceived view of your mailing practices. My last name is Zehnder and I work with a gentleman whose last name is Anderson who is also a BYTE subscriber. We live within 30 miles of each other. I have noticed that over the last several months he has received his issue of BYTE four to five days earlier than I.

At this point I would like to note two features of BYTE magazine: it is of broad interest and substantial content, i.e., it has a large physical structure (my wife still thinks it's a catalog); and it has a large subscription base because it is a leading reference magazine in the computer field (everybody gets it). These two features lead me to believe that McGraw-Hill has trouble mailing all of one month's issues on the same day.

My conclusion is that McGraw-Hill makes their monthly mailing over a period of about one week with the output sequenced alphabetically.

I feel that you are discriminating against those whose last name begins with a letter toward the end of the alphabet.

If BYTE is an influential information source, which I believe it is, then I think that the practice of mailing alphabetically means that those whose names begin with the letters "A," "B," or "C" rise in corporate structures faster in relation to their current information sources. I don't have the resources to perform a meaningful study to substantiate these assumptions, but the results of such a study would be interesting.

If BYTE is discriminatory in its mailing practices and if it is influential, then it is leading people whose names begin with something other than "A," "B," or "C" to take one of two actions: they can do nothing but also not rise in the corporate structure due to their lack of timely information; or they can inform BYTE that their "mailing name" is Aardvark or Aaron or the like. The second solution is only temporary because, as more people discover the problem and use this solution, an "alphabetic war" will break out. This will cause much havoc as subscribers race to change their names and move up on the BYTE mailing list.

Let me address a possible solution to this problem. I assume that BYTE has a computer-

(continued)

ized mailing list (it would be ludicrous to assume otherwise) and that the BYTE and McGraw-Hill staffs are computer literate (don't they read their own magazine?). Thus these staff members must be capable programmers who are only guilty of not completing the project. It should only take a small change in the algorithm to solve the problem. One solution might be to move the starting position by one-twelfth of the total subscription base each month. In this way each subscriber would get their issue on the first day once each year. This would at least even out the information gap. Although, as a point of justice, you might consider sending BYTE out in reverse alphabetic order for a period of time to correct past inequity (and let me get mine first).

I hope that you take prompt action to avert a major "alphabetic war" and the subsequent loss of personal integrity by your subscribers.

Don Zehnder
Tacoma, WA

In fact, our subscriber copies are mailed by ZIP Code rather than alphabetically. Our circulation department is taking steps to speed up delivery. We hope that these steps bring your BYTE to you earlier.

More on the Mac

I feel that I must defend Gregg Williams's Product Preview of the Apple Macintosh (May Letters, pages 14–20). I was an "Apple hater" before the company came out with this marvelous machine (I still don't like the IIe). If a previewer is justifiably excited about a new product, he should convey that excitement to the readers.

I can see why some people are thrilled about this radical new machine. If you have any idea of how ingenious the design of the Macintosh is, you probably are jumping for joy. It's about time a company comes out with a new machine rather than another clone.

I also would like to address the problem of the 128K-byte memory limitation. This is similar to the power race in home-stereo equipment several years ago. Everyone was trying to build the most powerful amplifier in the world (300 watts and above). Now the only place to find such behemoths is at flea markets. Can anyone recall that the Apple II and the Radio Shack Model III ran every piece of software imaginable with only 48K-bytes? With memory limits currently approaching 1 megabyte, sloppy programmers will continue to eat up all the memory they have until. . . (where will it end)?

Look hard at this machine and compare the hardware and software and you'll see how different the Mac is. Look at the potential it has compared with all the CP/M and IBM clones and you'll share the excitement too!

Wayne Daniel
Lafayette, LA

I'm college educated, worked as a nuclear engineer for several years in the Navy, taught high school for two years, and am employed by a major national corporation working with computer simulations. I've been working with computers since 1970 and even have designed several micros (I even have an 8008). Daily I work with state-of-the-art mainframes, minis, and micros, yet according to Gerald Evenden (May Letters, page 20) I am one of BYTE's "less-sophisticated readers" because this letter was drafted and typed on a Macintosh. The worst part is that I probably could have used this machine for years without ever realizing what Mr. Evenden was so quick to point out. I feel so ashamed!

Jonathan L. Poland
Berkeley, MO

In the bewildering personal computer marketplace, buyers often look to dependable, accurate, and honest magazines like BYTE for information. Many times they are misled by "experts" who recommend or condemn machines after only superficially examining them.

I'm writing in regard to a letter by George

(continued)

 Circle 162 for Dealer inquiries. Circle 163 for End-User inquiries.

Snoga (May Letters, page 14). It was disheartening to see someone try to compare a PCjr to a Macintosh. I was glad Gregg Williams pointed out that a Mac is much more of a PC than a PCjr, but I feel he should have gotten the point across more clearly. BYTE must maintain its respectability as a magazine by answering tough questions with tough answers. Mr. Williams's reply answered the letter writer but left me uneasy and hungry for more.

I'm surprised that Mr. Snoga said that the Mac isn't much more powerful than a PCjr because it lacks slots. Slots originally came into existence so hardware could be added to expand a machine. In those days it was necessary for microcomputers to share the microprocessor with the peripherals through the use of slots. Microprocessors were too expensive to individually implement on each and every peripheral. Today, single-chip micros cost about $8 apiece; they are inexpensive enough to put into modems, printers, plotters, etc. It is no longer necessary to have a direct processor bus connection for each peripheral because it is also no longer necessary to share the processor.

One of the best ways for the computer and it's intelligent peripherals to communicate is by means of the high-speed serial ports Macintosh uses. They transfer data at 1 megabit per second, unlike the slow RS-232C. With this arrangement you don't have to concern yourself with whether certain cards or peripherals are compatible with each other. Also, you can daisy-link the peripherals attached to the serial ports, meaning you can have more than one device on each serial port. You will *not* have to scrap your system. *Mac is truly expandable.*

As Mr. Williams pointed out, the only kinds of peripherals you can't add on are coprocessors and the like. If you really want to add this type of hardware to your machine, and if there is a very good reason for it, third-party vendors will probably pick up your problem and figure out a way around it. Besides, the speech/sound synthesizer, clock/calendar, disk controller, monitor/display circuitry, mouse interface/drivers, and serial ports are *all* built in. These are exactly the things you would fill up most expansion slots with anyway. People describe the IBM PC as having *only* five slots. But because almost everything is built in on the Macintosh, and because peripherals can be daisy-linked, it is unfair to say that the Mac has only two ports and is unexpandable.

I must admit that at first glance the PCjr and the Mac appear to be similar. Yet upon closer examination, it becomes obvious that a Macintosh is at least equal to the PC, if not better. IBM officially has no option for a second drive for the PCjr; only third-party vendors supply such. The Mac has a second drive from Apple. The Mac does not have a maximum memory of 128K bytes. The memory-upgrade motherboard (to 512K bytes using 256K-bit chips) will soon be available. The PCjr has minimal hardware expandability—it doesn't have high-speed serial ports to add peripherals as the Mac does, and it doesn't have true, open slots. You might say the Mac is upwardly compatible with the Lisa 2, but I like to view it simply as compati-

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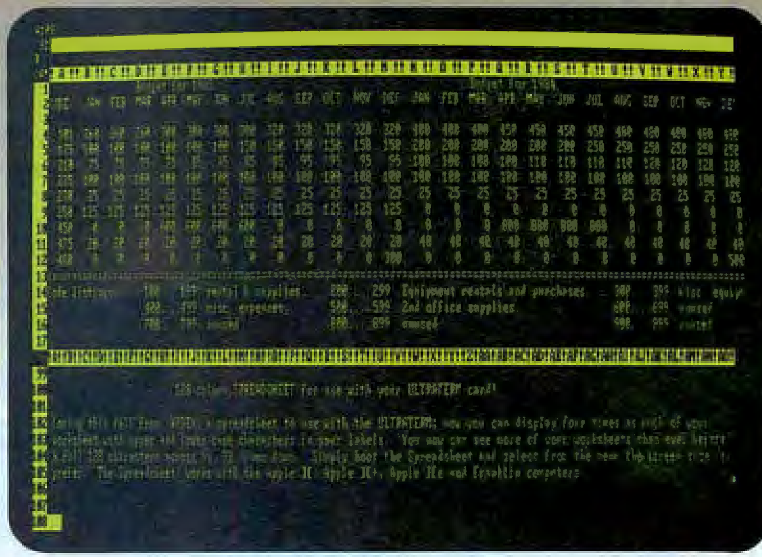

Actual photo of 128x32 screen.

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ble. The Lisa 2 is still slower than a Macintosh. It makes up for this by being able to do multitasking, but this difference may blur when Macintosh is expanded to 512K bytes. And, as Mr. Williams pointed out, who says the Macintosh can't have hard disks? There are at least two vendors working on it, excluding Apple itself. And as far as price goes, the PC and Mac are amazingly alike. After reading Mr. Williams's "Update on Apple Macintosh and Lisa 2" (May, page 339), I have to agree that the Mac would better penetrate the computer market if it were cheaper, but even at its present price, it represents a great value. Where else can you get a system with such power, fast bit-mapped graphics, and the unique user interface with the mouse for the price? Mac may no longer be inexpensive, but it's still a bargain.

Macintosh represents a breath of fresh air into the dry and dull world of me-too computers led by IBM. If Macintosh is a success, the innovation that computer companies used to put into their products will once more be felt.

J. JASON KIM
Honolulu, HI

Thanks to Gregg Williams for giving Apple the "one-two" in "Update on Apple Macintosh and Lisa 2" (May, page 339). I too feel that the Macintosh is overpriced but I bought one anyway. And let me tell you, I'm glad I did.

It's a fabulous machine that allows me the direct visual response I crave as an artist. I can't imagine going back to the old green screen after this. All computers should look this good. It looks even better with MacPaint and MacDraw. They turn this computer into a real computer-aided-design system.

I think that the Mac has a fine future, but Apple could have assured it if the Mac were priced about $500 cheaper. Maybe Apple will let us upgrade to 512K bytes for free, then it won't be so bad. One day a computer company is going to make a big hit when it realizes that price is an important consideration for the buyer, but until then, those characters look so nice. . . .

MICHAEL BRODSKY
Mt. Crawford, VA

MORE ON CLOCK-TIME BENCHMARKS

In response to Philip Ender's letter (May, page 26) regarding my article "Benchmarking FORTRAN Compilers" (February, page 218): while the user ultimately sees wall-clock time, Mr. Ender fails to note that there are all types of mainframe work loads. Also, you may have to wait in line to use a shared single-user office microcomputer or you may have to wait for a slow 16-character-per-second printer to finish printing. Because each mainframe installation may have various loads and types of loads, there is no way to include all these in a benchmark article without taking measurements at several places (such as Los Alamos, which has many heavy number crunchers; a university, with many users who do light editing; and Draper Lab, consisting of a mix of users). Usually the average waiting time in the execution-job queue is known for each mainframe site, thus no new information would be gained by including it in a benchmark. In fact, it would make comparisons difficult. Because a user also knows the difference in speeds between a slow teletype and a fast laser printer, no new information would be gained by including these I/O times in the benchmark. If a mainframe installation supports the recommended number of users and loads, then the mainframe still wins. Also note that the microcomputers are fast catching up with mainframes. Job-Step time is still the most accurate bound for comparing respective systems; you can go no faster with an unloaded mainframe system or when you don't have to wait in line to use a shared single-user office microcomputer.

AVRAM TETEWSKY
Cambridge, MA

FUTURE THEME SUGGESTED

In the Thinktank letter by John Glazer (May, page 32), Mr. Glazer states: "It is interesting to reflect on how the writing process itself is being transformed by what the computer makes possible."

This strikes me as food for thought for a future theme for BYTE: "Computers: How are they changing (can they change) the social sciences?"

In another flash of my imagination I can see BYTE keeping track of these changes.

A. C. POSADA
Charlottesville, VA

DISK PROTECTION

In regard to Steven A. Green's inquiry about airport security screens erasing his disks (May Letters, page 36): radiation is to varying degrees inhibited by lead foil; magnetic fields are not. I suggest he have someone weld him a mu-metal box big enough to hold his disk-file containers. This should protect them from all but the most intense fields he could encounter.

There are no end of devices that generate fields that can damage the fields on a disk (which are relatively feeble). Even an electric-window motor in a car or almost any solenoid valve could damage a disk close to it.

BILLY R. POGUE
Thatcher, AZ

CLOSING THE DEBATE

Douglas Davidson ("Address Calculation: The Forgotten Sort," November 1983, page 494) wrote that he had discovered a method of sorting n elements in time proportional to n. Greg Scragg (April Letters, page 20) wrote that this was impossible since it contradicted a well-known result in Knuth's *The Art of Computer Programming* that any sorting method requires time at least proportional to $n \log n$. The seeming

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contradiction is due to misconceptions by both of the writers. Scragg slightly misquotes Knuth's result. The result is that any method based on comparisons requires at least $n \log n$ comparisons to sort an arbitrary array of n elements.

Davidson makes the assumption that his method, which is actually the well-known technique of hashing, is a sorting method. In the simplest case, each element in the array gets sent to a different address according to some predetermined hash function. The order imparted by this hash function is no more a sorted order than is calling array element 1 smallest, array element 2 next smallest, etc.

Hashing is primarily a method of processing an array so that searching can take place rapidly. To find where a key is, simply compute its hash function and look in that location. This provides searching efficiently without having to sort first.

The most common situation has many elements in the array having the same hash value. These collisions are to be expected to occur frequently. They are generally resolved by using a field of each location for a pointer to a location for the colliding element, setting up a linked list. The standard measure of performance is the length of the array times the average length of the list.

RONALD J. LEACH
Washington, DC

I read with interest the article by Mr. Davidson on the subject of hash coding and the letter from Mr. Scragg in which he takes Mr. Davidson to task for his contention that the sort method he outlines performs in a time proportional to the number of items to be sorted: $[O(n)]$.

In his letter, Mr. Scragg quotes two sources that he says carry proof of this assertion that no sort can perform in a time faster than $O[(n \log n)]$. Unfortunately he is guilty of not reading the text quoted completely.

In *Fundamentals of Data Structures*, page 350, Horowitz and Sahni state quite definitely that the best time performance that can be achieved is a time proportional to n times the log base $2n$, e.g., $O[n \log n]$. This is exactly as stated by Mr. Scragg but in this case Horowitz and Sahni were discussing sort algorithms in which the only operations allowed on the keys were comparisons and interchanges. In hash coding, this is not the case, as the order of the keys is partially determined by a calculation performed on the key itself and thus it is possible to get execution time proportional to the number of elements to be sorted.

That is not to say that the method as described by Mr. Davidson is ideal or even approaching ideal. As implemented by him, the method is inefficient because it always requires much more data storage than elements to sort. It is this that produces the linear-time performance as the ratio of hits to collisions is kept nearly constant.

The real value of hash coding is in the implementation of look-up tables where there is no requirement for the data to be stored in lexicographical order and where, with more sophisticated collision-handling methods and hash-coding functions, very high percentage usage of storage can be achieved with little deterioration in response time.

The whole realm of storing and searching is complex with a great number of methods available, each with its advantages and disadvantages. It is important that before any one method is chosen all the factors are considered.

R. KENNETT
LaSalle, Quebec, Canada

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

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DEVELOPMENTS

Product News

VISICORP has cut the prices of its VisiSeries software. The price for the IBM PC version of VisiCalc has tumbled from $250 to $99. VisiWord Plus for the IBM PC has the top price in the line—$195. It once sold for $375. VisiSchedule and VisiLink for the Apple can now be bought for $149, dropping from $300 and $250, respectively. VisiCorp also announced that it recently inked a distribution agreement with First Software Corporation for 10,000 copies of FlashCalc, a $99 spreadsheet. FlashCalc, designed for the Apple IIc and IIe/II+, has variable-width columns and extensive formatting features.

MEAD DATA CENTRAL of Dayton, Ohio, has announced software that lets Apple and Wang microcomputer users gain access to its NEXIS, LEXIS, NAARS, and other information-retrieval services.

IBM ENTRY SYSTEMS DIVISION unveiled 256K-byte versions of the PC and PC XT, while at the same time reducing the price of the PC Portable and the PCjr. An entry-level PC with a 360K-byte floppy and 256K bytes of memory costs $1995. A 256K-byte PC XT starts at $4395. The Portable now costs $2595, or $3020 with a factory-installed drive. The base price of the PCjr now stands at $599. The larger version with 128K bytes of RAM and a drive has been reduced to $999.

INNOVATIVE SOFTWARE has begun marketing an enhanced version of its T.I.M IV database-management system. New features added to T.I.M., which runs on the IBM PC, let you transfer data between files while doing calculations and accumulating totals in a separate but related file. T.I.M.'s data files can handle 32,000 records; 128K bytes of memory is required. The price is $495. Owners of earlier versions can contact the company for update procedures.

EAGLE COMPUTER of Los Gatos, California, has unveiled the Turbo GT, an enhanced version of the Turbo XL. The GT comes with a 32-megabyte hard disk, 512K bytes of RAM, and a $6995 price tag. The $4995 XL has a 10-megabyte fixed disk and 256K bytes of RAM.

CORONA DATA SYSTEMS of Thousand Oaks, California, has announced 15 to 21 percent price reductions on its line of IBM PC-compatible computers. You can get a Corona desktop PC with 128K bytes of RAM, one disk drive, a keyboard, BASIC, and MS-DOS for $1950. With a monitor included, both the desktop model and the Portable PC cost $2195.

MORROW has unbundled the software packages from its Micro Decision line because surveys indicated that a majority of users didn't need most of the software packaged with the Micro Decision. The single-drive MD-1E and the MD-3E now come with the NewWord word-processing program. The MD-3E also includes a spelling checker. They go for $999 and $1499, respectively. Versions of the Micro Decision with the complete package of five application programs will still be marketed, according to spokespeople for the San Leandro, California, manufacturer.

INFOCOM's complete line of interactive fiction games now runs on the Apple Macintosh. Based in Cambridge, Massachusetts, Infocom publishes the Zork trilogy as well as a variety of whodunits and adventures.

CYBERLYNX COMPUTER PRODUCTS of Boulder, Colorado, recently demonstrated a version of its Smarthome I home-automation package that puts to work certain features of the Apple IIc. A starter kit costs $499.

VOLITION SYSTEMS recently reduced the price of its Modula-2 compilers and development systems. For the Apple II and III the prices are $295 and $395, respectively. Both the IBM PC and PC XT versions are $395. The price is $495 for Sage II/IV computers. The Advanced System Editor is $150. Volition Systems is located in Del Mar, California.

NORTH STAR COMPUTERS has slashed prices and bundled new software for its Horizon and Advantage systems. For $5400, you can get a 15-megabyte Horizon. Twice the storage can be picked up for $6400. Advantages with similar storage capacities are $200 less. A single floppy-disk drive Horizon now costs $2800, while a dual-drive Advantage goes for $2600. North Star, headquartered in San Leandro, California, is also offering fixed bundles of software at savings of from $600 to $1000 if purchased separately.

ATRON CORPORATION of Saratoga, California, recently held a series of technical seminars that demonstrated versions of its PC Probe and Software Probe that apply Microsoft's Windows environment. The Windows option includes enhancements to debug multiple programs and data areas running under different windows, hook up with symbol tables, and automatically track symbol tables and breakpoints after memory reallocation. Windows is available as an add-on software package.

NEC HOME ELECTRONICS is now selling its PC-8200 notebook computer and 14 programs for $599. For $799, you can buy a 24K-byte PC-8200 with a 300-bps modem. NEC is based in Elk Grove Village, Illinois.

LOTUS DEVELOPMENT CORPORATION, Cambridge, Massachusetts, announced that Hewlett-Packard's Portable Computer is the first system to have the 1-2-3 spreadsheet built into ROM. In a related development, a Lotus spokesperson said that 1-2-3 is available for the dual-disk and Winchester-disk-drive versions of Zenith Data Systems' Z-150.

LEADING EDGE PRODUCTS has revised the pricing of its Personal Computer. The new base price is $2695. A version of the Leading Edge computer with color graphics starts at $200 more. The company operates out of Needham Heights, Massachusetts.

FUJITSU MICROELECTRONICS reduced the price of its Micro 16s to $2350. The Micro 16sx with a 10-megabyte drive is $4250.

MICROSTUF's Crosstalk XVI data-communications software system is now included with Rixon's PC212A card modem for the IBM PC.

GENERAL ELECTRIC Information Service Company of Rockville, Maryland, has introduced and demonstrated an IBM Personal Computer interface to its computer-based comprehensive wire-transfer system, MoneyNET. MoneyNET allows corporate treasurers to initiate fund transfers and transaction processing with the Federal Reserve Bank and correspondent banks.

Industry Updates

THORN EMI COMPUTER SOFTWARE has acquired a license for the exclusive worldwide marketing and distribution rights for all products of Perfect Software Inc. The Berkeley-based Perfect Software is well known for its business applications software, including Perfect Calc and Perfect Writer. In a related development, Thorn spokespeople said that the company will publish and distribute personal computer software for business, entertainment, and education beginning in mid-1984. Thorn EMI Computer Software is a $7 million start-up company and a part of the Information Technology Group of Thorn EMI plc, a London-based multinational corporation with annual revenues in excess of $4 billion.

(continued)

COMPUTER ASSOCIATES INTERNATIONAL has acquired all the assets of Sorcim Corporation, makers of SuperCalc. Terms called for cash payments totaling $17.6 million over a five-year period, plus contingent payments of almost $9 million. Headquarters for Computer Associates is in Jericho, New York. Sorcim is based in San Jose, California.

PRACTICORP INTERNATIONAL is the new name resulting from the merger of Micro Software International and Computer Software Associates. Both companies developed and marketed PractiCalc and other products bearing the Practi- prefix for Apple, Commodore, and now IBM computers. Practicorp International Inc. maintains corporate offices in Newton Upper Falls, Massachusetts.

TAVA CORPORATION has agreed to bundle Computer Creations' Ultimate 5-in-1 with its IBM PC-compatible computer. The Ultimate is a combination package containing Z-Com electronic-mail, dictionary, word-processing, database-management, and mail-merge abilities.

SOFTECH MICROSYSTEMS announced an agreement with Business Solutions to market Jack2, an integrated package with word-processing, graphics, spreadsheet, and database-management capabilities. The list price is $495.

BYTE's Bits

TDI Brings ETH Modula-2 Software to Commercial Market

TDI Ltd. has signed an agreement with Niklaus Wirth and ETH Zürich that allows TDI to offer a family of portable, modifiable Modula-2-based operating systems and application programs derived from software created at ETH. The agreement allows TDI to license the enhanced software to commercial users (along with extensive documentation and support) for a per-machine price and to educational users at a lower per-site price. This is said to be in keeping with TDI pricing policies that "encourage the widest possible distribution and use of the software."

The software line, called Liberator, promises several advantages to both users and programmers because of the company's commitment to creating high-performance software that will run only on 32-bit microprocessors. Its use of Modula-2 guarantees that programmers can more easily modify software and move it to other computer systems (TDI will sell the source code for all products for an additional fee). Both operating-system and application software will use windows, menus, and mice; users can modify menu descriptions, error messages, and Help files by editing text files associated with the program.

TDI's first major product is a Modula-2 programming environment/operating system called Moses. Future products will include application programs and more sophisticated operating systems. TDI is serving as a clearinghouse for unsupported Modula-2-related compilers and application programs originally available from ETH Zürich. In a related development, TDI said that it will occasionally make changes or extensions to the Modula-2 implementations it provides; the company pledges that it will only make changes approved by Niklaus Wirth. For more information contact TDI Ltd., 29 Alma Vale Rd., Bristol BS8 4NJ, England; telephone (0272) 742796.

Omikron Reorganizes Under Chapter 11

On February 21, 1984, Omikron filed for bankruptcy under Chapter 11 of the Federal bankruptcy laws. Omikron made a name for itself supporting CP/M products for the Radio Shack TRS-80 microcomputer. Problems arose when a number of bugs forced a delay in a major project while at the same time several competitors entered the market.

The company continues to operate, but it has had to cut back on services such as toll-free customer lines and reduce its advertising budget and personnel staff.

Customers with products on order or refunds due will receive complete information shortly. Omikron has formulated a plan to meet its obligations but must await the approval of the bankruptcy court before it can be carried out.

Omikron maintains its offices at 1127 Hearst St., Berkeley, CA 94702.

Bug Snoops Sought

Want a checkbook system for the IBM PC? If so, contact Computer Tax Service in Incline Village, Nevada. For $30 you can pick up beta-test copies of a program called *Money Street*.

Testers will hunt for bugs, critique documentation, suggest improvements, and help fine-tune the product. In return, they will get the final version of Money Street free, a testers' newsletter, and discounts on future software purchases.

"We want testers to bash it, smash it, and try to crash it," says Bob Payne of Computer Tax Service. "Just to get their blood pumping, we hid a few bugs in it."

For more information, contact Computer Tax Service, POB 4845, Incline Village, NV 89450, (702) 831-4300 or 832-1001.

Kraft Announces Contest Winners

Paula Boge, a 16-year old from Dubuque, Iowa, won the grand prize trip to the EPCOT Center in Florida in the recent Kraft Kideo Game Contest. Ms. Boge elected to take the cash equivalent of the trip, approximately $4000, and buy a computer for her family.

The Kraft Kideo Game Contest challenged students 18 and under to devise a concept for a nutrition-oriented computer game geared toward younger children. Ms. Boge's entry, called Health Habits, was awarded top spot in the competition that featured more than 800 entries from 47 states. Nibbles, the main character of her game, takes children through the adventures and misadventures of achieving good health habits.

(continued)

UNIX™ System V from AT&T can help you close a sale, as well as open up new markets.

It's another reason why good business decisions are based on UNIX System V from AT&T.

More and more of your customers will be demanding multi-user and multi-tasking systems. The benefits of UNIX System V—portability, reliability, flexibility—make it the ideal software system for this lucrative market.

In addition, AT&T will support UNIX System V with the service, training, and documentation resellers need to prosper.

More choices, more opportunities

UNIX System V is virtually hardware independent. So you'll be able to configure systems using equipment from a variety of vendors.

You can use the flexibility of UNIX System V as a real selling point to customers who want to add hardware that is compatible with the machines they already have.

And over the long term, UNIX System V offers continuing opportunities to upgrade and expand your customers' systems. End-user flexibility translates into market opportunity for the reseller.

Software that sells

UNIX System V offers

In all, 22 prizes were awarded by a panel of computer experts, nutritionists, educators, and whiz kids.

Multiuser System Network Tested in Miami

An interactive multiuser computer system that allows 45 people to participate simultaneously is being tested in the Miami area by American Software Technology. The system, called Enternet, is designed to allow users to interact with each other and the host computer in real time.

For the test, the company has created Fazuul, an interplanetary adventure game. The player crash-lands on Fazuul, and he or she must pose questions and analyze clues to escape. Players can team up to beat the game or work against other participants. All game commands are in English.

If you live in the test area and own a 300- or 1200-bps modem, you can gain access to Enternet by calling 866-8060. The host computer will verify your telephone number and billing information (MasterCard, VISA, or prepayment) and provide instructions on how to play the game.

Call for Papers

The conference committee for the 1985 ASME International Computers in Engineering Conference and Exhibition has issued a call for papers that address the theme "Expert Systems: A New Dimension in Computer Engineering." The venue will be the Sheraton Boston Hotel, August 4–8, 1985.

Papers are solicited in all areas related to the research, development, and application of computers in mechanical engineering with a focus on expert systems, including computer-aided manufacturing, simulation, robotics, engineering software and standards, and finite-element techniques. Contributions in the form of a full-length paper or an extended abstract are sought.

A November 15, 1984, deadline has been set for the submission of abstracts. Three copies of the finished contribution must be submitted by January 15, 1985. The date for notification of acceptance is February 15, 1985. Contributions must be submitted to the appropriate technical program chairperson. For a list of names and addresses, contact the American Society of Mechanical Engineers, 345 East 47th St., New York, NY 10017.

Public-Domain Software Sales and Rentals

P.J.'s Company of Vista, California, offers noncopyrighted, public-domain software in its original source code. Three software libraries, CP/M, SIG/M, and IBM PC, are available. Each library is a collection of volumes from a users group and is made up of game, utility, and business programs. Computerists can freely copy and exchange the libraries using Digital Research's CP/M versions 1.4, 2.2, or 3.0 and 241K-byte 8-inch single-sided single-density IBM-3740-format drives. PC-DOS and most 5¼-inch floppy-disk-drive formats are supported.

The CP/M Users Group library has 92 volumes, the SIG/M library offers 148, and the IBM PC library has more than 100. Additional services include telephone ordering and automatic updates.

The complete CP/M library can be rented for $45. The SIG/M library rents for $75, and the IBM PC library rents for $99.50. Add $7.50 for shipping, handling, and insurance. The rental term is seven days after receipt, with a three-day grace period for return. For more information, contact P.J.'s Co., 1062 Taylor St., Vista, CA 92083, (619) 941-0925.

BYTE's Bugs

Misplaced Lines

Dr. Antonio Salvadori, associate professor of physical science at the University of Guelph in Canada, spotted a bug in Stephen Bourne's article "The Unix Shell" (October 1983, page 187). The five lines on page 190 in the third column that begin "is an append command . . . ," should be replaced with the following: "is the Shell program called temporarily to execute a file. Files have three independent attributes—read, write, and execute. If wg is executable, then. . ."

Sieve of Eratosthenes Algorithm Defended

A BYTE reader wrote us expressing his confusion over the validity of the Sieve of Eratosthenes algorithm that accompanied Jacques Bensimon's March article "STSC APL*PLUS and IBM PC APL: Two APLs for the IBM PC" (page 246). Specifically, the reader became befuddled with Mr. Bensimon's BASIC prime-number-generating program (listing 2b, page 254), which produces an answer of "'1899 PRIMES' when in fact there are only 1028 primes between 2 and 8191."

"The problem with this . . . program," the reader wrote, "seems to be a faulty method for incorporating a sure and certain speed-up of the 'standard' sieve; after discarding all multiples of 2, . . . one only has to eliminate the odd multiples of 3, 5, 7, 11, etc. . . . After spending a lot of time unsuccessfully trying to accomplish this using only one FOR. . .NEXT loop, I have come to believe that the most efficient way to obtain this speed-up is to eliminate all odd multiples of 2, 3, 5, etc., in a first pass. What remains is either prime or a power of 2. A second pass to eliminate 4, 8, 16, 32, etc., leaves only the primes. My Turbo Pascal version of this runs 10 iterations in about 13.5 seconds."

We sent a copy of the letter to Jacques Ben-

(continued)

simon, who responded by telling us ". . . the Sieve of Eratosthenes it certainly is!" According to Mr. Bensimon, the figure 1899 is the correct number of primes between 3 and 16,383 (i.e., 2 × 8191 + 1). The algorithm avoids even numbers entirely because it operates on flag vector **F** of 8191 elements, which represent all odd numbers between 3 and 16,383. The variable *P* steps through the 1899 distinct prime values during execution.

Tiger and Dragon Mixed with Wrong Formula

Dan Rollins's article "A Tiger Meets a Dragon" (December 1983, page 457) motivated Mexico City's Ruben Chaves Misrahi to write a Pascal program to graph dragons of different orders on his Apple IIe. In the process, Mr. Misrahi discovered a bug that has a solution that may not be obvious.

Mr. Rollins's generalized dragon formula in the last column on page 459 is incorrect. According to Mr. Misrahi, the correct formula is

$$S(n) = S(n'1) + d_n + \overline{S(n-1)}$$

using S(O) = 0 null <sequence>

In a letter to us confirming this bug and its correction, Mr. Rollins notes that many of his article's readers failed to realize that the Gendragon program (listing 1, page 460) does not have to be used with the plotter emulator (listing 2, page 475). In addition, if you replace the GOSUB 1500 in line 550 with PSET (X,Y), you can transport the program to many machines. Mr. Rollins also reports that an order-11 dragon curve can be displayed directly on an IBM PC's monitor and printed out with a graphics screen-dump program.

Important Biographical Info Omitted

We inadvertently left out some important biographical information about Scot Kamins, the author of "Macintosh BASIC" (April, page 318). Mr. Kamins coauthored with Mitch Waite *Apple Blackjack: Humanized Programming in BASIC* (McGraw-Hill/BYTE Books, 1982). He has written a number of manuals for Apple Computer Inc., including the *Applesoft Programmer's Reference Manual* and the *Macintosh BASIC Reference Manual*.

Mr. Kamins is currently writing a series of books on Macintosh BASIC that is to be published in the fall. He is a senior technical writer for Technology Translated Inc. (1047 Sutter St., San Francisco, CA 94109), a technical writing concern.

We apologize for our mistake.

Greater Memory Expansion

You can expand the RAM of Digital Equipment Corporation's Rainbow 100B *by* 768K bytes (for a total of 896K bytes), not *to* 768K bytes as we erroneously reported (June What's New, page 50). We apologize for the error.

It comes with 128K bytes of RAM, a pair of 400K-byte 5¼-inch floppy-disk drives, and dual Z80 and 8088 processors. Without a keyboard or monitor but with CP/M-80, CP/M-86 version 2.00, and MS-DOS version 2.05, it costs $2750. ■

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Introducing VidLink.™ The software-video technology that will literally revolutionize the way you see your computer.

Using a cable that connects a Pioneer® LD-700 Laser-Disc Player to your Commodore 64™ (and soon an IBM® PC or Apple® II), VidLink lets you key up visual information from virtually any videodisc. With

everything from *NFL Videodiscs* to a trivia quiz disc like *Maze Mania.*

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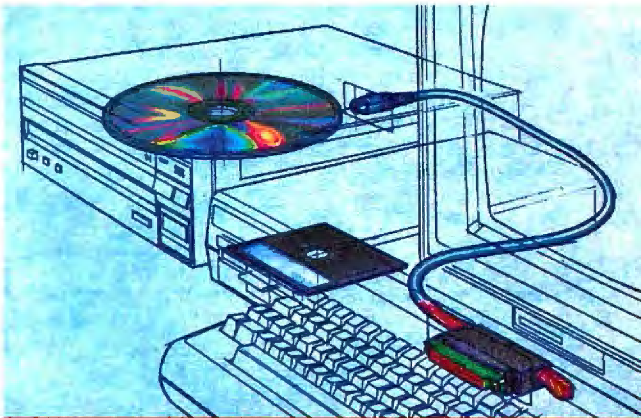
But perhaps the most unexpected feature is the price. Just $49.00* gives you VidLink, one of the many visions we see in the future of computer-video.

VidLink is only available direct from Digital Research. To order yours, and titles like *Murder, Anyone?*, *Maze Mania* or *First National Kiddisc,* just have your American Express,® Visa® or MasterCard® ready. Then pick up your old-fashioned phone and enter these familiar characters: 1-800-227-6703, or in California: 1-800-632-7979.



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Circle 102 on inquiry card.

Compaq Transportable Computers Get Stay-at-Home Brothers

Compaq Computer Corporation has expanded its product line to include four desktop machines based on a full 16-bit 8086 processor with a clock speed of 7.14 MHz. The new machines can use all software and hardware for the IBM PC and PC XT, the company says.

Because some telecommunications software and games will not run properly at the 7.14-MHz speed (the IBM's 8088 runs at 4.7 MHz), the clock can be slowed from the keyboard or by instructions in software. An LED on the front of the system unit indicates what speed the processor is operating at.

The entry-level machine in the Deskpro line is the Model 1. This $2495 machine has a single floppy-disk drive and 128K bytes of RAM. The Model 2, at $2995, has two floppy-disk drives and 256K bytes of RAM. The $4995 Model 3 has 256K bytes of RAM, one floppy-disk drive, one 10-megabyte Winchester-disk drive, and a serial/clock card. The top-of-the-line Model 4 costs $7195 and has 640K bytes of RAM, one floppy-disk drive, one 10-megabyte Winchester-disk drive, one 10-megabyte cartridge-tape drive for Winchester backup, and a serial/clock card. All models include a 12-inch green or amber monitor, an interface for an RGB color monitor, and a parallel printer port.

All models can accommodate up to 640K bytes of RAM on the main system board and support four half-height mass-storage devices in the system unit. These include combinations of up to two 360K-byte floppy-disk drives (controlled by one card, which also can control a tape-cartridge drive), two 10-megabyte Winchester-disk drives (controlled by one card), and one 10-megabyte tape-cartridge drive for Winchester backup. Technology developed for the Compaq Plus transportable with a Winchester drive is used to shock-mount all mass-storage devices in the Deskpro series. A 200-watt, 3-amp power supply is standard and can support any combination of internal mass-storage devices.

All models have eight expansion slots, seven full-length and one short. The floppy-disk controller (with parallel printer port) occupies one slot in all configurations, as does the video board. Models with hard-disk drives add the serial/clock card in the short slot and the Winchester controller in a long slot. This leaves five long slots and one short slot open in floppy-disk configurations and four long slots open in hard-disk units.

The display features auto switching between text and graphics on the same monitor. In alpha mode, the monitor has a 9- by 14-dot character matrix and overall resolution of 720 by 350 pixels. The alpha/graphics mode drops to a character matrix of 8 by 8 dots for a standard 80-character by 25-line screen or a 16 by 8 matrix for a 40-character by 25-line screen; resolution overall is 640 by 200 pixels monochrome or 320 by 200 in four colors or gray levels (each pixel requires 2 bits).

The IBM PC keyboard layout is used, but LEDs have been added to the Cap-Lock and Num-Lock keys. A 10-character type-ahead buffer is provided.

The tape system uses 8 tracks in a serpentine pattern with 59 tracks per inch and 158 blocks per track. Recording density is 6400 bits per inch encoded using MFM method. Data transfer rate is 250K bits per second.

Software, except for a diagnostics disk, is not bundled. Compaq's MS-DOS 2.11 and BASIC cost $60. A tilt-and-swivel stand for the monitor is $50, and a small platform to allow storing the keyboard under the system unit is $50.

For more information, contact Compaq Computer Corp., 20333 FM 149, Houston, TX 77070, (713) 370-7040.

Circle 600 on inquiry card.

Low-Cost Plotter Produces Four Colors

Sharp Electronics has set a $399 suggested retail price for its CE-515P four-color plotter. The CE-515P uses black, blue, green, and red pens that can be programmed to change automatically. The minimum shifting width of the ball pens is 0.2 mm. The size of an alphanumeric character when produced in the four-step by six-step mode is 0.8 mm wide by 1.2 mm tall. It can handle paper up to 8½ inches wide and plot on postcard-sized documents. Roll-feed paper and transparency sheets can be used.

Both EIA standard RS-232C serial and Centronics-type parallel interfaces are built into the CE-515P. The plotter can be driven by most microcomputers that use BASIC, such as the Apple. Other built-in features include circle, paint, and axis commands.

Softkey's Keychart is bundled with the CE-515P. Keychart, which provides IBM PC compatibility, is a presentation graphics product. It uses a menu-driven fill-in-the-blank format to produce a variety of multisized charts.

Sharp is working with a number of software houses to make a substantial software base for the CE-515P. Contact Sharp Electronics Corp., Systems Division, 10 Sharp Plaza, Paramus, NJ 07652, (201) 265-5600.

Circle 601 on inquiry card.

(continued)

The automatic transmission with a $250 differential.

What a way to travel! The Password™ modem is geared to transmit up to 120 characters a second from anywhere to anywhere else in the country at the push of a button. Adjusts automatically to any speed — moving at a high of 1200 baud, or down-shifting all the way to 300 baud.

Totally compatible, it lets any microcomputer phone-communicate with *any* other microcomputer. Easily portable, it parks almost anywhere thanks to the convenience of Velcro™ strips.

The Password modem turns out text ten times faster than an expert typist — sends thousands of words by phone for less than express mail. And our automatic transmission comes through in the clutch by automatically dialing or answering your calls. Now look at the sticker price! At $449, we're about $250 less than the best-known modem. A very sizeable difference. Especially considering that both send and receive at the same speeds, and both carry a two-year limited warranty.

The Password modem. High performance at a compact price.

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For a poster size reprint of this ad, send $3.00 to U.S. Robotics, Inc.

Circle 310 on inquiry card.

MS-DOS Portable, Pivot Has Modem, Drive Built In

Pivot, a portable 16-bit computer from Morrow, combines a modem, clock, calculator, and 5¼-inch floppy-disk drive in a 9-pound package. It's available in three 128K-byte versions, with prices starting at less than $2500.

Pivot uses Microsoft's MS-DOS 2.0 operating system, which provides access to hundreds of business applications. It's based on the CMOS 80C86 microprocessor and comes with a 16-line by 80-character, high-resolution LCD display.

The battery-backed real-time clock/calendar is accessed by the clock icon on the Pivot's keyboard, which has 63 programmable keys, 10 function keys, and a 22-key calculator overlay. If you need to know the time in Japan, you can get the correct time there by locating it on the world map Pivot can display. The four-function calculator will accept up to 256 entries of 16 digits each, and it automatically inserts decimal points and commas.

The built-in modem operates at 300 bps under AT&T 103 protocol. ROM-based software lets Pivot emulate a dumb terminal for data communications with electronic services. You can exit an applications program, access a database, and insert retrieved data into the application. With communications software, you can have a full-duplex modem with auto-answer and auto-dial features for both tone and rotary-pulse dialing.

All versions of Pivot run on 12-volt DC power. An optional rechargeable 1.5-pound VCR nicad battery provides up to five hours of additional power. The battery module fits inside Pivot and costs $50. Pivot measures 13 by 13 inches when open. When shut, it measures 13 by 5.6 by 9.5 inches.

The Pivot family includes one or two double-sided, double-density 5¼-inch floppy-disk drives using nine-sectored IBM PC format with memory capacities of up to 512K bytes and bit-mapped graphics with 480- by 128-pixel resolution. They have three interface ports: a parallel port that mimics IBM PC I/O, an RS-232C serial port with programmable data rates from 300 to 19,200 bps, asynchronous or synchronous, and an RJ11C port to connect the modem to standard telephone lines. For complete details, contact Morrow Inc., 600 McCormick St., San Leandro, CA 94577, (415) 430-1970.

Circle 602 on inquiry card.

10-Net: IBM PC Network

Fox Research markets a kit of hardware, software, and utilities for linking IBM Personal Computers into a high-speed local-area network. With 10-Net users can share applications, files, storage devices, and printers. 10-Net costs $695 per user.

10-Net does not require a dedicated file server. It works with twisted-pair cabling and operates at 1 million bps. 10-Net extends up to 3000 feet, and repeaters increase its range to 1 mile. It's Ethernet-compatible with regard to message formatting and addressing. Record locking and several levels of password security ensure file and data integrity. Network utilities provide a calendar and electronic mail.

As a complement to 10-Net, Fox Research has released a network version of its 10-Base relational database-management system. 10-Base permits single-query access to multiple files, and it places no restrictions on the number of files that can be created. A bridge feature lets you exchange information with more than 100 popular microcomputer programs, and a forms manager lets you design custom screens and forms.

The network version lets you set up a distributed database. With the assistance of a system configuration table, you can locate 10-Base's data dictionary, files, and other resources anywhere within the network. Its architecture provides for 65-character path names.

Minimum system requirements are an IBM PC, PC XT, or compatible, PC-DOS 2.0 or later, 128K bytes of RAM, and a disk drive. The network version of 10-Base is $895 per network system. Additional manuals are $75. Contact Fox Research Inc., 7005 Corporate Way, Dayton, OH 45459, (513) 433-2238.

Circle 604 on inquiry card.

Five Programs Constitute Enable

Enable for the IBM PC comprises five integrated software modules: word processing, spreadsheet, graphics, database management, and telecommunications. You can generate a graph from the spreadsheet, then insert the graph and spreadsheet in text and print the whole package. You can select information for the database using Enable's query language and insert it anywhere without worry because Enable automatically expands the column length and modifies formulas.

It uses a master control module (MCM) that supervises the activities of each module and serves as the sole interface between you and the modules. It has a consistent set of commands. English-language menus with explanatory messages are available in each module. Menu options can be selected with the cursor or a keystroke. Expert commands that bypass the menus are available.

Enable lets you run one application, one communications, and one printing program concurrently. Its macro facility can record keystrokes and commands as they are executed. You can edit stored commands with the word processor.

Enable provides up to eight separate windows that you can size, shape, overlap, or zoom to full-screen length. Data can be cut and pasted from window to window with a minimum of keystrokes. Files created by such programs as dBASE II, Lotus 1-2-3, WordStar, VisiCalc, EasyWriter I, and Volkswriter can be used without rekeying or conversion. Enable can create files in the proper format for each of these programs.

Two disk drives and 192K bytes of memory are required. It lists for $695. For full details on the word processor's editing features or the seven graph types of the graphics module, contact The Software Group, Northway Ten Executive Park, Ballston Lake, NY 12019, (518) 877-8600.

Circle 603 on inquiry card.

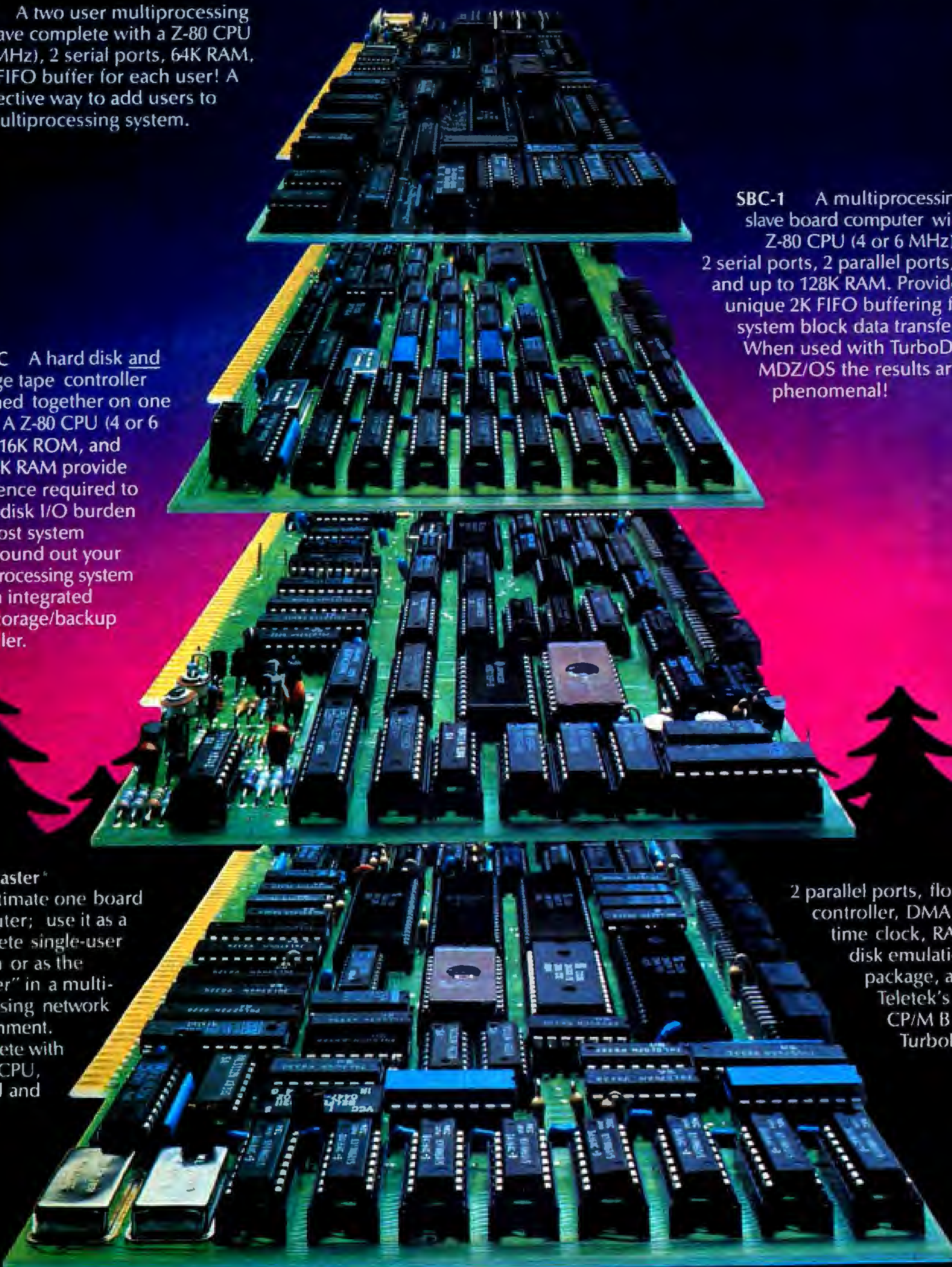
(continued)

Our Family Tree Is Growing Again

SBC-II A two user multiprocessing S-100 slave complete with a Z-80 CPU (4 or 6 MHz), 2 serial ports, 64K RAM, and 2K FIFO buffer for each user! A cost effective way to add users to your multiprocessing system.

SBC-1 A multiprocessing slave board computer with Z-80 CPU (4 or 6 MHz), 2 serial ports, 2 parallel ports, and up to 128K RAM. Provides unique 2K FIFO buffering for system block data transfers. When used with TurboDOS or MDZ/OS the results are phenomenal!

HD/CTC A hard disk and cartridge tape controller combined together on one board! A Z-80 CPU (4 or 6 MHz); 16K ROM, and up to 8K RAM provide intelligence required to relieve disk I/O burden from host system CPU. Round out your multi-processing system with an integrated mass storage/backup controller.



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The ultimate one board computer; use it as a complete single-user system or as the "master" in a multi-processing network environment. Complete with Z-80A CPU, 2 serial and 2 parallel ports, floppy controller, DMA, real time clock, RAM drive disk emulation package, and Teletek's advanced CP/M BIOS or TurboDOS.

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TELETEK

Preprogrammed Hero

Heath's preprogrammed personal robot, Hero Jr., roams, explores, sings, and speaks English. It'll wake you in the morning (a 10-minute snooze period is built-in), play games, and guard your house with an optional security system. A Motorola 146818 CMOS 100-year calendar/clock provides the date, day of week, and time, and it adjusts itself for biannual time changes.

Hero Jr. trundles about randomly on its three wheels, and a wireless remote control lets you drive it around. For sound sensing, it has a 256-bit resolution sound sensor with adjustable range and a 200- to 5000-Hz bandwidth. A 256-bit resolution light sensor with adjustable range and a 25-degree reception angle is provided. Its ultrasonic sonar can accurately measure distances from 4 inches to about 25 feet. Speech synthesis equipment includes a Votrax SC-01, with 4 pitch levels and 64 phonemes.

It can carry up to 10 pounds on a 94-cubic-inch compartment. A 17-key keypad lets you modify its personality or initiate a special task. Eight data LEDs flash in time with its speech or indicate sound levels when it listens. Rear connectors include a charger jack, on/off switch, sleep switch, and an RS-232C interface.

The operation of Hero Jr.'s personality traits can be increased or decreased through software. A Hero Jr. BASIC cartridge permits programming through its RS-232C port. Additional preprogrammed game/entertainment cartridges will be available.

Hero Jr. uses a Motorola 6808 microprocessor. It has 32K bytes of monitor ROM, 8K bytes of RAM, and provisions for up to 16K bytes of ROM or RAM as well as for 4K or 8K bytes of plug-in ROM cartridges. It's built with three circuit boards: microprocessor, power supply/sense, and keyboard. Two Motorola 6821 parallel interface adapters are incorporated into its design.

For steering, it uses a 180-degree rotation, stepper-type motor, and a 12-volt DC motor for the drive. It's powered by two 6-volt, rechargeable lead/acid gelled-electrolyte batteries; two optional cells double operating time. It stands 19 inches tall and weighs 21.4 pounds.

Hero Jr. costs approximately $1000. Contact Heath Co., Dept. 150-375, Hilltop Rd., Benton Harbor, MI 49022.

Circle 605 on inquiry card.

Input Console Eliminates Rote Commands

Polytel Computer Products' Keyport 300 is a 300-key programmable input device for the home, office, and school. Available for the Apple II series, the Commodore 64, and the IBM PC or PC XT, Keyport uses interchangeable overlays known as Keyware. These overlays organize the commands associated with, for instance, a spreadsheet in such a fashion that anyone, regardless of computer expertise, can use the program immediately. The need to learn a command language is eliminated.

With the Keyware overlays, Keyport translates commands into languages the computer understands. It uses single keystrokes, and the command outlines are written in plain English.

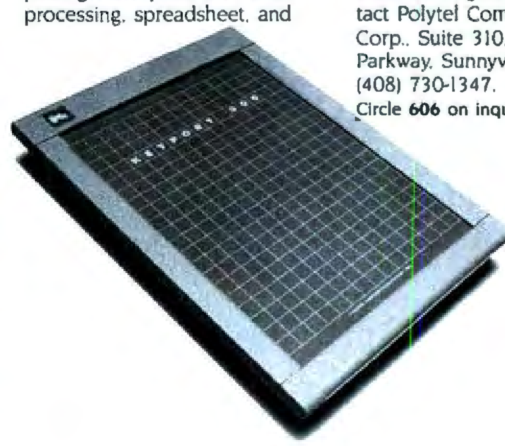
A library of preprogrammed Keyware overlays for spreadsheet, word-processing, and integrated programs is available. You can create custom overlays using Keyport's programmable keys.

Keyport 300 uses a membrane keyboard; it has no integrated circuits or moving parts. It measures 9½ by 12¾ inches. To use this system, you plug Keyport into the computer, load a Keyware disk, fit the program overlay onto Keyport, and begin programming.

A larger version of Keyport, the 717, which features 717 programmable keys, is available for the Apple only.

An Executive Keyport 300 package, complete with word-processing, spreadsheet, and graphics demonstration overlays, is available for $299. The Keyport 717 with educational software begins at $179. Contact Polytel Computer Products Corp., Suite 310, 1250 Oakmead Parkway, Sunnyvale, CA 94086, (408) 730-1347.

Circle 606 on inquiry card.

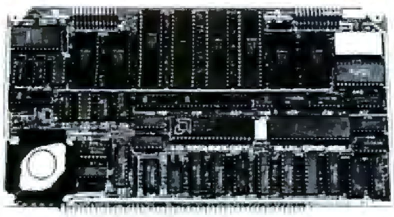


(continued)

INPUT/OUTPUT TECHNOLOGY, INC.

25327 Avenue Stanford, Unit 113, Valencia, CA 91355 • (805) 257-1000

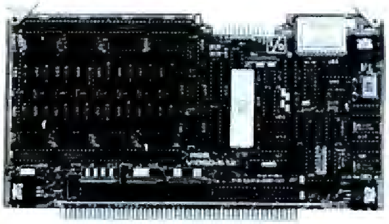
Uncompromising Additions to your S-100/IEEE-696 BUS



DUAL GPIB-488 INTERFACE BOARD

A Stand-Alone, Independently Controlled Dual Channel IEEE-488 I/O Processor. Interface Activity Modes for Controller-in-Charge, Controller Assigned or Terminal Bus Slave, and all Interface Functions are handled transparent to Host System CPU through an on-board CPU and DMA controller. User Friendly operation.

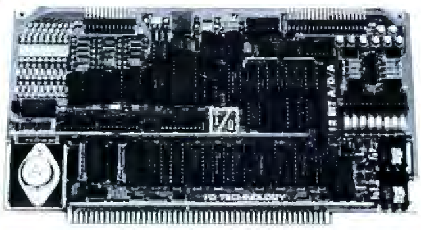
A&T, P/N 52748-800-102



RGB COLOR GRAPHICS BOARD

Programmable resolution up to 512 x 512 pixels with 4 local video planes and on-board graphics processor. Color mapper allows 16 colors from a palette of 4096. Light pen input. Plus more ...

A&T, P/N 52748-300-101



12-BIT A-D-A CONVERTER BOARD

8 Channel A-D: 12 microsec. Conversion, 50KHz Sample Rate, Programmable Gains, Offset and Diff./Single Modes.
8 Channel D-A: 2 microsec. Settling, Bipolar V or Unipolar I Output. Programmable Reference levels, Dual-Ported Channel Refresh RAM. **16/8-Bit Data Transfers** via I/O or Memory Mapped

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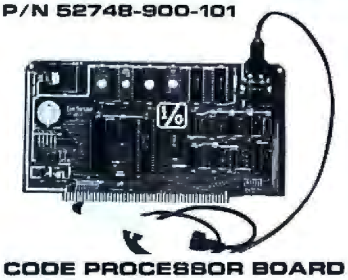
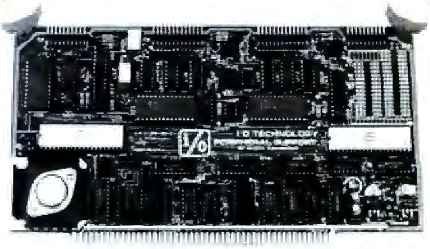


BAR CODE PROCESSOR BOARD

The BarTender is a stand-alone I/O Processor that reads and prints most common Bar Codes. Includes bi-directional reading, wand interface, clock/calendar with battery. Extensive documentation and software.

A&T, 52748-500-101 Without Wand
A&T, 52748-500-201 With Wand



PERIPHERAL SUPPORT BOARD

Two Serial SYNC/ASYNC Ports with RS-232, TTL or Current Loop Outputs, three 8-Bit Parallel Ports, three Timers, Real Time Clock/Calendar and Response Programmable Interrupt Controller. Small Proto Area with +5 and ±12v.

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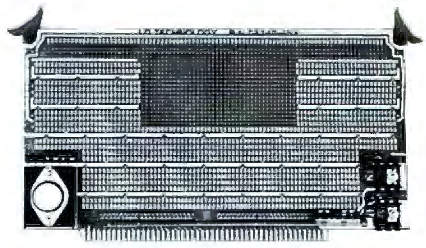


MULTI-PURPOSE PROTOTYPING KIT

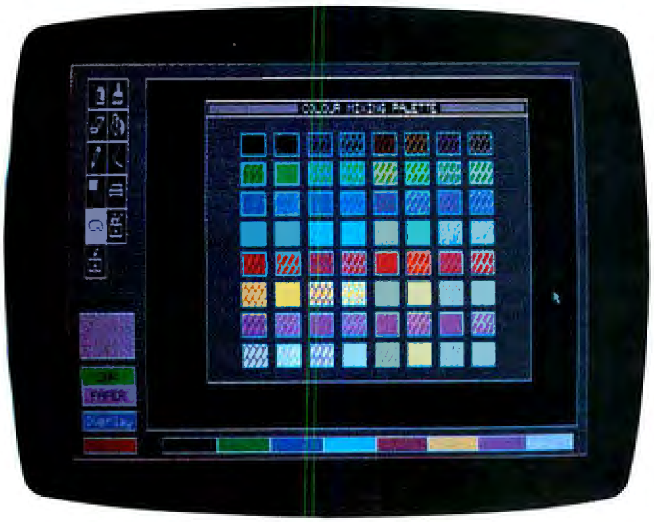
Industrial Quality with Plated-Thru holes for Wire-Wrap or Solder projects. Complete with +5, ±12v Regulators, Bus Bar, Filter Capacitors, and Manual.

P/N 52748-450 Circle 157 on inquiry card.

ALSO AVAILABLE: MULTI-FUNCTION I/O BOARD, SMART PROTOTYPING KIT, 128Kx8/64Kx16 STATIC RAM MODULE

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

SagePaint Drawing Program



SagePaint is a color-graphics drawing program from Sage Computer.

Written in UCSD Pascal, it runs on a Sage II or IV computer enhanced by the Pluto graphics subsystem. The program uses a three-button mouse to draw eight-color graphics in 288- by 568-pixel resolution. Using the metaphor of pen and ink, the user can mix foreground and background colors to create a wider variety of "paints" than the eight pure colors that are supplied.

The user can select functions from a menu of graphic icons displayed on screen. The program can draw brush strokes and thin lines, erase, fill an enclosed area, copy and modify rectangular areas of graphics, and enter text in one size.

SagePaint's price was not available at press date but was estimated to be about $400 for the program itself and $1000 for the source code.

For further information, direct your inquiries to Sage Computer, 4905 Energy Way, Reno, NV 89502, (702) 322-6868.

Circle 607 on inquiry card.

Photo 1: *SagePaint's color mixing palette. On the left-hand side of the screen, you can select functions from the icon menu.*

Portable Drive for Notebook Computers

The Bullet, a mass-storage system for such notebook computers as the Radio Shack TRS-80 Model 100, the Olivetti M-10, and the NEC 8201, is produced and manufactured by Holmes Engineering. It plugs directly into the computer's RS-232C port and operates using menu-driven commands from the computer. Power is drawn from rechargeable batteries or from a battery charger/power transformer.

The Bullet uses thin wafer-type tape cassettes; each can store up to 64K bytes of data on its continuous loop. A ROM-based operating system gives the Bullet a rapid load/save response time; for example, a 10K-byte file can be saved and verified in about 40 seconds.

It's housed in a cabinet that complements the Model 100's color. The 3¾-pound Bullet measures 8 inches wide, 5½ inches deep, and 2½ inches high. With cables, wafer tape, manual, and battery charger/power transformer, the Bullet is $369.95. Contact Holmes Engineering Inc., 5175 Green Pine Dr., Salt Lake City, UT 84107, (801) 261-5652.

Circle 608 on inquiry card.

Intelligent Copier/Printer Uses 68000

The K-2 intelligent copier/printer from Kentek Information Systems has the ability to merge multiple fonts, customized logograms and signatures, and business graphics. It uses electrophotographic technology and is designed to print letter-quality text and graphics from virtually any host microcomputer.

Its on-board intelligence centers around a Motorola MC68000 microprocessor, supported by a 5¼-inch floppy disk. It can perform a variety of program control functions ranging from the selection of page sizes, print orientation, and fonts to the generation of highly complex vector graphics such as computer-aided designs, statistical symbols, line drawings, and technical diagrams.

The data stream of text and graphics can be fed from your computer to the K-2's on-board controller. In turn, the controller computes the corresponding all-points-addressable bit-map pattern for transfer to the LED array printing head, which is focused on an organic photoconductor belt. It yields a 240- by 240-pixel-per-inch image at a rate of 12 pages per minute.

The print engine uses a two-component dry toner that is heat and pressure fused.

Two paper cassettes are available to feed 16- to 64-pound bond, letterhead, transparencies, pressure-sensitive labels, perforated sheets, and envelopes. Paper sizes range from 5½ by 8½ inches to 8½ by 14 inches. Envelope sizes are 8¾ by 4⅛ inches to 6½ by 3½ inches.

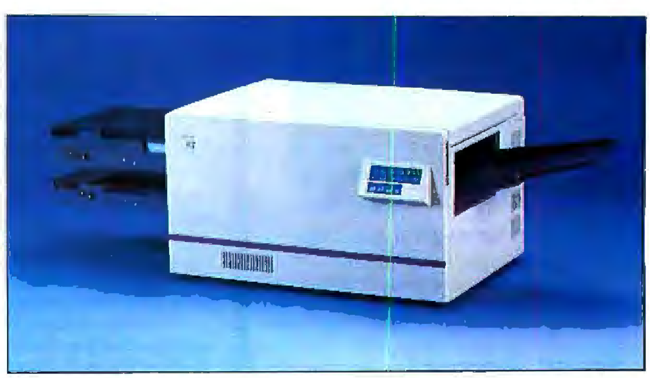
The K-2 supports character variables, including line density in standard text of 5, 5.33, 6, 8, and 24 lines per inch. Line spacing is available in single, double, triple, half, and one and a half. Character pitches include 10, 12, and 15 with or without proportional spacing. All characters can be rotated.

Font selection and management is controlled by the host computer and limited only by the capacity of the floppy disk. Disks are capable of storing more than 30 fonts of 154 characters each.

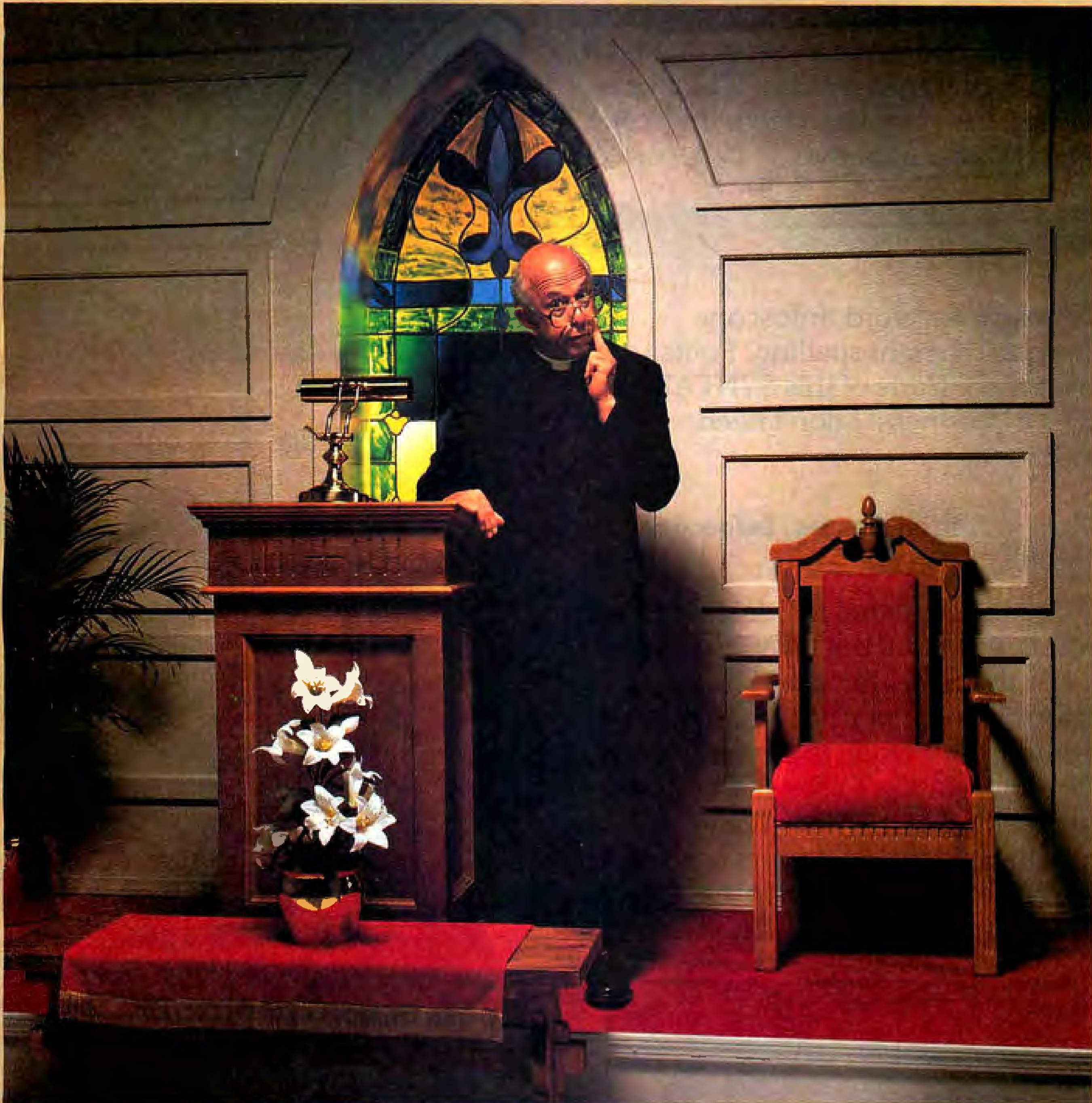
Connections are through either an RS-232C or an RS-422 port. The K-2 supports three asynchronous protocols at concurrent levels. Pricing begins at less than $10,000. Contact Kentek Information Systems Inc., Six Pearl Court, Allendale, NJ 07401, (201) 825-8500.

Circle 609 on inquiry card.

(continued on page 431)



"Heaven Knows How I'd Keep Track of My Flock Without Infoscope."



Before we got Infoscope, I frankly didn't know what to do with our church's personal computer. Now I don't know what I'd do without it. Infoscope lets me put virtually anything in our computer, and take anything out in whatever form I need. I can see how a business could use data management like that. But my "business" is my congregation — and I never knew my congregation so well before.

Wait till you see what we get out of Infoscope ...

"Our Computer Never Did So Much Before."

I've got every church member in here. Names. Addresses. Children. Anniversaries. Pledges. Special needs. Volunteer projects. Infoscope makes it easy to enter information. If I make a mistake (no man is perfect), Infoscope suggests an alternative.

If I misspell a word, Infoscope suggests the right spelling. Politely, I might add. None of this SYNTAX ERROR business. I don't need scolding.

I Forget Anniversaries. Infoscope Doesn't.

Once I've entered the data, I just ask Infoscope to pull out all anniversaries of our members for, say, January. Before I can blink my eyes, I've got it. I remember birthdays the same way. My congregation thinks it's wonderful, the kind of memory I have. It's hard to believe that pastors used to keep all this in their heads. Or, forgive me, but maybe they didn't ...

Building Fund Pledges Here. Contributions Here.

Anytime you want to compare data, Infoscope lets you create windows.

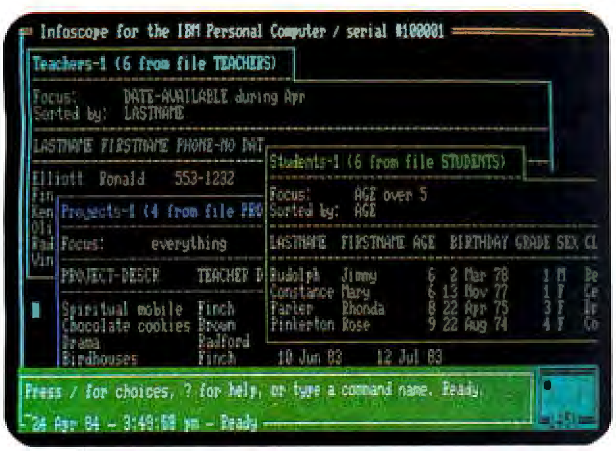
I can see our pledge list in one window, and

contributions in another. The only thing Infoscope doesn't know is that Bill Martin is late paying his pledge because Sue has been sick. That's my department.

I Can Create a Window for Everything.

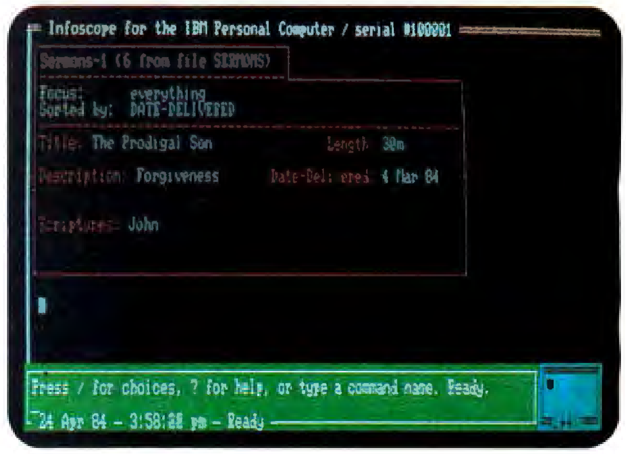
For example, Vacation Bible School. In one window, I pull out and display all the volunteer teachers. In another, I scroll through last year's students. In another, all the class projects.

And so on. I can make each window as large as I want, and put it anywhere on the screen I want.



At Last, Our Computer Performs Miracles.

It just took the right program. With Infoscope, we can enter data ... sort it



... compare it in expanding movable windows ... even pull out data from a larger data base. No software ever did so much to make a microcomputer so valuable. I swear by — well, I appreciate very much what it does for me.

*Infoscope operates on data in RAM, so it's 4 to 100 times faster than other information management programs. For a demonstration, see your retailer. Or, write for details:

infoscope™

MICROSTUF®

1000 Holcomb Woods Parkway / Roswell, Georgia 30076

Circle 212 on Inquiry card.

A·S·K B·Y·T·E

Conducted by Steve Ciarcia

TI Keyboard for IBM PC?

Dear Steve,

Having seen the Texas Instruments PC keyboard (November 1983 BYTE, page 232) and owning an IBM PC, I feel as Bobbi Bullard does, that TI "started out right" in designing its keyboard. Is it possible to convert the TI PC keyboard to work with the IBM PC? If it is possible, what would be involved in the conversion?

Will Madison
Anchorage, AK

While it is probably possible to adapt the TI Professional Computer's keyboard to the IBM PC, it would require extensive changes to the IBM BIOS (basic input/output system) keyboard-interpretation routine and possibly some hardware changes—not an easy task.

Alternatives do exist, however, if you want to get a keyboard with a softer touch and move the much-maligned left-hand Shift key and the Return key to a more conventional location. A few keyboards on the market, while they make no attempt to duplicate the TI Professional's 97 keys, may satisfy your needs. Some of these are produced by Key Tronic Corp., POB 14687, Spokane, WA 99214; Maxi-Switch Co., 9697 East River Rd., Minneapolis, MN 55433; and Qubie Distributing, 4809 Calle Alto, Camarillo, CA 93010. Advertised prices for these keyboards are in the $200–$300 range.

A cheaper alternative is to use one of the keyboard-customizing programs that modify the keyboard interrupt-service routine to change some of the key functions to your specifications. Some of these are Keyswapper 2.0 from Vertex Systems, 7950 West 4th St., Los Angeles, CA 90048; Magic Keyboard from Lifeboat Associates, 1651 3rd Ave., New York, NY 10028; ProKey from RoseSoft, POB 45808, Seattle, WA 98105; and SmartKey II from Heritage Software, 2130 South Vermont Ave., Los Angeles, CA 90007.

I hope one of these options will meet your requirements with less work than adapting the TI keyboard.—Steve

CP/M from Apple II to C-64

Dear Steve,

I have been searching for a way to transfer data from an Apple II CP/M disk to Commodore 1541 disk-drive format. I want to use the Commodore 64 with a Z80 cartridge and CP/M 2.2. I have seen disk-format converters available for other machines.

Darwin Yu
Livingston, NJ

I am not aware of a format converter that will change Apple II CP/M disk files to the Commodore 1541 format. The Commodore CP/M implementation is new and has not yet gained widespread use.

Files can be transferred from one machine to the other by the use of serial ports and some communications software. The transfer can be accomplished either by means of a modem or by direct connection through a serial cable. The files are then uploaded or downloaded as required.

Many communications software packages are available for each computer. Consult the ads in BYTE or machine-specific magazines for manufacturers.—Steve

Questions on Apple and BASIC

Dear Steve,

I have an Apple IIe with two disk drives, a Gemini-10X printer, and a Monitor III. First, what is a good inexpensive program or peripheral device to speed up the processing time of my computer?

Second, I have an 80-column card in the auxiliary slot. I want to know if any other card can be used in Slot 3 while the 80-column card is in use? If so, which ones or what type?

Finally, can the Einstein compiler (January, page 349) be used to compile copy-protected programs?

Melvin C. Etheridge
Camp Lejeune, NC

You can speed up the processing time of your Apple IIe in several ways. The one best suited to your application, however, depends on the type of program. For example, if your program requires a lot of disk interaction, a RAM disk will greatly improve speed. If your program does a lot of number crunching, the RAM disk will not be effective. A faster microprocessor can result in speed increases of three to four times.

Alpha Logic Business Systems (4119 North Union Rd., Woodstock, IL 60098, (815) 568-5166) sells the Accelerator II board ($599), which increases the processor speed by three-and-a-half times, and the Saturn 32K-, 64K-, and 128K-byte memory boards ($219, $349, $499) with software to use the board as a RAM disk. Omega Microware (222 South Riverside Plaza, Suite 2234, Chicago, IL 60606, (312) 648-4844) sells the Ramex 128K, a multipurpose expansion card with disk-emulation software ($499.99).

The Apple IIe maps the auxiliary connector as Slot 3 to maximize compatibility with existing 80-column software. When one of the IIe 80-column text cards is plugged into this connector, a PR#3 command enables this card and disables the ROM (read-only memory) or firmware on any card plugged into Slot 3.

The Einstein compiler (or any other BASIC compiler) converts a BASIC program into a machine-language program that executes faster.—Steve

Monochrome Graphics on a PC

Dear Steve,

I have an IBM PC with its monochrome-display and printer-adapter card, color/graphics card, and monochrome display. I want to get the monochrome graphics output from my display—without spending more than $100.

I know that some vendors have introduced a simple interface circuit to enable the IBM monochrome display to be connected with the color/graphics card to get the result.

Please tell me if this method is technically and economically suitable. Will it do any harm to the monochrome display? Also, please describe in a future BYTE how such a circuit is built, if possible.

Matthew Lim
Republic of Singapore

The IBM monochrome display is designed to work at a horizontal sweep rate of 18 kHz and a vertical scan rate of 50 Hz. This differs enough from the NTSC (National Television System Committee) sweep rates output by the graphics-display adapter to cause problems. IBM warns that operating the monochrome display from the graphics adapter will damage the display. I have also heard of damaged power supplies in these displays from operating this way.

For this reason, I don't recommend using the monochrome display with the color-graphics adapter. Instead, I recommend that you buy an inexpensive monochrome monitor that follows NTSC standards, many of which are available from advertisers in BYTE for around $100, that will give as good a graphics display as the IBM monochrome display. This gives the added advantage that both monitors are available on your system, so you can have the excellent text display of the monochrome-display system with the ability to switch to the graphics display when doing graphics. Programs such as Lotus 1-2-3 make this switch automatically when both display systems are installed.

A pair of programs in the IBM BASIC Manual

(continued)

Free and Easy

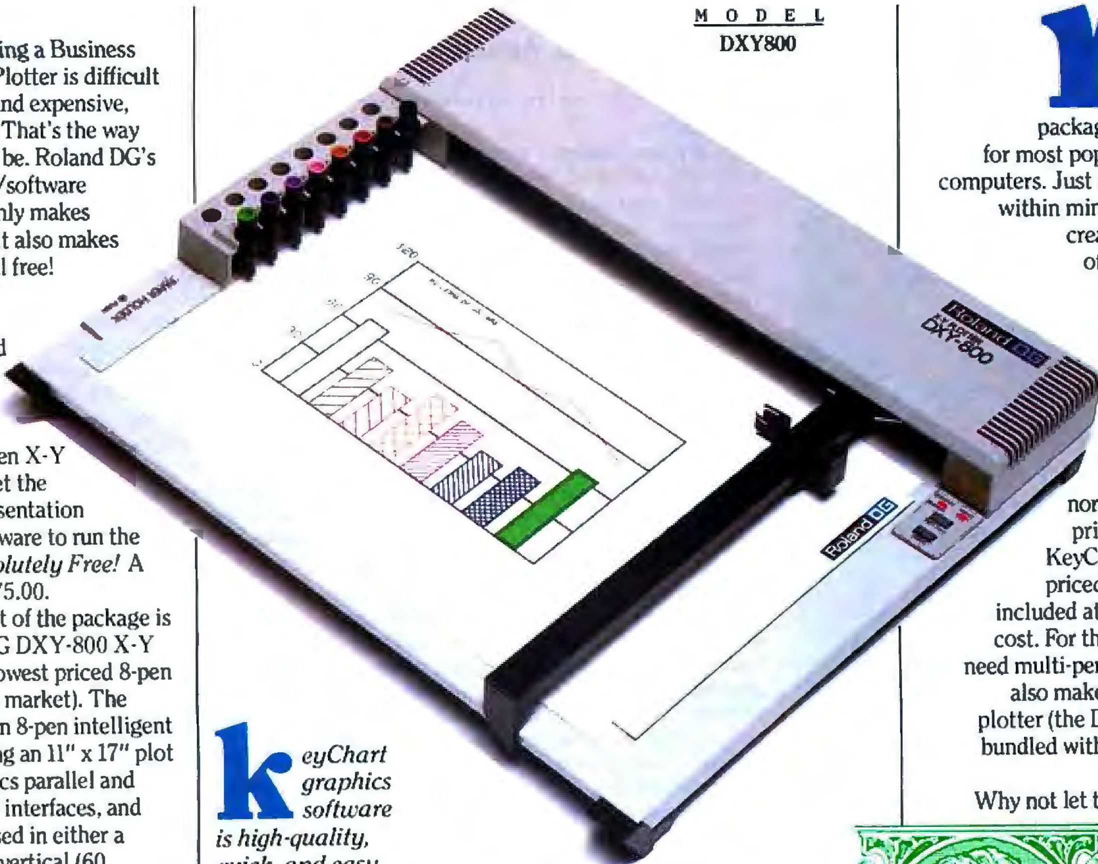
Using a Business Plotter is difficult and expensive, right? Wrong! That's the way things used to be. Roland DG's new hardware/software package not only makes plotting easy, it also makes part of the deal free!

During the months of April, May and June with the purchase of a Roland DG DXY-800 8-Pen X-Y Plotter, you get the KeyChart Presentation Graphics Software to run the plotter—*Absolutely Free!* A savings of $375.00.

At the heart of the package is the Roland DG DXY-800 X-Y Plotter, (the lowest priced 8-pen plotter on the market). The DXY-800 is an 8-pen intelligent plotter offering an 11" x 17" plot bed, Centronics parallel and RS-232 serial interfaces, and can also be used in either a horizontal or vertical (60 degree inclined) position, to conserve your desk-top space. Use regular paper or even acetate to produce overhead projection graphics.

Next add KeyChart, probably the quickest, and easiest software program for generating presentation-quality business graphics. You don't have to be a programmer to use KeyChart. It is completely menu-driven and can provide automatic default values for every characteristic. Load in your data from the keyboard, or from almost any electronic spreadsheet, including Lotus 1-2-3.

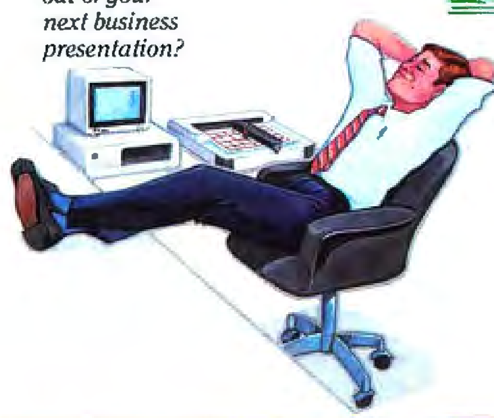
MODEL
DXY800



KeyChart graphics software is high-quality, quick, and easy.

Thanks to Roland DG, KeyChart can come to you for free.

Why not take the work out of your next business presentation?



Roland DG's DXY-800 KeyChart package is available for most popular personal computers. Just plug it in, and within minutes you'll be creating the kind of graphics you thought might take days of programming. All of this comes to you for the DXY-800's normal low retail price of $995.00. KeyChart, normally priced at $375.00 is included at no additional cost. For those who don't need multi-pens, Roland DG also makes a single pen plotter (the DXY-101), also bundled with KeyChart for only $750.00

Why not let the Roland DG graphics system improve the quality of your business presentations? But you'd better hurry, this kind of free and easy dealing isn't going to last forever, just until June 30th. For a dealer near you contact: Roland DG, 7200 Dominion Circle, Los Angeles, CA 90040, (213) 685-5141.

KeyChart is a trademark of SoftKey Software Products Inc. Lotus and 1-2-3 are trademarks of Lotus Development Corp.

Roland DG

(Appendix I, page 8) switch the output back and forth between monitors. A more versatile program, VMODE by Ray Duncan, was published in the September 1983 issue of Softalk for the IBM PC (page 178).—Steve

Replacing the Apple II Keyboard

Dear Steve,

I have three questions I would like answered. What do I have to do to replace the Apple II keyboard? Can I use an Apple-compatible disk drive on an IBM PC? What can I build or buy to allow me to access the game I/O port as a plug-in socket from outside the Apple II cabinet?

David A. Fong
San Jose, CA

The Apple II keyboard plugs into a socket on the motherboard. A replacement keyboard can be added simply by plugging its cable into this socket. Several keyboards are available for the Apple II. Some feature preprogrammed functions, single-keystroke commands, uppercase and lowercase, and a full numeric keypad. Consult the ads in BYTE or an Apple-related magazine for further information.

The Apple II disk drives are quite different from the IBM PC disk drives even though they both use 5¼-inch disks. Apple uses a software approach to control many of the disk-drive functions; the PC uses on-board hardware. Many of the functions required by the PC drives are missing from the Apple drives. They are incompatible.

An extension socket can be made from a piece of flat cable, a 16-pin plug, and a socket to bring the connection outside the computer. A zero insertion-force socket facilitates the insertion and removal of accessories. One company featuring several such products ($16.95 to $34.95) is Happ Electronics Inc., 4640 Island View, Oshkosh, WI 54901, (414) 231-5128.—Steve

C-64 Video Signals

Dear Steve,

I recently began a project to transform my Commodore 64 into a portable unit. I have a used case and monitor originally designed for an Osborne 1 system. Since the Osborne monitor requires horizontal and vertical synchronizing signals along with an input video signal, I need to convert the composite output from the VIC II chip to the component signals so I can see a display. Is there a simple solution to my dilemma?

Gregg Peele
Greensboro, NC

A circuit to separate the horizontal and vertical synchronizing signals from the composite video signal from your Commodore 64 is known as a sync separator. A suitable circuit was presented in the January 6, 1982 issue of EDN. "Sync Separator Provides Speed, Accuracy" by Bradley Albing (page 207) describes a method to obtain the desired signals.—Steve

Apple Software on S-100

Dear Steve,

I'm currently running CP/M on my CompuPro 20-slot S-100 mainframe using Advance Micro Digital's Supernet S-100 single-board computer with an 8-inch Qume Data Track double disk drive, a TeleVideo 925 terminal, and an Epson MX-80 printer. My problem is that the company I work for has its software written for the Apple II; some is standard DOS, and some is Apple/CP/M.

Is there an S-100 board that can be added to my system along with an Apple disk drive that would permit the direct use of this Apple software or the ability to read the Apple/CP/M programs onto my CP/M 8-inch disks and run them on my equipment?

If I use Modem7 to transfer the Apple/CP/M files to my 8-inch S-100 system, will those programs execute acceptably or must I modify the program files to make them work? They are all written in BASIC, with which I'm somewhat familiar.

Also, do you know of a computer (desktop or portable) that can run Apple, IBM, and CP/M software interchangeably?

Verne Carey
Windom, MN

I am not aware of an S-100 board that will allow direct reading of Apple software. Since the instruction sets for the two processors are greatly different, there is no benefit.

As for transferring Apple/CP/M files to the S-100, Modem7 works fine. There should be few, if any, changes required, since the BASICs for each system are comparable. A direct serial connection can be used if the two systems are in close proximity. Otherwise, a modem must be used.

If you have an IBM PC and a lot of money, you can run Apple, CP/M-80, and IBM software on the same machine. The Quadram Quadlink card will handle the Applesoft programs, and the Trump Card from Sweet Micro Systems or the Baby Blue card from Xedex will run CP/M-80 programs on the PC. For further information, contact Quadram Corporation, 4357 Park Dr., Norcross, GA 33093, (404) 923-6666; Sweet Micro Systems, 50 Freeway Dr., Cranston, RI 02920, (401) 461-0530; and Xedex Corporation, 222 Route 59, Suffern, NY 10901, (914) 368-0353.—Steve

Robot Eyes

Dear Steve,

I am presently designing a robot and want to give it electronic eyes for recognition and data retrieval. In your series, "Build the Micro D-Cam Solid-State Video Camera" (September and October 1983), you describe a unit using a RAM chip. In this series you did not mention how the lens was mounted. I would like to know how you did this. I would also like to know how to make this unit work with three others. These four units could have a dedicated 1802 processor that would give out only information that was requested from it or that the 1802's pro-

(continued)

gram demanded to be on the data lines. The processor is to communicate strictly parallel and must collect data from all four units and process it before any information can be obtained. It is to run and store this information until requested from another processor in the robot system.

I would also like to know why you chose a 16-millimeter lens for this project. Can an 8mm movie camera or a 35mm still camera lens be used with a better result?

Finally, do you know of any way to increase the resolution of the unit?

CHOIS BLACKWELL JR.
Waco, TX

I don't see any reason why you can't use the Micro D-Cam as robot eyes. The binary characteristic of the image produced might limit its ability to recognize objects in cases where tonal gradations are important, but this can be circumvented to a large extent by techniques described in the articles if you have time enough to take the several pictures needed. If you want to use a dedicated processor instead of the Apple or IBM PC, you will need to write control software for it. The program should be modeled after the Apple program listed on pages 512 to 538 of the October 1983 BYTE. If you want to use four cameras for special vision properties, the same program could be modified to control them all and read the images in sequence. Further processing will depend on your specific application.

The output from the Micro D-Cam's IS32 sensor chip is serial, primarily because the chip is organized as a 64K by 1-bit memory array. Part 2 of the article shows how to convert this to a parallel data stream.

The selection of a lens for the camera also depends on the application. A lens for a 16mm movie camera was chosen as one that provides a standard mount, a "C" mount in this case, and has a focal length short enough to provide a usable field of view. Remember that the field of view and magnification are determined by the lens focal length, not the type of camera it was made for. The longer the focal length, the higher the magnification and the smaller the field of view for a given sensor size. Lenses designed for 8mm or 35mm cameras could also be used, since the sensing element is about the width of an 8mm film frame and much smaller than 35mm film.

If you want to mount your own lenses, buy short extension tubes (the kind sold at photography stores for close-ups) and attach them to your robot for use as lens mounts. The lenses then screw or bayonet into the mounts. The resolution of the element is close to the resolution limit of most inexpensive lenses, so the decision you make must achieve a good balance between magnification and field of view. High magnification (longer focal length) will allow your robot to see a little bit of an object very clearly; a short focal length will allow it to see more but with less detail.—Steve

8-INCH DISKS FOR APPLE II

Dear Steve,

I have an Apple II and two 8-inch disk drives (Pertec type FD400). I want to connect both drives to the computer. I would be pleased if you would let me know how to do so.

MARC KLEYN
Merchtem, Belgium

Converting 8-inch disk drives to run on your Apple II is quite involved since a different disk-controller card is required. Many of the disk functions of the Apple are implemented in software rather than hardware, thus the controller card is relatively simple. The 8-inch drives have on-board circuitry that handles these functions, and the controller must provide the proper interface.

Advanced Computer Products (1310B East Edinger, Santa Ana, CA 92705, (800) 854-8230) sells the Vista A800 8-inch Disk Controller Card for the Apple II. It uses all the standard Apple DOS commands except INIT.

(continued)

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Polyphonic Tones	YES	NO	YES	YES
Music Synthesizer	YES	NO	NO	NO
Hi-Fi Output	YES	NO	YES	YES
VIDEO				
TV Output	YES	EXTRA COST	EXTRA COST	YES
Video Monitor Output	YES	YES	EXTRA COST	YES
INPUT/OUTPUT				
Intelligent I/O Bus	YES	NO	NO	YES
RS-232 Communications	YES**	EXTRA COST	YES**	EXTRA COST
"Smart" Peripherals	YES	NO	NO	YES

*Prices shown are common retail and may vary slightly in different markets.
**Requires an adapter to operate.

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And 64K. That's how much memory the Commodore 64 has. It's also how much memory Apple IIe and the IBM PCjr have.

This computer lesson is brought to you as a public service by Commodore (certainly not by Apple or IBM), the only computer company that can afford to show you a chart like the one above.

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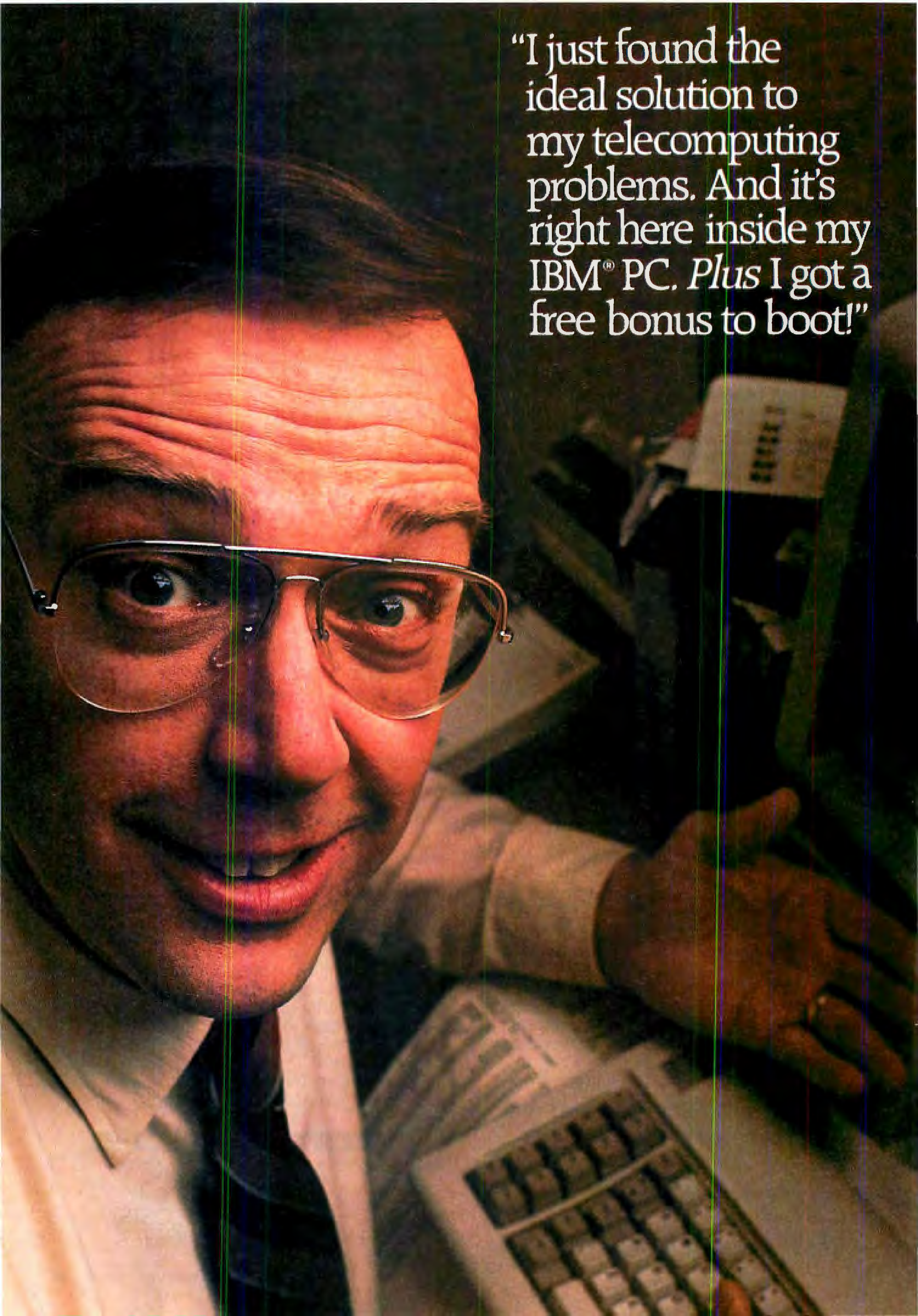
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The introductory offer for CompuServe's Executive Information Service includes a free subscription plus $15 worth of free connect time.

Circle 141 on inquiry card.

The latter has been improved and enhanced in a different format. A high-speed DMA (direct memory access) data rate of 1 microsecond per byte is provided, and it is compatible with DOS 3.3, Pascal 1.1, and CP/M 2.2 (with optional Z80 card). The A800 sells for $299.95.—Steve

PUNCH-CARD READER

Dear Steve,

I would like information on how to construct a mark sense punch-card reader or a source from which I could purchase one at a reasonable price.

I believe that card input would be more accurate for data entry than punching a set of keys. Also, keyboard entry is a large waste of "on time" for a system.

STEPHEN MIZGALA
New York, NY

Punch cards are an excellent way of feeding data to a computer if you can find them all punched with the correct data. After you've had the pleasure of punching a few hundred cards and checking them for errors before submitting them to the computer, I'm sure you'll never again want to sit at a terminal typing in data and correcting it as you go.

Seriously, though, if you want a card reader, used units are sometimes available on the surplus market. I found one listed for $34.50 in the H&R March 1984 catalog. The catalog number is TM20K917, and the address is H&R Corporation, 401 East Erie Ave., Philadelphia, PA 19134.

If punched tape turns you on, you can get a punch and a reader from John H. Meshna Inc., 19 Allerton St., Lynn, MA 01904. The catalog numbers are SPL 339A and LBXB1. The punch interfaces with an IBM Selectric typewriter that you can get for about the price of an inexpensive computer.—Steve

IBM PC MEMORY SEGMENTS

Dear Steve,

All the material I've read regarding memory segmentation for the IBM PC states that each physical segment can be up to 64K bytes long. However, the sample device driver for an in-storage disk that is listed in the back of the DOS 2.0 manual for the IBM PC defines a 180K-byte virtual-disk area contiguous to the code segment. The program is initialized with the CS, ES, and DS registers all pointing to the code segment, and the virtual-disk area appears to be addressed using the "based and indexed addressing" mode. How does this work?

CURTIS L. JEWS
Gaithersburg, MD

First, to make the answer to your question a little easier to understand, let's review the memory-addressing method used in the IBM PC.

The PC uses the 8088 processor, which has the capability of addressing four segments of memory at the same time by putting the start-

(continued)

ing address of each segment in one of the segment registers. The four segments can start at any 20-bit address whose last 4 bits are zero, or in other words, on a paragraph boundary. Thus, a 20-bit address is specified completely by multiplying the contents of a 16-bit segment register by 16 and adding the offset into the segment as defined by the program. The multiplication isn't the programmer's job; it results from the hardware design that loads the segment registers in the high 16 bits of the 20-bit address register before the offset is added.

Each segment can be up to 64K bytes long. The usual arrangement is to put the program code in the segment designated by the CS register and the data in the segment starting at the address in the DS register. If a stack is required, it is defined by the SS register, and the ES register can be used for data in addition to the DS segment. The ES register is usually used to identify the segment of the destination address in string moves. These are used in the virtual-disk program to transfer data to the virtual disk.

Now we get to the workings of the addressing used in the DOS 2.0 virtual-disk program. The segment definition at the beginning of the vdsk procedure (line 69) sets the CS, DS, and ES registers to the same address, as you say. Equally significant, it does not define a stack segment. The result is that the constants and variables defined in the beginning of the program will be stored in the body of the program rather than in the virtual-disk storage area, and it also tells the assembler that we want to use the stack area defined by DOS. These segment definitions are, however, temporary. They get changed as soon as we want to address an area outside the program segment.

Notice that around line 100, variables named VDISK_PTR and START_SEC are defined. These are used to point to the beginning of the virtual-disk area, and their values are changed as required to put data into the virtual-disk area without overwriting files. To see how this is done, we can follow part of the procedure for writing a file.

First, on entering the program by requesting a write operation, a jump to the procedure OUTPUT will occur. This routine determines how many sectors are to be written and the address of the starting sector, and it calls another routine called SECTOR_WRITE. This routine in turn calls CALC_ADDR to get the beginning address of the sector to be saved and loads this into the ES register. An offset address is then loaded into the DI register to make the complete ES:DI destination address for a string move. The DS and SI registers are also set in this routine to point to an area called the DTA (data-transfer area), which contains the data to be saved to the virtual disk.

While this explanation leaves out a lot of detail about how this program uses variable segment boundaries on the fly to make use of large blocks of memory, I hope it will help you understand the program. As you can see from the description above, the general procedure is to use an area in the code segment to calculate segment addresses for data-storage areas as needed and load these into the ES or DS registers as appropriate. The DI and SI registers are used as described above for string moves, but for other types of storage or retrieval operations, any of the general-purpose registers can be used to hold the offset address.—Steve

Project Management

Dear Steve,

Do you know anyone who offers Q-GERT for the IBM PC? Reportedly, this software (code-size equivalent to about 10,000 IBM cards) was produced on the basis of work done by Alan B. Pritsker and can be used for personnel management, hardware-project management, etc., similar to PERT.

F. R. Cappelletti
Washington, DC

A survey of several current application-software listings reveals no mention of the use of Q-GERT on an IBM PC.

However, a number of software publishers offer other project and resource-management programs that can run on the PC under a wide variety of system configurations (operating systems, memory, display, storage, etc.). These include

*Data•Easy Software
877 Bounty Dr. #EE203
Foster City, CA 94404
(415) 571-8100*

*Harvard Software Inc.
Software Park
Harvard, MA 01451
(617) 456-3400*

*McClintok Corporation
9655 South Dixie Hwy. #305
Miami, FL 33156
(305) 666-1300*

*Earth Data Corporation
POB 13168
Richmond, VA 23225
(804) 231-0300*

*Morgan Computing Co.
10400 North Central Expwy. #210
Dallas, TX 75231
(214) 739-5895*

*Aha Inc.
1475 Rodriquez St.
Santa Cruz, CA 95063
(408) 475-8705*

*SoftCorp Inc.
#L244, 2304 State Rd. #580
Clearwater, FL 33575
(813) 799-3984*

*Peachtree Software
3445 Peachtree Rd. N.E.
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(805) 255-2922

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29 Bala Ave. #224
Bala-Cynwyd, PA 19004
(215) 667-8600

Scitor Corporation
710 Lakeway #290
Sunnyvale, CA 94086
(408) 730-0400

In addition, you may be interested in a few BYTE articles dealing with PERT and CPM: "Programming PERT in BASIC" by Steven Zimmerman and Leo M. Conrad, May 1982, page 465 and "Programming the Critical-Path Method in BASIC" by Steven Zimmerman and Leo M. Conrad, July 1982, page 378.—Steve

CARRIER-CURRENT MODEM

Dear Steve,

I am in the process of building your power-line carrier-current modem (August 1983, page 36). I have had no problems except locating a few of the components listed in the schematics. If possible, would you supply me the part number and manufacturers for the following components: 0.22-μF, 600-V capacitor (line-coupling capacitor) and fused capacitor (line-to-line coupling).

FRED MATHEWS JR.
Las Vegas, NV

In this day and age of microelectronics, finding high-voltage capacitors is becoming more difficult. Few computer or electronics supply houses carry the 600-V capacitors used in my article on carrier-current modems. However, any electronics supply house that handles radio or television components will surely have the 0.22-μF, 600-V capacitor. A typical part number for such a capacitor is Sprague 6PS-22 (orange drop-dipped tubular).

The fused capacitor is exactly what it implies, a capacitor with a series fuse to provide protection in case of capacitor failure. Since the current through the capacitor is small, any low-value (1-amp) fuse will suffice.—Steve

TELETYPE PARTS

Dear Steve,

I have an old TDR33 Teletype (an ASR33 with a paper-tape punch/reader). The tape reader has a few parts missing, and the feed wheel is broken. Is there any place to get parts for these old machines?

DOUGLAS COOK
Exeter, NH

Amateur-radio operators used Teletypes for radioteletype transmission long before their application to personal computers. While solid-state units are now more popular, there is still some interest in the older units.

A scan through a recent amateur-radio magazine revealed the company Typetronics, POB 8873, Ft. Lauderdale, FL 33310. A self-addressed, stamped envelope will bring a list of parts, supplies, and gears.

Also, Teletype parts may be available from Morris Precision Parts Co., POB 157, Morris Plains, NJ 07950, (201) 993-9669.—Steve ■

IN "ASK BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to
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● MODUS OPERANDI
MODUS, the Modula-2 Users Association, first met in Zürich, Switzerland, as part of the 8th International Conference on Programming Languages and Program Development. It is made up of a nucleus of institutional and corporate charter members that includes the ETH Institut für Informatik (Zürich), Volition Systems Inc. (Del Mar, California), the Modula Research Institute (Provo, Utah), and Logitech Inc. (Palo Alto, California, and Appels, Switzerland). MODUS plans to produce a quarterly newsletter, *Modula-2 News*. Although the association has offices in Zürich, contact MODUS, c/o the Pacific Systems Group, POB 51778, Palo Alto, CA 94303.

● EPSONS IN BRITAIN
The HX-20/QX-10 (International) Users Group, specializing in information about Epson products, enables members from 25 countries to exchange information on peripherals and software via its monthly newsletter. Members are offered introductory prices on items premiered in the newsletter and can further benefit from educational articles, program listings, and free software bonuses. Members can also exchange programs and ideas via an electronic mail facility, the Closed-User Group Network, on Telecom Gold. In addition, the group provides consultants who, for a moderate fee, give demonstrations to Epson end-users. Contact Terence L. Ronson, HX-20/QX-10 (International) Users Group, 25 Sawyers Lawn, Drayton Bridge Rd., London W13 OJP, England.

● HEATH USERS IN LEHIGH VALLEY. The Lehigh Valley Heath Users Group (LVHUG) welcomes all Heath/Zenith users to join the newly formed club. The meetings are informal gatherings held at Lehigh University at 1 p.m. on the last Saturday of every month. Upcoming plans include selection of club officers and determination of dues to cover postage of a monthly newsletter, which is presently distributed at the meetings. The newsletter covers minutes of the last meeting, goals of the club, and suggested future presentations. An exchange column is planned for members who wish to exchange their equipment. At this time, no dues have been set. Call Carol Bloch for details at (215) 770-4640, or contact James Batug, LVHUG, 1425 North Broad St., Allentown, PA 18104, (215) 770-5993.

● CLASSROOM CREATIVITY
Creative Word Processing in the Classroom is for educators who want to explore the use of computers in developing children's reading and writing skills. The three annual editions—fall, winter, and spring—have color-coded sections relevant to administrators, librarians, and teachers of kindergarten through grade 12. Lessons, discussions of hardware and software, and articles on educational theory are written by educators with experience in several computer-assisted creative-writing projects. A subscription is $9 a year. Write to *Creative Word Processing in the Classroom*, Suite 365, 2210 Wilshire Blvd., Santa Monica, CA 90403.

● LEGAL REVIEW
The Computer Law Newsletter, a publication from Delphi Data of Riverside, California, is a concise review of legal issues in the rapidly changing software industry. It reviews current cases and offers suggestions about protecting computer software, acquiring rights to software, and marketing software. A subscription to the bimonthly publication is $96 for one year. Access is available via modem at no extra charge. For details, contact Clyde Sparks, 3425 Meadowview Dr., Riverside, CA 92503, (714) 689-7408.

● A LEGACY FOR JUNIORS
The first bulletin-board service (BBS) for use exclusively by owners or potential owners of the IBM PCjr is open 24 hours a day at (402) 466-8114. Legacy Technologies Ltd. of Lincoln, Nebraska, is offering the public service as a forum for the exchange of technical and general information about the PCjr. Both technical and nontechnical users can communicate with other users, dealers, and distributors. Questions can be answered by Legacy engineers within 24 hours. Contact Greg Brehm, Legacy Technologies Ltd., 4817 North 56th St., Lincoln, NE 68504, (800) 228-7257; in Nebraska, (402) 466-8108.

● MAC NEWS OF SAN DIEGO
The San Diego Macintosh Users Group meets on the fourth Wednesday of every month. Membership is free, but to receive the monthly newsletter, *San Diego Mac News*, you must pay a subscription fee of $15. The newsletter is prepared and produced using a Macintosh. Columns include the Chairman's Corner, Editor's Note, Minutes, and a Gallery. Articles, drawings, letters, or other contributions related to the Apple Macintosh or Lisa are welcome. For further details, contact the San Diego Macintosh Users Group, POB 12561, La Jolla, CA 92037.

● FREE ADVICE FOR USER GROUPS. A monthly help column is available to all user groups for the price of the postage. The columnist offers help for frustrated users and guarantees a reply on questions about CP/M, Pascal, UNIX, XENIX, WordStar, MailMerge, programming techniques, and criteria for selecting software and microcomputers. For details, write B. Bhavisyat, Land of the Blind, Route 1, Box 318, Moundsville, WV 26041.

● MAC SUPPORTS THE COMMUNITY. The founder of Club Mac offers a free Macintosh communications program, a monthly newsletter, access to an on-line idea exchange, and a professionally staffed help line. Current or prospective Macintosh owners, software or peripheral vendors, Mac artists, and other interested persons can join by sending $35 in annual dues to Club Mac, 735 Walnut, Boulder, CO 80302, (303) 449-5533.

● FIND OUT HOW
The Computer Analyst & Programmers Association (CAPA) consists of professional people working with computer hardware and software. Practical guidance is submitted by members to improve programming languages, operating systems, system documentation, and input/output (I/O) devices. The focus is on CP/M, MP/M, MS-DOS operating systems, BASIC, Pascal, FORTH, and hardware-interfacing capability. For information, send a self-addressed stamped envelope to CAPA, POB 5762, Rockford, IL 61125-0762.

● CO-OP ITEMS FOR EPSONS
The National Epson QX-10 Users Group (EUG) produces a bimonthly newsletter that lists items that can be bought at a discount by members, contains numbers of public BBSs for the Epson QX-10 that span the continental U.S., and provides news and comments on topics of interest to Epson users. The

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CLUBS & NEWSLETTERS *is a forum for letting BYTE readers know what is happening in the microcomputing community. Emphasis is given to electronic bulletin-board services, club-sponsored classes, community-help projects, field trips, and other activities outside of routine meetings. Of course, we will continue to list new clubs, their addresses and contact persons, and other information of interest. To list events on schedule, we must receive your information at least four months in advance. Send information to BYTE*, Clubs & Newsletters, POB 372, Hancock, NH 03449.

membership dues are $25 per user; $15 per student user. For information, contact EUG, Box 1076, Lemont, PA 16851, (814) 237-5511.

● LIBRARY MICROCOMPUTER DATABASES. The Public Library Association Task Force on the uses of microcomputers in public libraries is compiling national and regional databases of library microcomputer users. For details, contact Phil Clark, 216 South 4th Ave., Highland Park, NJ 08904.

● 6809 PEOPLE UNITE
People with an interest in MC6809 machine code and the 6809's hardware applications can join a user group that is based in England but welcomes an international audience. The bimonthly newsletter will cost £75 and will feature software and hardware sections, an assembly-language course for updates, advertisements, letters, and articles of interest to 6809 enthusiasts. For details, contact Paul Hill, 28 Woburn Rd., Launceston, Cornwall PL15 7HH, England.

● HERO ROBOTS ORGANIZE
The Hero Resource Exchange is an organization for the benefit of Hero 1 owners to exchange information, programs, and ideas about their robots. For details, contact Walter Glod Jr., 10802 Condrey Ridge Court, Richmond, VA 23236.

● EVENS AND ODDS OF SECAUG. The South East Connecticut Apple Users Group (SECAUG) meets at 7:30 p.m. every month. In odd-numbered months, the group meets every third Thursday at the Groton Public Library; in even-numbered months, it meets every third Tuesday at the Mohegan Community College in Norwich. Special-interest groups include DOS, machine language, and BASIC programming. The group maintains a library of public-domain software in disk format and produces a monthly newsletter, *Statements*, a subscription to which is included in the $20 annual membership fee. For details, contact Warren Nordgren, 42 Terry Rd., Gales Ferry, CT 06335, (203) 464-9372.

● MALDEN CATHOLIC HS ACTIVITY. Students at the Malden Catholic High School and members of the Malden Catholic Computer Club produce the *MC Microcomputer News* six times during the school year. Although the focus is on Radio Shack's TRS-80 Models III and 4, the newsletter also covers Apple Logo, BASIC programming tips, printer information, a glossary, and suggested periodical readings. Readers are encouraged to contribute comments and criticism. Newsletter exchanges are welcome. For further details, contact *MC Microcomputer News*, Malden Catholic High School, 99 Crystal St., Malden, MA 02148.

● SOFTWARE LAW UPDATE
The coverage of *Software Protection*, a monthly publication, includes international developments and software-licensing law relevant for software vendors, users, and legal advisors. The expanding editorial board is international. A sample copy is $5; a year's subscription is $72; and $90 covers airmail outside the U.S. For further information, contact Law & Technology Press, 1112 Ocean Dr. #201, Manhattan Beach, CA 90266.

● BILINGUAL MEDICAL JOURNAL. Micromed, devoted to practical applications of microcomputers in medicine, is a nonprofit, independent group that produces a monthly newsletter in English and Italian. Exchanges with other newsletters are welcome. The $10 membership fee outside Italy covers the cost of printing and mailing. For details, contact Francesco Di Girolamo, V.le della Rimembranza, 25, 66034 Lanciano, Italy.

● EPSON USERS UNITE
An international Epson users group provides access to a remote BBS throughout the country. The 32-page monthly newsletter, *EpsonConnection*, will contain information on forming regional groups for Epson users. The annual fee is $24. For details, contact Carolyn McCarthy, *EpsonConnection*, POB 14027, Detroit, MI 48214, (313) 822-0090. ■

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Niklaus Wirth, creator of Modula-2, asserts that Modula-2 is an abstract tool for the construction of computing machinery: "In my opinion, the term *programming language* is ill chosen and misleading. *Program notation* would be eminently more appropriate."

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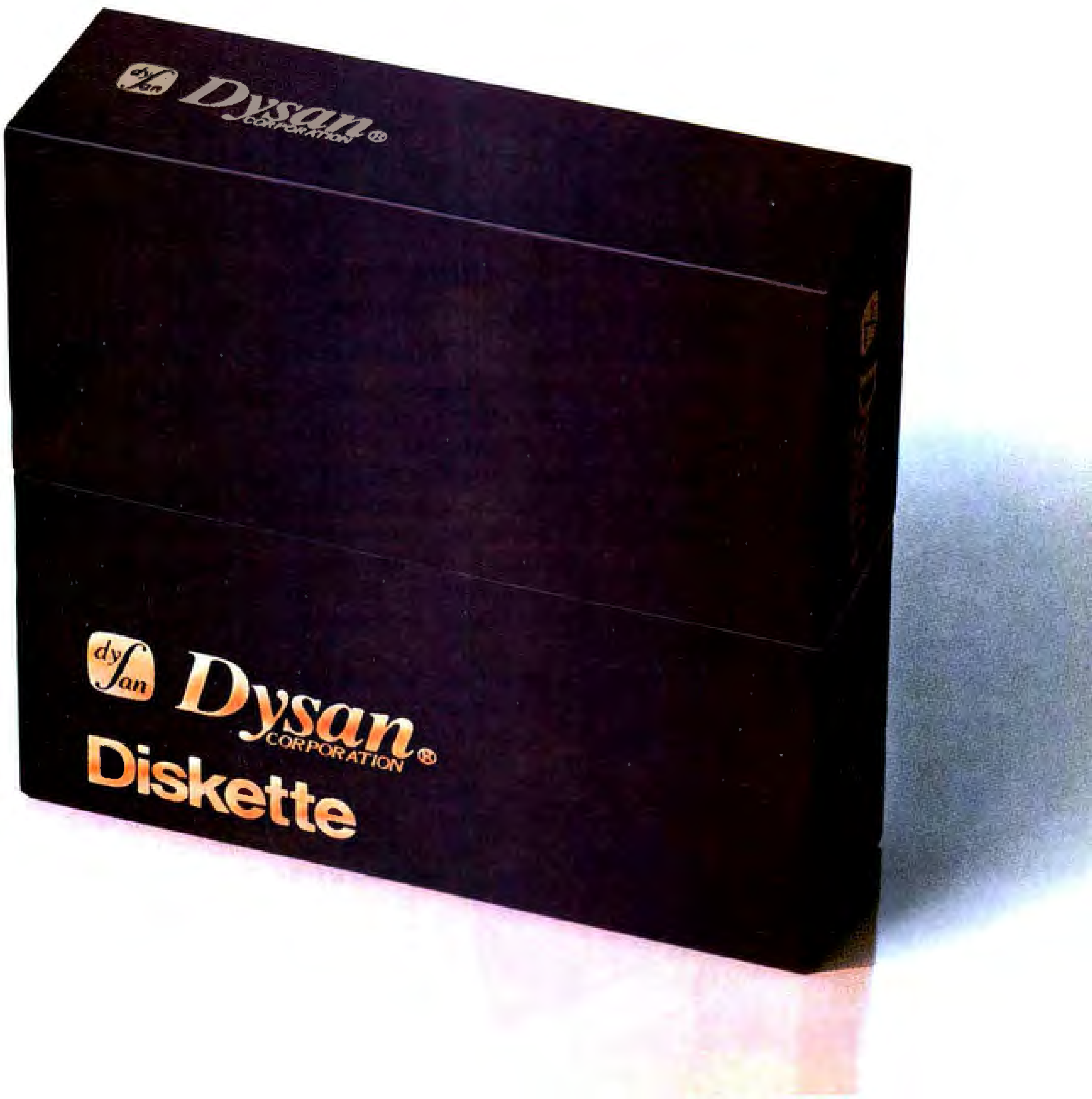
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Warner Books
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224 pages, $8.95

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Osborne/McGraw-Hill
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User friendliness is one approach discussed in a review of two books on software design this month.

PROGRAMMING IN MODULA-2
Reviewed by David D. Clark

By now, everyone has heard about Niklaus Wirth's new language, Modula-2. You've probably also heard that it will be the programming language of choice in the near future, replacing Pascal and preferred over Ada. For these predictions to come true, however, people have to learn the language. Niklaus Wirth's book, *Programming in Modula-2*, is designed to teach programmers the fundamentals of the language.

Professor Wirth describes the rationale behind the development of Modula-2 in the book's preface:

> In 1977, a research project with the goal to design a computer system (hardware and software) in an integrated approach, was launched at the Institut für Informatik of ETH Zürich. This system (later to be called Lilith) was to be programmed in a single high-level language, which therefore had to satisfy the requirements of high-level system design as well as those of low-level programming of parts that closely interact with the given hardware. Modula-2 emerged from careful design deliberations as a language that includes all aspects of Pascal and extends them with the important module concept and those of multiprogramming. Since its syntax was more in line with that of Modula than with Pascal's, the chosen name was Modula-2.

The text of the book was prepared in camera-ready form using a Lilith minicomputer and printed with a laser printer. All of the programs to format the text, control, and interface to the printer were also written in Modula-2 on a Lilith.

STRUCTURE

The book is divided into five parts followed by the technical Modula-2 report (mentioned later in this review in more detail), two appendixes, and an index. The first nine chapters describe the basic concepts of variables, expressions, statements, and simple data types. Although the preface states that the book is intended for persons with some knowledge of programming, in several instances it goes into detailed discussions of very elementary concepts, explaining, for example, that the order in which statements are executed affects the outcome of a calculation.

The next five chapters explore the concept of the subprogram or procedure. This second part starts with an explanation about breaking down a large problem into simple parts, which can be further subdivided. It is this process of stepwise refinement, of yielding simple tasks that can be implemented in single procedures, that is the power in any programming language. The reader is also introduced to the ideas of locality or scope, recursion as a programming strategy, and the methods of transferring parameters and results to and from procedures.

The third logical division of the text begins with chapter 15 and covers the concepts of data type and structure. In a general sense, the purpose of computer programs is to perform some useful transformation on some piece of

(continued)

data. Using an appropriate data structure facilitates the implementation of a program from such a transformation. One of the great strengths of Pascal, and now Modula-2, is the richness of this capability. This section of the text describes the data-structuring facilities clearly and completely.

OVERVIEW

The first 22 chapters can be skimmed by an experienced Pascal programmer with little chance of missing anything important. Modula-2 has several changes in syntax from Pascal, usually well-designed extensions and refinements. With the exception of some interesting examples, though, we've seen it before.

The really interesting stuff begins with the exposition of modules in chapter 23. Modules, familiar to people already acquainted with UCSD Pascal UNIT or Pascal Plus's ENVELOPE, provide a means of grouping related tasks into separately compiled pieces for inclusion in libraries. This capability to logically group related procedures further enhances the process of stepwise refinement.

After presenting the module in various forms, the book provides examples for the implementation of common tasks such as character input/output (I/O) from video terminals and file stores. As with the C programming language, I/O is not explicitly provided for by the language. This is because it is such a hardware-dependent activity. To be complete, each implementation should provide a library of modules containing procedures and data types to perform the functions required.

The chapter on screen-oriented input and output is one of the most interesting in the book. It presents definition modules for line-drawing primitives, a mouse handler, and a window handler. As an aside, the Lilith minicomputer, on which Modula-2 was the systems' programming language, has a high-resolution, bit-mapped display that is perfect for graphics-intensive applications.

DETAILS

In demonstrating the use of the line-drawing primitives, Professor Wirth returns to an example presented in one of his previous books, *Algorithms + Data Structure = Programs* (Prentice-Hall, 1976). The program generates a Sierpinski curve. This program was used to illustrate recursive techniques in the older book. The algorithm employs four mutually recursive procedures (A, B, C, and D).

The program in the older book, which was written in Pascal, would not compile because some of the procedures had not been previously declared. To remedy the situation, Pascal provides a FORWARD statement. The situation in Modula-2 is slightly different; all objects at the same scope level are known to

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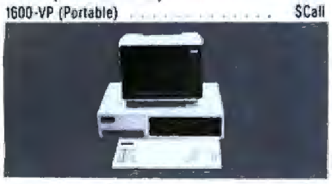

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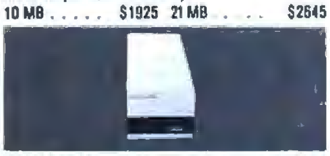

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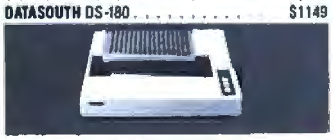

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one another. This is *the only* example I could find in the book that even indirectly addresses the relaxed declaration sequence accepted by Modula-2. One of the improvements in the syntax of language relative to Pascal is that it allows for declarations of constants, types, variables, and procedures to be declared in an arbitrary order in arbitrary locations, within the same scope level. Such syntax allows global variables to be declared right in front of the group of procedures that uses them. Although this fact can be determined from close examination of the formal syntax (in my case, by recourse to someone who is already an expert in the language), I think this new syntactical feature should have been explicitly mentioned.

The fifth division of the text consists of three chapters that cover language facilities for system programming and other low-level tasks. When Pascal was created, it was originally intended only to teach good programming practices. Because it was so easy to write reliable, structured programs in Pascal, several extensions of it were created to enable it to handle systems-level programming. The UCSD project, for example, wrote the entire operating system in its extended version. In order to access the underlying hardware, programmers resorted to tricks to get the job done. Because of such practices, programs written in one variant often were not portable to implementations using a slightly different version.

As stated in the preface, a major objective in the design of Modula-2 was creating a general-purpose programming language that could also program low-level tasks. The topics discussed in the fifth division of the book include multiprogramming, concurrency, coroutines, peripheral interfacing, and interrupts. While unleashing the programmer on these low-level facilities, an attempt is made to instill a sense of solid, sound, conservative design when using them. These language features enable the programmer to greatly damage the system and should be used cautiously and deliberately. This part of the book is the most terse, possibly by design. My advice is, if you don't understand what the text is discussing, don't even attempt to use the facilities described.

Following the main body of the text is the "Report on the Programming Language Modula-2." This document is the technical reference mentioned earlier that describes the language. It defines the standard language, at least until national standards committees create new ones. While a book review need not comment on the technical merits of a language definition, a few comments on its presentation are in order. In this case, the most obvious observation is that it is understandable. The 25-page document clearly specifies the syntax and semantics of the language. It is remark-

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able that so powerful a language can be described so concisely. It is also in marked contrast to the technical description of some other languages, notably COBOL, PL/I, and Ada.

DRAWBACKS

The book does have some flaws. It seems ironic that the creator of such beautiful languages as Pascal and Modula-2 should use one of the most unattractive programming styles I have ever seen. Indentation is shallow (often less than one character per level) and hard to follow in some of the longer examples. There is a tendency to cram several statements onto the same line. The use of proportional spacing in the listings is bothersome. Because different letters occupy varying widths in the listings, corresponding letters in consecutive lines do not always line up. This can be particularly annoying when character arrays are padded with blanks: there is simply no way of knowing how many blanks to use.

The listings in this book do, however, have one advantage over the Pascal listings presented in Professor Wirth's previous books. The presentation listings that appear in typeset text and regular listings as produced by common printers are the same. One typeface is used for all program tokens instead of reserved words in bold, identifiers and operators in italics, and surrounding text in Roman. This makes it easier to write about the language and programs written in it.

Another slightly annoying property of the book is the level of presentation. It tries to be all things to all programmers. By presenting many very basic concepts of programming in general, it is probably too terse for the beginner to learn how to program without additional instruction. All the detail for beginners just slows down the experienced programmer. Such a person can skip large sections of the text, thereby possibly missing important details. I think Professor Wirth should have directed his presentation to the more experienced audience because at this stage in the life of Modula-2, very few persons will learn it as their first programming language. Instruction for the beginnner can be provided by tutorial books that will appear as the popularity of the language increases, just as they did for BASIC and Pascal.

Possibly the most disconcerting thing about this book is its index. Although it appears complete, it is hard to use. Printed in a two-column format, scanning it in alphabetical order means looking at an entry in the first column, checking the same line in the second column, moving down one line, checking the first column, and so on. It's not easy to break the habit of looking straight down the list when searching hurriedly. Such an index is a handicap in a book intended as a reference.

(continued)

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PRAISE

On a more positive note, this book covers almost all of the facilities of the language quite well. Professor Wirth infuses his exposition with the importance of stepwise refinement, the choice of appropriate data structures, and the separation of related tasks into isolated modules. In many cases, the programming examples given are quite interesting. The book seems to have been prepared carefully: I didn't notice one typographical error. To top it off, the book is reasonably priced, something quite rare in computer science books. And finally, this is an important book. It contains the report on Modula-2 and thus defines the standard language. As the language becomes more popular, it will serve as the arbiter of what constitutes a correct implementation. Simply, this book can help you resolve questions regarding the legality of syntax and recognition of nonstandard, nonportable use concerning Modula-2.

THE ELEMENTS OF FRIENDLY SOFTWARE DESIGN

THE ABC'S OF DEVELOPING SOFTWARE

Reviewed by Chris H. Pappas

A tension exists between two opposing software-design theories. One school of thought maintains that an efficient program must be structured, modular, and easily maintained. The other approach focuses on and caters to the needs of the user.

I have just finished reading two texts on software development. The first book is *The Elements of Friendly Software Design* by Paul Heckel and the second is *The ABC's of Developing Software* by Sheldon D. Softky. Both are written for beginning to experienced programmers. I see, as do the authors, that these two approaches are not mutually exclusive, even though both texts represent opposite ends of the spectrum. The amount of space Heckel devotes to program-design structure in his book is similar in length to the space Softky devotes to user friendliness.

THE FRIENDLY WAY

The information in *The Elements of Friendly Software Design* is both entertaining and instructional. The major thrust of the text indicates that software design, if approached from the user's point of view, is the most recent addition in the field of communications crafts. Precursors include literature, theater, music, film, and other art forms.

Significant examples are included that support user friendliness: quotes from famous movie directors, authors, inventors, painters, and other people whose livelihood revolves around communications. Heckel suggests that software engineers go beyond proper program syntax and structure and concern themselves with addressing user needs.

(continued)

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In the second chapter, "Our Counterproductive Instincts," the author points out that software engineers are primarily concerned with the logic in a program. Not enough time is devoted to the visual aspects of the program: How does it look to the user? Throughout the book the words create visual images that link thoughts with experience; Heckel believes that this use of familiarity is critical for successful software design.

If computers are to be accepted by the general population, Heckel declares, it is the job of software engineers to make the first experience a positive one. For instance, to design a word processor for a secretary, try to emulate a typewriter. Make the new user feel at ease and not intimidated by the product. With a positive, familiar approach, it is maintained, you can then lead the user on gradually to the more advanced features of the package.

"How to Design Software that People Will Want to Use" is a section that contains many aspects to ponder in friendly software design. For instance, "Most software is run by confused users acting on incorrect and incomplete information, doing things the designer never expected." How true! Judgmental commands, such as "Illegal Command," simply increase a user's defensiveness. Use empathy, not superiority. Give the user control. Involve the user. Orient the user to the world. In a word processor, the designer can not only show users the page they're typing on but can also tell them which document, page, line, and position is in use. Avoid frustrating the user. Don't bore them or go over their heads. Allow for help menus but don't make them automatically invoked. Put yourself in the user's place. To be a competent software engineer, you must know the medium's capabilities well. Be willing to rewrite. Don't expect to get it right at the first effort.

A Logical Approach

If you're on a software-development team that isn't doing as well as it might, then Softky's *The ABC's of Developing Software* presents a totally different view of program design. The text describes how to design and implement a major software project.

The example used throughout this

(continued)

The two authors occasionally agree.

book concerns the development of a software package that will simulate power-regeneration capabilities of energy sources placed strategically throughout California. The energy input is to come from solar cells, turbines, windmills, waste-burning systems, and tidal-wave energy generation occurring over varying seasonal conditions for a period lasting two years.

Due to the immensity of the project, the author calls for tremendous initial development to ensure that the project is successful, affordable, and delivered on time.

The process begins with a solid proposal, explaining in full detail what the project is all about, even suggesting people who should be hired. Because the software will be used and repaired by the people on hand, it is important to keep them in mind when the design is started. Here's where Softky states, agreeing with Heckel's point of user friendliness, "the simulation will be operable by staff who are not professionally trained programmers or software engineers."

Several interesting and upsetting statistics are woven throughout. One is that during the development life of any software project, the developer can expect a 30 percent turnover in staff. Softky stresses that a good initial problem design includes time to bring new engineers on board and train them to the point where they can be productive. If this happens late in the development phase, this training period can take six months.

The author points out that software developers must use the same system the customer owns. This could require some retraining of the developers. Also, because the software engineers cost so much, it makes sense to have terminals and printers for them all. Softky illustrates how to organize and structure the entire project and includes an excellent problem description using Program Definition Language (PDL).

Unlike Heckel, Softky sees the program controlled by data, control, input, output, and control logic, or sequential files. Excellent discussions center on data-management systems (DMS). Some programs are designed to free the software engineer from worrying about any links between the program and the system's peripheral devices.

The ABC's of Developing Software contains informative guidance for the software-development phase. This includes the realization that as time slips, so does the quality of the entire project because important steps, such as keeping the documentation up to date, are bypassed. Quality monitoring is an ongoing process.

Softky states, "User's needs are so pervasive that they ought to affect the list of requirements. It is important to always remember that most software isn't operated by people who built it, and as a result, some of it must exist to 'hold the user's hand.' It also happens that the design effort can turn up hard spots, those places where the user could easily make a wrong decision. Conscientious designers then include virtual requirements, which lead to improvements in design solely for the user's benefit." Here again, we find direct agreement between the two authors.

Softky stresses closely organized structured design, ranging from the high-level, broad design down to the detailed subprograms. He mentions the needs for good design-test plans and the usefulness of well-written software-maintenance and user's manuals.

The last step Softky mentions is integrating and testing the software. This is where the efforts of many subgroups come together under the master control program. Debugging occurs during the walk-through where the engineers, senior programmers, and the systems analysts have all done their parts; what hopefully emerges is a useful, well-documented, efficient, reliable, and on-time software package.

What I gained from Heckel's book will affect the way I program from now on. What I gained from Softky's text is an appreciation and respect for upper management. After you've read both books, you'll have a handy combination. You'll have the knowledge to correctly define, structure, code, and implement a software design, combined with the craftiness of a car salesman and the empathy of a psychiatrist.

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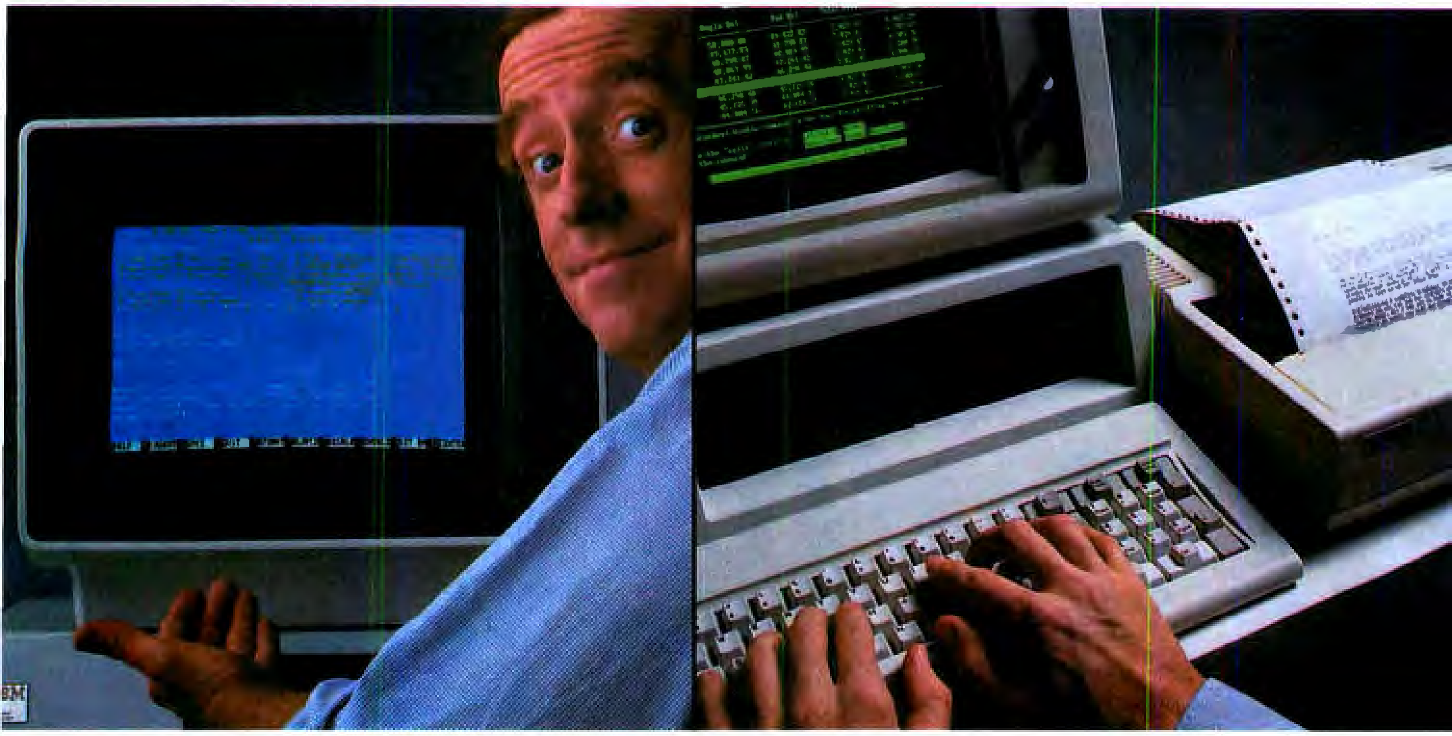

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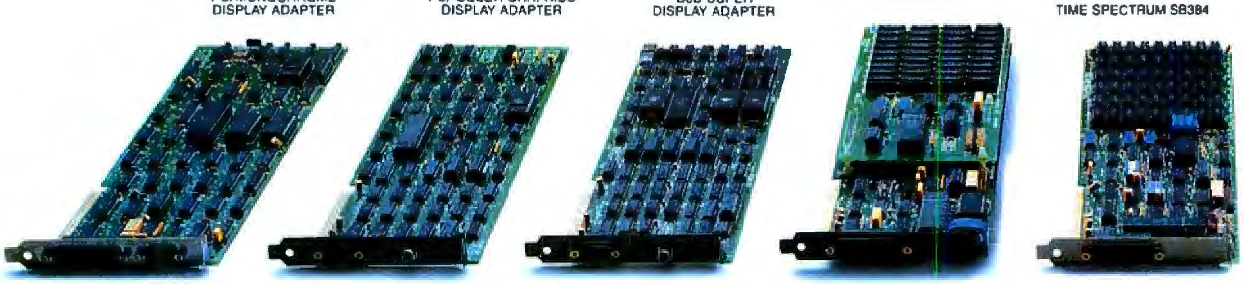

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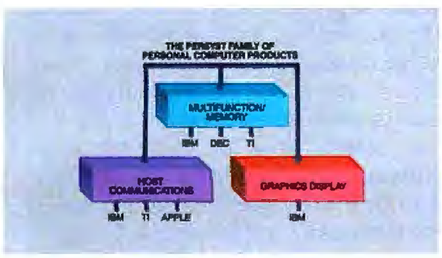

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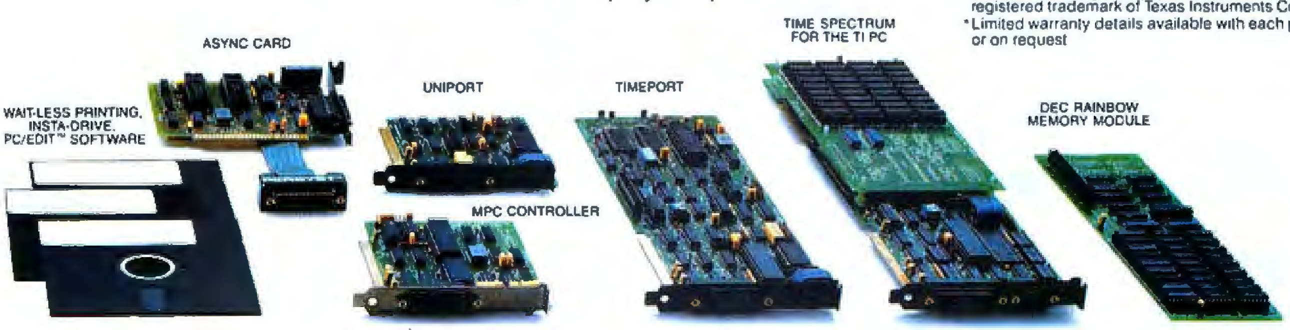

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The Programmer's CP/M Handbook

Reviewed by Wayne W. Shearer Jr.

If you write assembly-language programs for CP/M systems, this book is for you. I could end this review right here and not receive any complaints from anyone who reads *The Programmer's CP/M Handbook*. The author, Andy Johnson-Laird, has provided the long-awaited definitive book on CP/M programming. Explanations of each function are explicit, filled with examples, and are the most complete I've seen about CP/M in print.

To the Point

The first sentence of chapter 1 explains the author's direction and purpose: "This book is a sequel to the *Osborne CP/M User Guide* by Thom Hogan" (Osborne/McGraw-Hill, 1982). The first chapter outlines the contents of the book, the notation used in its examples, the mnemonics and languages in the program listings, and the type of reader for whom the book is written. And make no mistake, this is not a beginner's book. In chapter 4, a couple of paragraphs are devoted to each built-in command in the console command processor (CCP), and that's it. The book is for serious programmers who write applications, utilities, and systems for CP/M.

Ample Comment

Without a doubt, *The Programmer's CP/M Handbook* provides the best explanation of the CP/M file structure and disk interfacing that I have found. A full chapter explains the file structure in CP/M. The file control block (FCB) is described byte by byte—in English, not computerese. And I believe that I now actually understand the disk-definition tables and disk-parameter blocks used in the CP/M basic input/output system (BIOS). I won't say the book is easy reading, but the explanations are about as clear as you can muster in assembly-language programming, and all explanations are accompanied by heavily commented program listings.

One chapter is devoted to the basic disk operating system (BDOS) and another to the BIOS. Each call to the BDOS is discussed, including a short section on each, titled "Notes," that warns of common mistakes, misunderstandings, and pitfalls that await the CP/M programmer. The same is done for the BIOS calls. Character input/output (I/O) is given the full treatment, untangling the difference between logical and physical devices and providing in-depth explanations of such mundane subjects as serial and parallel interfacing. The chapter ends with a sample BIOS listing. No, this isn't the same stripped-down BIOS that's been appearing in the back of the *CP/M Alteration Guide* for years; it's a well-documented, full-blown BIOS that the author has developed and tested himself. This could be the first assembly-language program that I've seen with more lines of comment than code.

But Johnson-Laird isn't satisfied with expanding the CP/M manuals. He describes enhancements that can be added to the BIOS to correct deficiencies in CP/M and to expand the features and facilities available. Programmers can learn to customize a CP/M BIOS configuration and implement an enhanced BIOS. These enhancements fall into two groups—expanded I/O facilities and improved error handling. Each group is given its own chapter. Adding I/O redirection, interrupt-driven input, serial protocols, terminal function keys, date and time, and device-configuration blocks are covered in one chapter. This may sound like a lot, but the chapter ends with a listing of an enhanced BIOS with over 4500 lines of source code. By an admittedly rough estimate, I figure the comment lines outnumber the source code lines by about 3 to 1. If you can't understand this listing, you weren't paying attention. All programmers should be so kind.

Debugging

The next chapter describes CP/M's error handling. Obviously, this didn't take long. The author describes methods of detecting and correcting hardware errors. The goal is to build a CP/M that reduces the possibility of losing data. The result of this effort is a CP/M where the message "BDOS ERROR" seldom appears.

The chapter titled "Debugging a New CP/M System" should be lifted in its entirety and included in Digital Research's documentation for CP/M—with appropriate compensation to its author, of

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course. This section covers troubleshooting the CP/M BIOS from basic debugging techniques (called "the Orville Wright approach") to the use of extensive built-in debugging code (listings included, naturally). Page after page is filled with checklists of potential problems and possible remedies. Detailed techniques for testing I/O, disk, and interrupt routines are provided, as those areas are especially hard to debug because they are very hardware dependent. The use of pass counters, error trapping, and a discussion of bringing up the bootstrap loader are all covered.

The final chapter provides expanded utilities for the system. A major change is made here: the author switches from assembly language to BDS C. While I have not yet used C, the program listings and examples are clear enough to follow the logic of the utilities and debugging aids described. In fact, these utilities looked so good that I am now in the market for a C compiler. I just can't resist changing data rates, hiding files from the directory, reassigning I/O devices at will, and changing serial protocols as needed. With the understanding of CP/M that I gained after reading this book, I can already think of a few new utilities that I just might develop.

This book has been needed by the CP/M community for some time now. The fact that it was written by someone as talented and knowledgeable as Johnson-Laird is a pleasant surprise. I recommend this handbook to anyone who desires an intimate and serious understanding of CP/M. I assure you that it will become a valuable but tattered addition to your technical literature, as you open it repeatedly to gleen yet another fact from its pages. ■

David D. Clark (246 South Fraser St. #2, State College, PA 16801) is a postdoctoral research scholar in the chemistry department of Pennsylvania State University.

Chris H. Pappas is a professor of computer science at Broome Community College, Binghamton, New York, and is currently writing a book on APL.

Wayne W. Shearer Jr. (1143 South University Blvd., Denver, CO 80210) is general manager of Shearer Associates, a consulting firm based in Denver.

August 1984

● C, UNIX COURSES
Courses in C Language and UNIX, Concord, MA, Somers Point, NJ, and College Park, MD. Three five-day courses are offered: "C Programming Workshop," "Advanced C Topics Seminar," and "UNIX Workshop." Contact Joan Hall, Plum Hall Inc., 1 Spruce Ave., Cardiff, NJ 08232, (609) 927-3770. *August*

● DATABASE SEMINARS
SoftwareBanc Seminars, various sites in the U.S. and Canada. Such seminars as "Problem Solving with 1-2-3," "dBASE II," and "Exploring UNIX" are planned. Contact SoftwareBanc Inc., 661 Massachusetts Ave., Arlington, MA 02174, (800) 451-2502; in Massachusetts, (617) 641-1241. *August*

● DBM SEMINARS
Digital Consulting Associates Classes and Seminars, various sites in the U.S. Seminars and classes on information centers, database administration, and other microcomputer topics. Contact Digital Consulting Associates Inc., 339 Salem St., Wakefield, MA 01880, (617) 246-4850. *August*

● ENGINEERING SUMMER CONFERENCES, Chrysler Center, North Campus, University of Michigan, Ann Arbor. Topics include aerospace, chemical, electrical, nuclear, marine, metallurgical, mechanical/automotive, industrial, and computer, information, and control engineering. Fees range from $450 to $1000, depending on course length. Contact Engineering Summer Conferences, 200 Chrysler Center—North Campus, University of Michigan, Ann Arbor, MI 48109, (313) 764-8490. *August*

● WORKSHOPS FOR EDUCATORS, Compuworkshops Computer Seminars for Educators, various locations in California. Among the seminars offered are "Computer Literacy for Educators" and "How to Set Up a Computer-Based Education Program in Your School or District." Each course is $50. Contact Compukids of Seal Beach, Rossmoor Shopping Center, 12385 Seal Beach Blvd., Seal Beach, CA 90740, (213) 430-7226; in West Los Angeles, (213) 473-8002; in Tarzana, (213) 343-4008; and in Rancho Bernardo/San Diego, (619) 451-1742. *August*

● DEC SEMINARS
Technical and Management Seminars for Professionals, various sites in the U.S. Subject areas: system-performance management, networking, personal computing, applications design and programming, real-time applications design, and management development. On-site seminars can be arranged. Contact Educational Services, Seminar Programs BUO/E58, Digital Equipment Corp., 12 Crosby Dr., Bedford, MA 01730, (617) 276-4949. *August–September*

● EFFICIENT COMPUTING TECHNIQUES, Microcomputers: Techniques for Improving Your Computer Efficiency, Valley Inn and Tavern, Waterville Valley, NH. Four intensive two-day seminars: "Microcomputers: Programming in BASIC," "Introduction to VisiCalc," "Micro Database Applications," and "Engineering and Management Applications." Tuition is $495, or $679 with meals and lodging. Contact New Hampshire College, Resource Center, 2500 North River Rd., Manchester, NH 03104, (603) 668-2211, ext. 175. *August–September*

● MANAGERIAL SEMINARS
Computer Competence Seminars, Boston University Metropolitan College, Boston, MA. A series of hands-on presentations tailored for managers who know little or nothing about computers and for those who wish to sharpen their computing skills. On the docket are "PCs for Improving Financial Analysis and Decision Support," "dBASE II," and many others. Fees range from $225 to $595. In-house programs can be organized. Contact Joan Merrick, University Seminar Center, Suite 415, 850 Boylston St., Chestnut Hill, MA 02167, (617) 738-5020. *August–September*

● RAINBOW SEMINARS
All-Hands-On, Boston, MA, Chicago, IL, New York City, and San Francisco, CA. A series of applications seminars featuring the DEC Rainbow 100. Contact Carol Ericson, BUO/E50, Educational Services, Digital Equipment Corp., 12 Crosby Dr., Bedford, MA 01730, (617) 276-4572. *August–September*

● PROFESSIONAL EDUCATION
Seminars from the Institute for Professional Education, various sites in the U.S. Programs in statistics, management, simulation and modeling, personal computers, and computer science. Contact the Institute for Professional Education, POB 756, Arlington, VA 22216, (703) 527-8700. *August–December*

● COMPUTERS IN ENGINEERING, The 1984 ASME International Computers in Engineering Conference and Exhibit, Hilton Hotel, Las Vegas, NV. More than 60 panel discussions and paper sessions. Product exhibits. Contact American Society of Mechanical Engineers, 345 East 47th St., New York, NY 10017, (212) 705-7100. *August* 12–16

● MICROS & VOC EDUCATION
Microcomputers and High Technology in Vocational Education Conference, Vocational Studies Center, University of Wisconsin, Madison. Concurrent sessions, formal classes, presentations, speeches, and videotaped programs. Preregistration fee is $55, or $65 at the door. Contact Dr. Judith Rodenstein, 964 Educational Sciences Building, University of Wisconsin, 1025 West Johnson St., Madison, WI 53706, (608) 263-4367. *August* 13–16

● COMPUTERS AND BIOLOGY
The Fourth Annual Notre Dame Short Course Series: Computers in Biology, University of Notre Dame, Notre Dame, IN. Three concurrent short courses: "Computers in Bioeducation," "Microcomputers in Classroom and Laboratory," and "Computerized Data Analysis in Biological Research." Technical expertise is not required. Tuition is $450. Contact Theodore J. Crovello, Biocomputing Short Course Coordinator, Department of Biology, University of Notre Dame, Notre Dame, IN 46556, (219) 239-7496. *August* 13–17

● COMPUTING IN SCHOOLS
The Third Annual Harvard Institute on Computing in Schools, Harvard Graduate School of Education, Cambridge, MA. Designed for educators and administrators. Software demonstrations and group discussions will be featured. Prior computer experience not required. Contact Institute on Computing in Schools, Programs in Professional Education, Harvard Graduate School of Education, 339 Gutman Library, Cambridge, MA 02138, (617) 495-3572. *August* 13-17

● PROGRAM COMPUTER GAMES, Programming Games on Computers, Salzburg Inn, Stowe, VT. Presented by Monty Newborn and David Levy, computer-game experts, this course is designed to show you how to program a computer to play chess, bridge, othello, checkers, and blackjack. Ability

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to program in BASIC, FORTRAN, or Pascal is advised. The fee is $550. Contact Dr. Monty Newborn, 4874 Westmount Ave., Westmount, Quebec H3Y 1Y1, Canada, or call (514) 481-1766. *August* 13-17

● COMPUTERS, GRAPHICS, AND BUILDING. Computers/Graphics in the Building Process—BP '84, Embarcadero Center, Hyatt Regency San Francisco, CA. Exhibit of equipment and services, tutorials, and technical sessions exploring the theme "The Building Process in Transition." Contact Conference Director, BP '84, Suite 333, 2033 M St. NW, Washington, DC 20036, (202) 775-9556. *August* 19-23

● ADA COURSE
Hands-On Programming in Ada, Washington, DC. Upon completion students will be able to design, code, and test Ada programs in an interactive environment. Enrollment is limited to individuals with programming experience in at least one high-level language. The fee is $875. Contact Continuing Engineering Education, George Washington University, Washington, DC 20052, (800) 424-9773; in the District of Columbia, (202) 676-6106. *August* 20-24

● PROGRAM COMPUTER GAMES. Programming Games on Computers, Salzburg Inn, Stowe, VT. See August 13-17. *August* 20-24

● HAMFEST/COMPUTERFEST
The Central Pennsylvania Repeater Association Eleventh Annual Hamfest/Computerfest, Hershey, PA. Indoor dealer and flea-market areas. Registration is $3. Children and spouses free. Contact Timothy R. Fanus, WB3DNA, 6140 Chambers Hill Rd., Harrisburg, PA 17111, (717) 564-0897 (noon to 8 p.m.). *August* 26

● INFO CENTER CONFERENCE
Information Center Conference and Exposition, Sheraton Boston and Hynes Auditorium, Boston, MA. More than 60 educational sessions on hardware, software, and organizational topics of interest to information-center managers will be featured. Contact Warren/Weingarten Publications, 38 Chauncy St., Boston, MA 02111, (617) 542-0146. *August* 26-30

● PCB TECHNICAL SEMINAR
The 1984 Printed Circuit Fabrication Technical Seminar, Boston, MA. Contact Donna Esposito, PMS Industries, 625 Sims Industrial Blvd., Alpharetta, GA 30201, (404) 475-1818. *August* 27–29

● ADA WORKSHOP
Workshop in Ada, Atlanta, GA. This course combines lectures with laboratory sessions and emphasizes the design and implementation of Ada programs. Programming experience with FORTRAN, PL/I, Jovial, Pascal, C, or another high-level language required. Fee: $900. Contact Elaine Hadden Nicholas, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385, (404) 894-2547. *August* 27-30

● EUROMICRO
The Tenth Annual Euromicro Symposium—Euromicro 84, Copenhagen, Denmark. One of the largest European computer events, Euromicro features speeches, tutorials, and technical sessions. Also featured will be the annual Euromouse contest in which robotic mice zip through a maze, racing against time and foreign competitors. Contact Euromicro, p/a TH Twente, Department INF, Room A306, POB 217, 7500 AE Enschede, The Netherlands; tel: (31) (53) 338799; Telex: 44200 THES. *August* 27-30

September 1984

● COURSES FROM ICS
Courses from Integrated Computer Systems, various sites throughout the U.S. Among the courses offered are "Computer Network Design and Protocols" and "Data Communications." Fees are generally $895. Contact Integrated Computer Systems, 6305 Arizona Place, POB 45405, Los Angeles, CA 90045, (800) 421-8166; in California, (800) 352-8251 or (213) 417-8888. *September-October*

● ERGONOMICS CONFERENCE
World Conference on Ergonomics in Computer Systems, various sites throughout the U.S.
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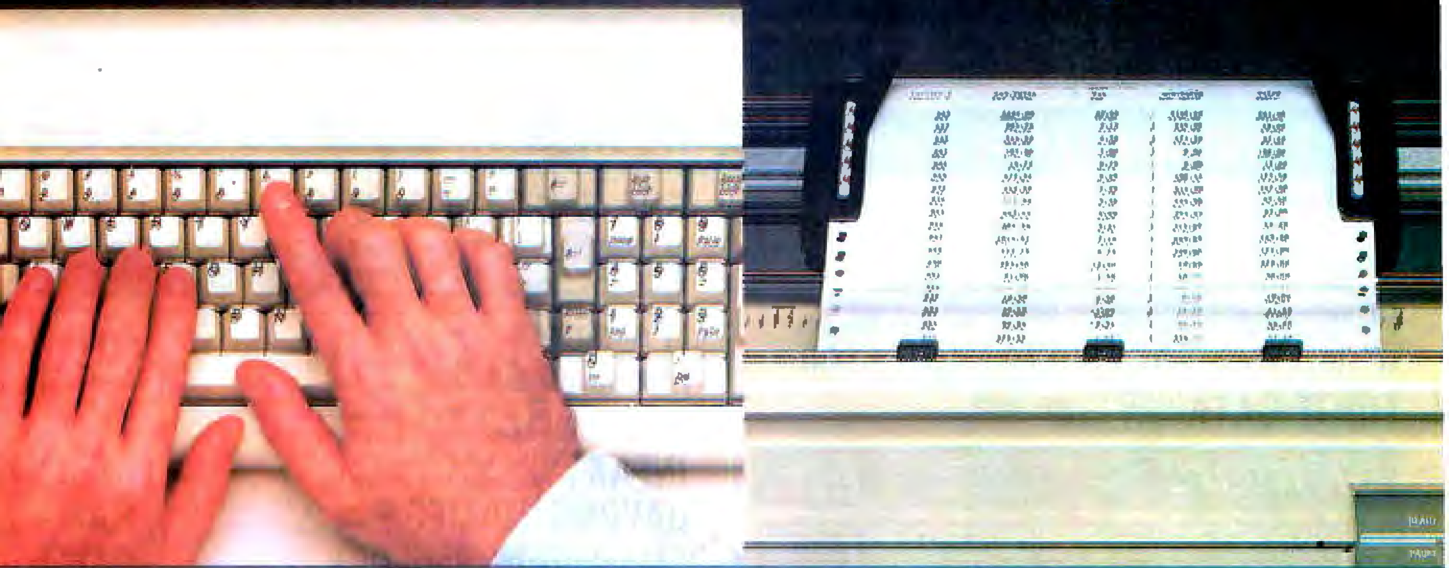

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and Europe. Ergonomic experts and computer professionals and users will exchange information and observations. Contact Computer Psychology Inc., 54 East Main St., POB 16, Mendham, NJ 07945, (201) 543-9009. In Europe, Telefonaktiebolaget LM Ericsson, LM Ericssons väg 4-8, S-12625 Stockholm, Sweden; tel: (8) 7190000. *September-October*

● HIGH-TECH TUTORIALS
Tutorial Short Courses from Hellman Associates, London, England, and various sites in the U.S. Among the courses offered are "VLSI Design," "Digital Control," and "Error Correction." Fees are generally $895. Contact Hellman Associates Inc., Suite 300, 299 California Ave., Palo Alto, CA 94306, (415) 328-4091. *September–October*

● MEDICAL COMPUTER SEMINAR. Medical Computer Weekends, various sites throughout the U.S. For cardiologists, internists, and primary-care physicians. Focuses on the role of the multipurpose medical office computer. Seminars qualify for 13 hours CME Category I credit. Contact International Medical Education Corp., 64 Inverness Dr. E, Englewood, CO 80112, (800) 525-8651; in Colorado, (303) 790-8445. *September-October*

● SEMINARS FOR PROFESSIONALS. Professional Development Seminars, various sites throughout the U.S. Topic areas: data communications, database management, EDP operations, microcomputers, software engineering, CAD/CAM, personal computers, IBM mainframes, office automation, management, and administration. Fees range from $195 to $1095. Contact Institute for Advanced Technology, 6003 Executive Blvd., Rockville, MD 20852, (800) 638-6590; in Maryland, (301) 468-8576. *September-October*

● CONTINUING ENGINEERING EDUCATION. George Washington University, Continuing Engineering Education, Washington, DC. For a schedule, contact George Harrison, Continuing Engineering Education, George Washington University, Washington, DC 20052, (800) 424-9773; in the District of Columbia, (202) 676-6106. *September-November*

● SHOWS IN GERMANY
Chip Microcomputer Weeks, various sites throughout West Germany. Microcomputer products, trends, and applications will be demonstrated. Sponsored by *Chip*, a leading German computer magazine. Contact Network GmbH, An der Friedenseiche 10, D-3050 Wunstorf 2, Bundesrepublik Deutschland (West Germany); tel: (0 50 33) 10 56; Telex: 92 45 45. In England, Network Events Ltd., Printers Mews, Market Hill, Buckingham MK18 1JX, England; tel: (02 80) 81 52 26; Telex: 83111. *September-November*

● INTEL WORKSHOPS
Microcomputer Workshops, various sites throughout the U.S. and Canada. Intel, the semiconductor memory manufacturer, is offering more than 20 workshops on microprocessor applications. A brochure is available. Contact Customer Training, Intel Corp., 27 Industrial Ave., Chelmsford, MA 01824-3688, (617) 256-1374. *September-December*

● IBM SYSTEMS SHOW
The IBM System User Show, Olympia 2, London, England. Covers the full spectrum of IBM mainframes, minicomputers, and microcomputers. A focus on business. Contact EMAP International Exhibitions Ltd., 8 Herbal Hill, London EC1R 5JB, England; tel: 01 837 3699. *September* 3-5

● AI IN EUROPE
The Sixth European Conference on Artificial Intelligence, Pisa, Italy. Covers programming languages, expert systems, natural-language processing, robotics, and computer vision. Tutorials. Contact the Programme Chairman, Institute of Educational Technology, Open University, Walton Hall, Milton Keynes MK7 6AA, England. In Italy, Stefano A. Cerri, Dipartmento di Informatica, Universita di Pisa, Corso Italia, 40, Pisa 56100, Italy; tel: Pisa 40862/3/4; Telex: CNUCE 500371. *September* 5-7

● SOFTWARE ONLY
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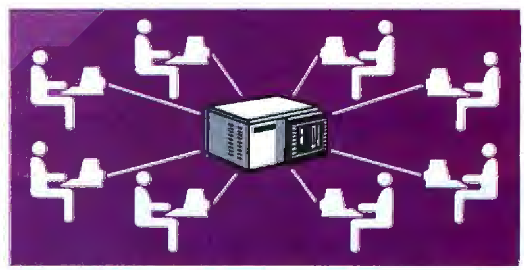

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puter software. Contact Raging Bear Productions Inc., Suite 175, 21 Tamal Vista Dr., Corte Madera, CA 94925, (800) 732-2300; in California, (415) 924-1194. *September* 5-7

● COMPUTER INTERFACING FOR SCIENCE, Personal Computer and STD Computer Interfacing for Scientific Instrument Automation, Washington, DC. A hands-on workshop costing $395. Contact Dr. Linda Leffel, C.E.C., Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, (703) 961-4848. *September* 6-8

● COMPUTERS IN COMMONWEALTH, Halifax Computer and Office Automation Show, Metro Centre, Halifax, Nova Scotia, Canada. Contact Industrial Trade Shows, 20 Butterick Rd., Toronto, Ontario M8W 3Z8, Canada, (416) 252-7791. *September* 6-8

● BYTE SHOW
The BYTE Computer Show, Brooks Hall, San Francisco, CA. Seminars, conferences, and displays of interest to BYTE and *Popular Computing* subscribers. Contact The Interface Group, 300 First Ave., Needham, MA 02194, (800) 325-3330; in Massachusetts, (617) 449-6600. *September* 6-9

● FUTURE DBMS
Fourth Generation Data Management Software, Washington, DC. Topics include user-friendly DBMS, applications generators, data dictionaries/directories, database designers, and decision-support systems. Registration fee: $650. Contact Software Institute of America Inc., 8 Windsor St., Andover, MA 01810, (617) 470-3880. *September* 10-11

● MOTION CONTROL SEMINAR, Electronic Motion Control Seminar, Boston, MA. Sponsored by the Electronic Motion Control Association. Contact EMCA Headquarters, Suite 1200, 230 North Michigan Ave., Chicago, IL 60601, (312) 372-9800. *September* 10-11

● ELECTRONICS SHOWS
Midcon/84 and Mini/Micro Southwest-84, Dallas, TX. Concurrent conferences exploring practical applications and the state of the art of electronics, including computers, graphics, and networks. Contact Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045, (213) 772-2965. *September* 11-13

● UNIX EXPOSITION
UNIX Systems Expo/84, Convention Center, Los Angeles, CA. More than 200 exhibits of UNIX-related products and services, as well as presentations and panel discussions. Contact Computer Faire Inc., 181 Wells Ave., Newton, MA 02159, (617) 965-8350. *September* 11-14

● EUROPEAN COMPUTER GRAPHICS, Eurographics '84—The Fifth Annual European Computer Graphics Congress, Copenhagen, Denmark. A congress with an international lineup of speakers and product exhibits. Contact Kenness International, 1 Park Ave., New York, NY 10016, (800) 235-6400; in New York, (212) 684-2010. *September* 12-14

● INTRO TO DATA COMMUNICATIONS, Introduction to Data Communications, Atlanta, GA. An overview of data-communications terminology, technology, hardware, and software. Participants will learn to design a batch data-collection system and estimate the response time of a multipoint circuit. Fee: $725. Contact Elaine Hadden Nicholas, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385, (404) 894-2547. *September* 12-14

● SOFTWARE EXPO
The Fifth Annual Software/Expo, Hyatt Regency, Chicago, IL. A conference and exposition. Contact Software/Expo, Suite 205, 2400 East Devon Ave., Des Plaines, IL 60018, (312) 299-3131. *September* 12-14

● TECHNOLOGY FOR DISABLED, Computer Technology for the Handicapped, Raddison South Hotel, Minneapolis, MN. A national conference and exhibit for special education, rehabilitation, and medical professionals. Presentations and workshops. Registration is $150 before September 1; $175 after. Admission to the exhibit floor only is $3. Contact Closing the Gap,

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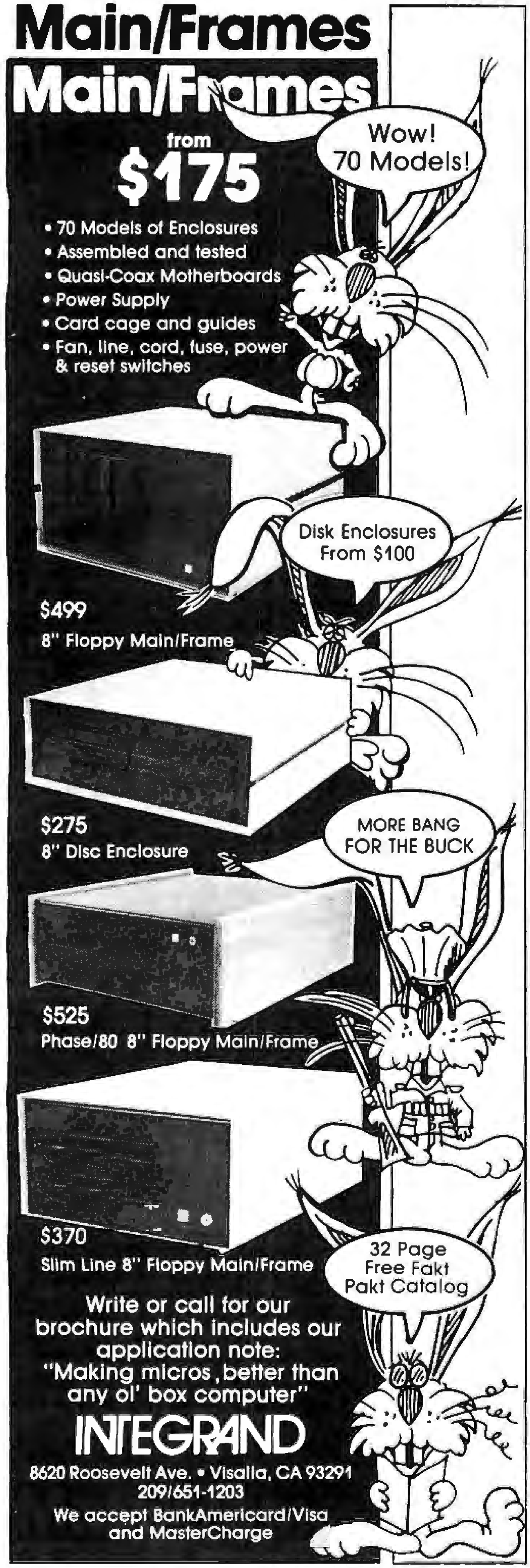

POB 68, Henderson, MN 56044, (612) 665-6573 or (612) 341-8299. *September* 13-16

● GULF COAST COMPUTING The Heart of Texas Computer Show, Bayfront Plaza, Corpus Christi. Seminars and displays. Contact Heart of Texas Computer Show, POB 12094, San Antonio, TX 78212, (512) 681-2248. *September* 14-16

● PEOPLE AND COMPUTERS The 1984 SME World Congress on Human Aspects of Automation, Hotel du Parc, Montreal, Quebec, Canada. Contact Society of Manufacturing Engineers, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-1500, ext. 369. *September* 16-19

● COMPUTERS AND MODERN WORLD, COMPCON Fall '84, Hyatt Regency Crystal City, Arlington, VA. Tutorials, panels, demonstrations, sessions, and papers will explore the theme "Small Computer (R)Evolution." Contact COMPCON Fall '84, IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-8142. *September* 16-20

● MEDICINE, BIOLOGY, ENGINEERING, The Thirty-Seventh Annual Conference on Engineering in Medicine and Biology, Los Angeles Hilton, Los Angeles, CA. Papers, short courses, and scientific and commercial exhibits will be featured. Contact The Alliance for Engineering in Medicine and Biology, Suite 402, 4405 East-West Highway, Bethesda, MD 20814, (301) 657-4142. *September* 17-19

● NETWORK COMPONENTS COURSE, Data Communications Network Components, Atlanta, GA. Covers the use, operation, application, and acquisition procedures for 25 major communications components. Fee: $750. Contact Elaine Hadden Nicholas, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385, (404) 894-2547. *September* 17-19

● ADA WORKSHOP Future Ada Environment Workshop, Miramar Hotel By-the-Sea, Santa Barbara, CA. Workshops, addresses, presentations, working groups, and discussions. Registration: $400 to $700 depending on room choice. Contact ACM AdaTEC Future Ada Environment Workshop, TRW R2/1134, One Space Park, Redondo Beach, CA 90278, or register directly with Carolyn Gannon, GRC, POB 6770, Santa Barbara, CA 93160. *September* 17-20

● KENTUCKIANA EXHIBITION CompuFest '84, Commonwealth Convention Center, Louisville, KY. Computer consultant services and approximately 100 hardware, software, peripheral, and word-processing system vendors will man exhibits. Technical sessions will be offered. A full day's worth of seminars costs $15. Registration fee is $2. Contact the Kentucky Society of CPAs, 310 West Liberty St., Louisville, KY 40202, (502) 589-9239. *September* 18-20

● OFFICE PRODUCTS IN OK CITY, The First Annual Southwest Office Products Show, Oklahoma City, OK. Contact SWOPS, POB 950, Norman, OK 73070, (405) 329-3660 or (918) 587-9550. *September* 18-20

● ADA WORKSHOP Workshop in Ada, Atlanta, GA. See August 27-30. *September* 18-21

● PARISIAN COMPUTING The Thirty-Fifth SICOB—International Exhibition of Data Processing, Teleprocessing, Communication, Office Procedures, and Office Systems, CNIT, Paris-La Défense, Paris, France. Microprocessing and videotex will be major highlights of the exhibition. International visitors presenting their passports will have a special reception room. Some of the congresses and conferences will feature simultaneous interpretation in English and French. Contact International Trade Exhibitions in France, 8 West 40th St., New York, NY 10018, (212) 869-1720. *September* 19-28

● EDUCATIONAL CONFERENCE The First North Carolina Educational Microcomputer Conference, Benton Convention Center and Hyatt Hotel, Winston-Salem. Educational sessions, hands-on workshops, and product displays. A network of various computers will be set up. Contact Jeanette Gann, NC

(continued)

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EVENT QUEUE

Regional Education Center, POB 21889, Greensboro, NC 27420, (919) 379-5764. *September* 20-21

● PROJECT MANAGEMENT SEMINAR. Software for Project Management and Estimating, Los Angeles, CA. Fee: $425. Contact CIP Information Services Inc., 1105-F Spring St., Silver Spring, MD 20910, (301) 589-7933. *September* 20-21

● DOCUMENTATION METHODS How to Document a Computer System, Holiday Inn—Thomas Circle, Washington, DC, and Hyatt Cherry Hill, Cherry Hill, NJ. A series of documentation procedures will be presented. The fee is $155. Contact Technical Communications Associates, Suite 210, 1250 Oakmead Parkway, Sunnyvale, CA 94086, (800) 227-3800, ext. 977; in California, (408) 737-2665. *September* 21 and *September* 24, respectively

● PACIFIC COAST FAIR The Fifth Annual Pacific Coast Computer Fair, Robson Square Media Centre, Vancouver, British Columbia, Canada. This event features exhibits, user-group displays, and more than two dozen speakers. Workshops, presentations, and panels will discuss the Apple Macintosh, MS-DOS, software and hardware marketing, publishing, Modula-2, and graphics. Admission is $4 per day. Contact Pacific Coast Computer Fair Association, POB 80866, South Burnaby, British Columbia V5H 3Y1, Canada, (604) 581-6877. *September* 22-23

● GRAPHICS STANDARD COURSE. Introduction to GKS, Hyatt Regency Hotel, Austin, TX. A course on the Graphics Kernel System (GKS) standard. The fee is $495. Contact Nova Graphics International Corp., 1015 Bee Cave Woods, Austin, TX 78746, (512) 327-9300. *September* 24-25

● ASIAN COMPUTER SHOW The Fifth South East Asia Regional Computer Conference and Exhibition and Hong Kong Computer 84, Hong Kong Exhibition Centre, China Resources Building, Wanchai, Hong Kong. Contact Cahners Exposition Group, 7315 Wisconsin Ave., POB 70007, Washington, DC 20088, (301) 657-3090. *September* 24-27

● OFFICE AUTOMATION IN OTTAWA. The Seventh Annual Ottawa Computer and Office Automation Show. Lansdowne Park, Ottawa, Ontario, Canada. Contact Industrial Trade Shows, 20 Butterick Rd., Toronto, Ontario M8W 3Z8, Canada, (416) 252-7791. *September* 26-27

● COMPUTERS, COMMUNICATIONS, AND CONTROL Eurocon 84—The Sixth European Conference on Electrotechnics, Brighton, England. A conference that seeks to identify the impact of computer-based technology on communications and control. Contact Manager, Conference Services, Institution of Electrical Engineers, Savoy Place, London WC2R 0BL, England; tel: 01-240 1871, ext. 222; Telex: 261176. *September* 26-28

● MID-ATLANTIC SHOW The Fifth Annual Mid-Atlantic Computer Show and Office Equipment Exposition, Convention Center, Washington, DC. Contact CompuShows Inc., POB 3315, Annapolis, MD 21403, (800) 368-2066; Annapolis, (301) 263-8044; Baltimore, 269-7694; District of Columbia, 261-1047. *September* 27-30

October 1984

● TECHNOLOGY FOR DISABLED. Discovery '84: Technology for Disabled Persons, Chicago, IL. Presentations, demonstrations, and exhibits on computers, technological products, and services for disabled persons. Before September 1, registration is $125; after, it's $175. Contact Office of Continuing Education, University of Wisconsin-Stout, Menomonie, WI 54751, (800) 457-8688; in Wisconsin, (800) 227-8688. *October* 1-3

● INFO/MANAGEMENT CONFERENCE. Information Management Exposition and Conference: Info 84, Coliseum and Sheraton Centre Hotel, New York City. Contact Banner & Greif Ltd., 110 East 42nd St., New York, NY 10017, (212) 687-7730. *October* 1-4

● NORTHWEST ELECTRONICS SHOW. Northcon/84 and Mini/

(continued)

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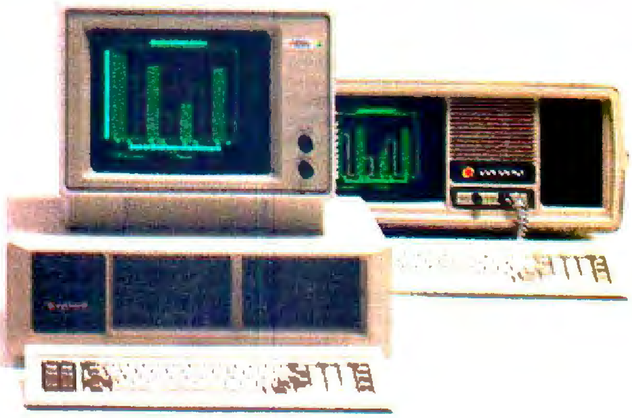
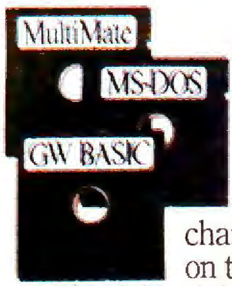
HOW TO RUN THE WORLD.





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Micro Northwest-84, Seattle, WA. Among the topics are automation, CAD/CAM, local area networks, and personal computing. Contact Electronic Conventions Management Inc., 8110 Airport Blvd., Los Angeles, CA 90045, (213) 772-2965. *October* 2-4

● GLOBAL INFO/MANAGEMENT CONGRESS, The Sixteenth Annual International Information Management Congress, Hyatt Regency Hotel, Singapore, Republic of Singapore. Seminars, displays, and more than 30 conference sessions. Contact IMC Infomatics '84, POB 34404, Bethesda, MD 20817, (301) 983-0604. *October* 2-4

● ADA WORKSHOP
Workshop in Ada, Atlanta, GA. See August 27-30. *October* 2-5

● PC EXPO
PC-World Exposition, Market Hall, Dallas, TX. Contact Mitch Hall Associates, POB 860, Westwood, MA 02090, (617) 329-8090. *October* 3-5

● MOTION CONTROL SEMINAR, Electronic Motion Control Seminar, Philadelphia, PA. Contact Electronic Motion Control Association, Suite 1200, 230 North Michigan Ave., Chicago, IL 60601, (312) 372-9800. *October* 8-9

● VIRGINIA IS FOR COMPUTERS, The Tidewater Ninth Annual Computer Fair, Radio Amateur Hamfest/Electronic Flea Market, Virginia Beach Pavilion, Virginia Beach, VA. Dealers, a giant flea market, displays, and forums. Advanced tickets are $4; at the door, $5. Contact Jim Harrison, 1234 Little Bay Ave., Norfolk, VA 23503, (804) 587-1695. *October* 8-9

● ANNUAL CONFERENCE OF ACM, ACM 1984 Annual Conference, Hilton Hotel, San Francisco, CA. Papers, sessions, and panel discussions will address the theme "The Fifth Generation Challenge." Contact Association for Computing Machinery, 11 West 42nd St., New York, NY 10036, (212) 869-7440. *October* 8-10

● NETWORK CONFERENCE
The Ninth Conference on Local Computer Networks, Minneapolis, MN. Papers, conference sessions, and tutorials. The theme is "Local Computer Networks—The Exploding Marketplace." Contact Ninth Conference on Local Networks, c/o Harvey Freeman, Architectural Technology Corp., POB 24344, Minneapolis, MN 55424. *October* 8-10

● INFO SYSTEMS CONFERENCE and EXPO, INTECH—The Integrated Information Technology Conference and Exposition, Convention Center, Dallas, TX. Seminars, sessions, and panels addressing total information systems integration. Contact National Trade Productions Inc., 9418 Annapolis Rd., Lanham, MD 20706, (800) 638-8510; in Maryland, (301) 459-8383. *October* 9-11

● SOUTHWEST COMPUTING
The Third Annual Southwest Computer Conference, Convention Center, Tulsa, OK. A business and industry event featuring more than 50 seminars as well as 250 exhibits. Contact SWCC, POB 950, Norman, OK 73070, (405) 329-3660 or (918) 587-9550. *October* 9-11

● MID-WEST ELECTRONICS
The Mid-America Electronics Convention—MAECON/84, St. Louis, MO. Exhibits, seminars, tutorials, and symposia. Contact Electronic Representatives Association, 20 East Huron St., Chicago, IL 60611, (312) 649-1333. *October* 10-11

● NETWORKS EXPLORED
LocalNet '84, Sheraton Harbor Island Hotel, San Diego, CA. Speakers, papers, and exhibitions will look at local network technology and the effects of office automation. Contact Online Conferences Inc., Suite 1190, 2 Penn Plaza, New York, NY 10121, (212) 279-8890. *October* 10-12

● PROJECT MANAGEMENT SEMINAR, Software for Project Management and Estimating, Washington, DC. See September 20-21. *October* 11-12

● COMPUTERS IN SUNSHINE
Great Southern Computer Show, Centroplex Expo Centre, Orlando, FL. Seminars and exhibits of hardware, software, peripher-

(continued)

EVENT QUEUE

als, and accessories. Contact Great Southern Computer Shows, POB 655, Jacksonville, FL 32201, (904) 356-1044. *October* 11-13

● GOLDEN STATE EXPO
Computer Expo and PC Faire, Cal Expo, Sacramento, CA. Contact Computer Expo & PC Show, Suite 395, 2020 Hurley Way, Sacramento, CA 95825, (916) 924-9351. *October* 11-14

● EDUCATIONAL COMPUTER FAIR. Fourth Annual Educational Computer Fair, Cleveland, OH. Contact Educational Computer Consortium of Ohio, 4777 Farnhurst Rd., Cleveland, OH 44124, (216) 291-5225. *October* 12-13

● LONE STAR COMPUTING
The Second Annual Heart of Texas Computer Show, Convention Center, San Antonio, TX. Exhibits of computers, games, robots, and other high-tech products. Contact Heart of Texas Computer Show, POB 12094, San Antonio, TX 78212, (512) 681-2248. *October* 12-14

● COMPUTERS IN LABORATORY. Laboratory Computer Interfacing, McGill University, Montreal, Quebec, Canada. Two short courses, "Computers in the Laboratory" and "Laboratory Computer Interfacing," are offered. Contact Dr. Eric Salin, Department of Chemistry, McGill University, Montreal, Quebec H3A 2K6, (514) 392-5784. *October* 13-14

● FUTURE OF VIDEODISC
The Second International Conference on the Future of Optical Memories, Videodiscs, and Compact Disks to the Year 2000, Loew's Summit Hotel, New York City. Speakers and demonstrations. The fee is $795. Contact Technology Opportunity Conference, POB 14817, San Francisco, CA 94114-0817, (415) 626-1133. *October* 15-17

● UNIX INSIDE AND OUT
UNIX Operating System Exposition and Conference, Sheraton Centre Hotel and Marina Exposition Complex, New York City. Seminars, social functions, and 350 exhibition booths. Contact National Expositions Co. Inc., 14 West 40th St., New York, NY 10018, (212) 391-9111. *October* 16-18

● OFFICE COMPUTERS
The Sixth Annual Calgary Computer and Office Automation Show, Roundup Centre, Calgary, Alberta, Canada. Contact Industrial Trade Shows, 20 Butterick Rd., Toronto, Ontario M8W 3Z8, Canada, (416) 252-7791. *October* 17-18

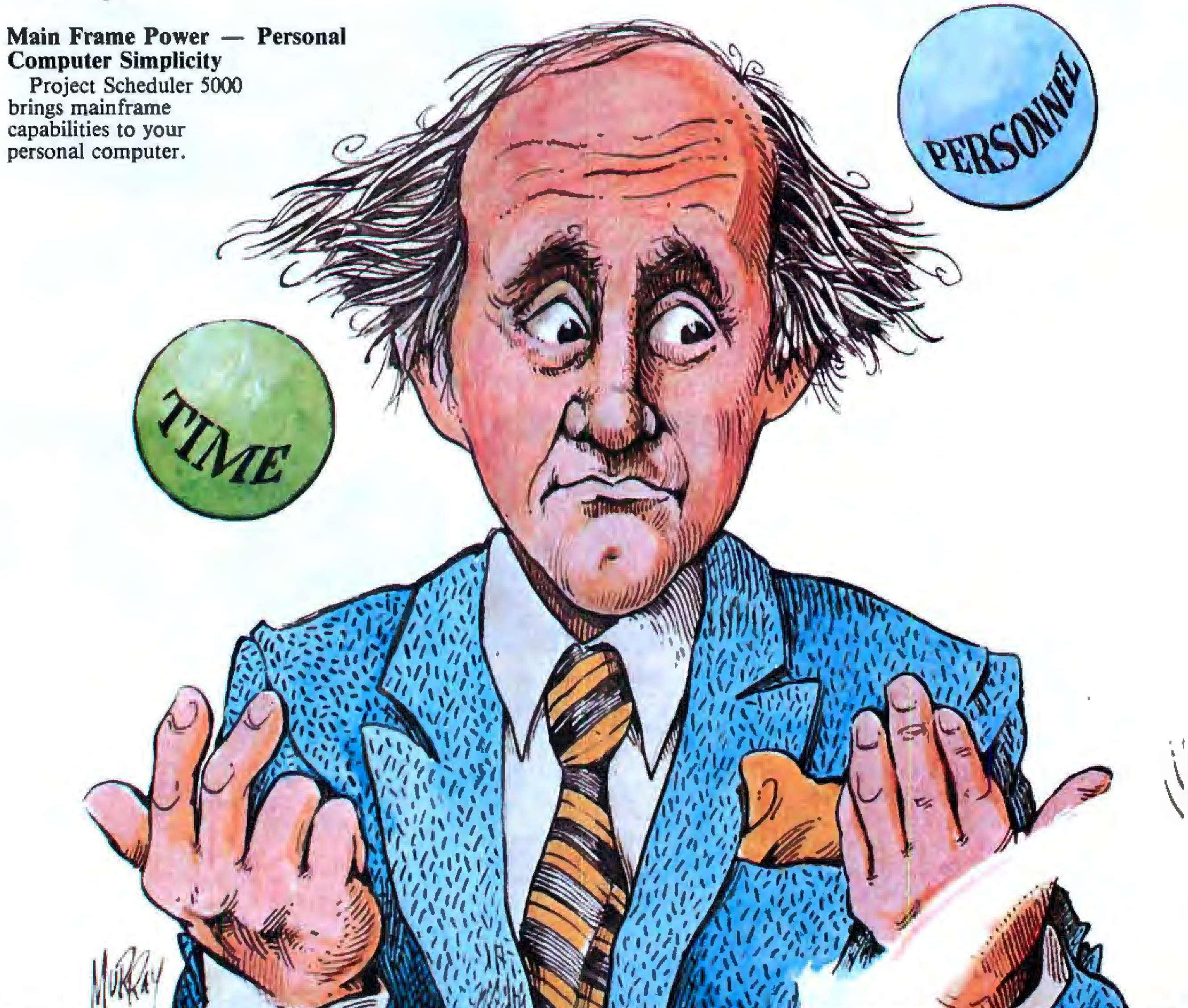
● COMPUTERS, COMMAND, CONTROL. The Second Annual Symposium and Exhibition of AFCEA, Inn at Executive Park, Kansas City, MO. The theme for this year's symposium is "The Role of Knowledge-Based Systems in Command and Control." Panel discussions, paper presentations, and exhibits. Contact Armed Forces Communications and Electronics Association, POB 456, Leavenworth, KS 66048, (913) 651-7800. *October* 17-19

● ASIS MEETING
The Forty-Seventh Annual Meeting of American Society for Information Science, Franklin Plaza, Philadelphia, PA. This year's theme is "1984—Challenges to an Information Society." Contact 1984 ASIS Convention, The Automated Office, 3401 Market St., Philadelphia, PA 19104. *October* 21-26

● HOOSIER COMPUTERFEST
Indy/Con '84, Indiana Convention Center and Hoosier Dome, Indianapolis. The largest microcomputer/electronics exhibition and conference in the state. Contact Indy/Con, 5160 East 65th St., Indianapolis, IN 46220, (317) 842-3024. *October* 23-24

● COMPUTERS IN CONSTRUCTION. Computers in Construction, Atlanta, GA. Fee: $425. For further details, contact CIP Information Services Inc., 1105-F Spring St., Silver Spring, MD 20910, (301) 589-7933. *October* 25-26

● COMPUTERS IN ARTS
Symposium on Small Computers in the Arts, University Hilton Hotel, Philadelphia, PA. Introductory and advanced courses in computer animation, music, graphics, interfaces, and legal issues complemented by talks, exhibits, research presentations, a computer art gallery, and film shows. Contact Symposium, POB 1954, Philadelphia, PA 19105. *October* 25-28 ■



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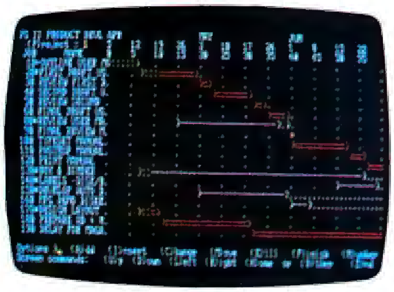


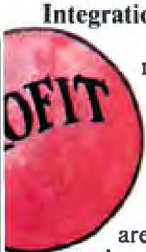
At a glance, unique plot symbols will let you know whether or not the project is on time and on target and if not, why. Meeting performance goals will become a habit.

Project Scheduler 5000 keeps you constantly informed through its partial complete capabilities. Partial complete status is displayed, reported and used to calculate "value earned".

Accurate Resource Assignment

Extensive resource categories allow you to schedule more efficiently. Using these categories, you can assign to an activity an almost limitless amount of resources. In addition, these resources can be assigned at any point within the activity timeline providing the accuracy you need to build realistic resource profiles by person, labor grade, or other types.

Integration Of Multiple Projects



Keeping track of how a resource is used from project to project can be extremely difficult. Not with Project Scheduler 5000. The program can combine projects to give you a complete overview of where and when resources are used. Graphic presentations can be condensed allowing you to visually compare multiple projects quickly and easily. Think of it! You can simultaneously manage several projects and be on time and meet or beat cost projections on each one.

Get The Picture Any Way You Want It

Hours, days, weeks, and months. You can select the resolution you need. In addition, you can break days into as many as 99 units to provide detailed shift or hour resolution. Get the big picture of your schedule on the screen or report by selecting a compressed format which displays up to 60 days, weeks or months of a project.

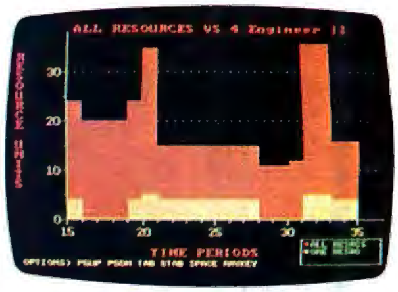
Fast Comprehensive Reporting

Communicating project information is no longer the time consuming task it used to be. An enhanced report generator synthesizes project information into reports on resource allocation, status, schedule and cost at both the project and the detailed activity level. You can interactively define special reports to give you all the detail you need. Reports and Gantt plots can be printed on hard copy or stored on disk for future use. Presentation quality graphics are available on a color plotter. Additionally, a spreadsheet interface provides labor and cost transfers for further analysis.

Integrated Graphics Power

Project Scheduler 5000 plus Graphics complements the outstanding scheduling and reporting features provided by Project Scheduler 5000. Using presentation quality financial line graphs, resource histograms, resource bar graphs and other high impact displays, Project Scheduler 5000 plus Graphics provides additional insight as you study in depth the effects of resource allocation, labor usage distribution and cost spreads.

With this control tool you can also track your original cost estimates against updated forecasts and expenditures. Project Scheduler 5000 plus Graphics will help eliminate the possibility that you'll overlook critical costs and deadlines.



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*Project Scheduler 5000 plus Graphics available 4th quarter 1984.

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Features

THE 6502 MICROPROCESSOR has a history as brilliant as that of the Beatles or the Boston Celtics. Not just the heart and soul of a still-evolving line of Apple computers (see the May BYTE, page 276, for John Markoff's product description of the new Apple IIc), the 6502 has given life to personal computers made by Commodore, Ohio Scientific Instruments, and Atari, plus single-board computers by Rockwell and Synertek, two early second-source makers of the chip. After its invention in 1974 by a team of eight ex-Motorola employees working at a calculator-chip company called MOS Technology, the 6502 quickly became an engineering success owing to its compact instruction set, high clock speed, extended addressing modes, and memory-mapped I/O.

But what has become of the 6502 in the 16-bit microprocessor age? Is a CMOS 65C02 the end of the evolutionary ladder for this popular chip? This month, Steven P. Hendrix provides details on a recently announced 16-bit version of the venerable 6502, a microprocessor called the 65816 made by Western Design Inc. of Mesa, Arizona. Capable of addressing 16 megabytes of memory and running at clock speeds up to 10 MHz, the 65816 offers complete software compatibility with its 8-bit predecessors. It is rumored to be at the heart of a new Apple computer called the Apple IIx. Hendrix's examination of this enhanced microprocessor's software is part 1 of a two-part story that concludes next month with a detailed look at the hardware.

In the wake of our preview of Symphony comes a look at Ashton-Tate's Framework in a feature put together by our West Coast staff. Using an outline processor for its underlying structure, this integrated program uses frames instead of windows (will the next generation product use window frames?) and can peer through a frame into a dBASE II database presenting the data laid out in a table, so you don't have to create an arcane report form to view data. Our product description shows Framework to be a significant offering.

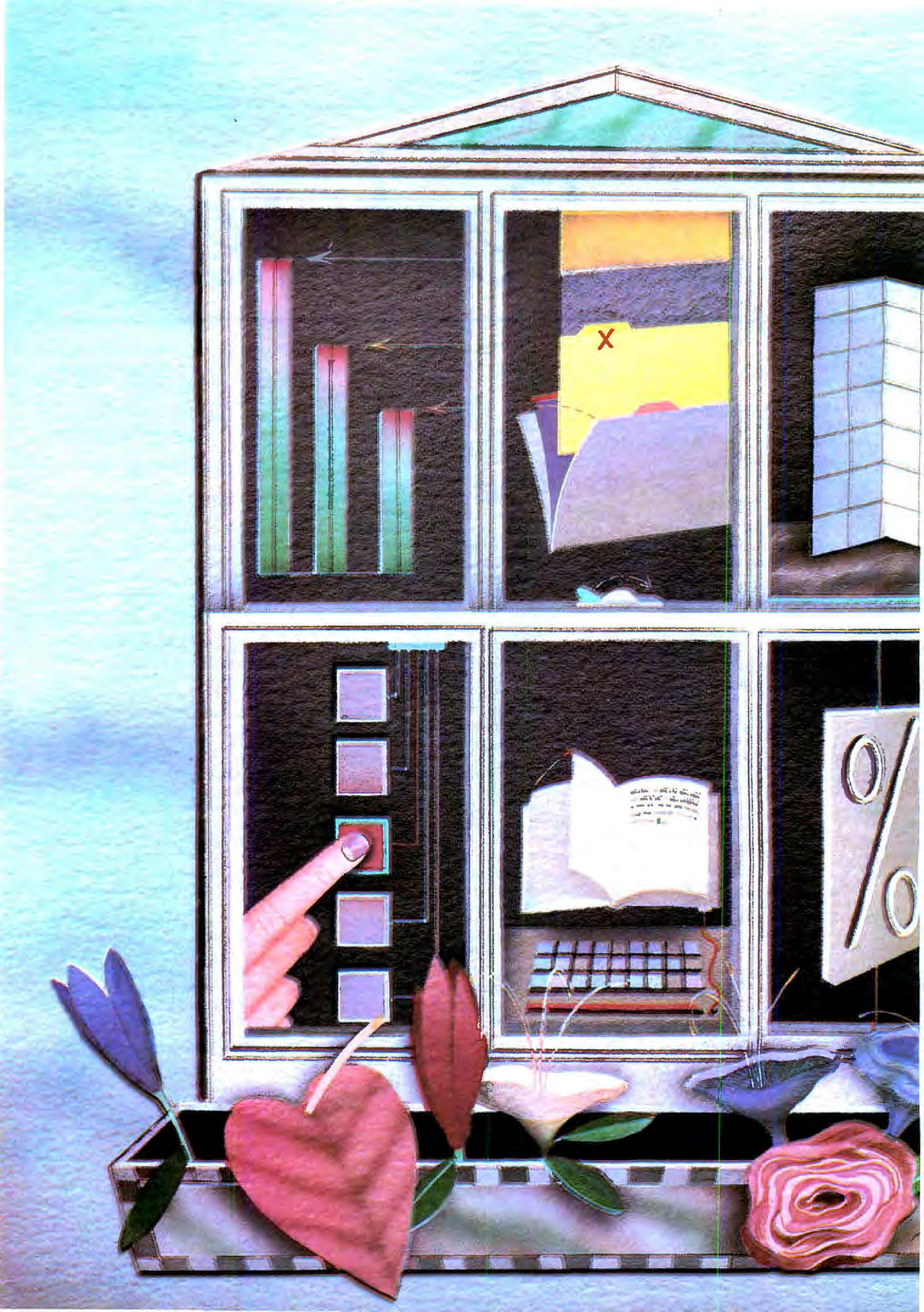
Since readers and editors alike have a minimum monthly requirement for benchmarks, this month we put UNIX through its paces on several mini- and microcomputers to time functions like performing disk reads and writes, making function calls, and finding prime numbers (using the infamous Sieve benchmark). David F. Hinnant's report may give you some insights into how UNIX works as well as information on how different versions perform.

The FORTH language community has more fodder for its debates on the merits of FORTH's different "official" versions now that FORTH-83 has been adopted by the FORTH Standards Committee. As author and committee member C. Kevin McCabe describes, FORTH-83 differs significantly from FORTH-79, even going so far as to redefine some FORTH keywords. Nevertheless, you can expect this newest version of FORTH to win substantial support from many threaded-code proponents.

The hazy days of summer prompt Steve Ciarcia to take a project-building break this month. He takes advantage of the respite to answer letters from readers about projects covered in past issues. Steve's answers can help to clarify those occasionally tricky problems that crop up when late-night soldering sessions make your eyes blur while reading a crucial part of a schematic. A new Circuit Cellar project returns to these pages next month.

Next month also brings articles on the 65816, disk coatings, and a fascinating analysis technique called cluster analysis, along with reports from the microcomputer frontier.

—G. Michael Vose, Senior Technical Editor, Features



FRAMEWORK

BY RIK JADRNICEK,
JOHN MARKOFF, AND EZRA SHAPIRO

Integrated software that combines familiar features within a novel structure

Framework, a new program for the IBM Personal Computer (PC) and work-alikes, was developed by Forefront Corporation and is now being distributed by Ashton-Tate. This package has something for everyone. All the usual elements of integrated software packages—word processing, database management, financial modeling, business graphics, communications, and a macro language—are combined in a window environment built around an outline-processing system.

The result falls somewhere between the two most popular approaches to integration: Framework is neither a shell that enables independent applications to exchange data (as are Visi On and DESQ), nor is it a "seamless" integrated program (like Ovation). Nevertheless, the logical structure of Framework provides an easy transition between text and data operations and the generation of coherent, seemingly continuous final reports.

Framework is designed to be self-contained, including as it does all the major business applications. However, it is also an operating environment; you can open a window to DOS (disk operating system) and run a program. When you're finished, you'll find yourself back in Framework. As

(continued)

Rik Jadrnicek, a BYTE *contributing editor, is president of* Micro Flow (POB 1147, Mill Valley, CA 94942), *a microcomputing consulting firm.*

Ezra Shapiro is BYTE's *West Coast bureau chief. He can be reached at* McGraw-Hill, 425 Battery St., San Francisco, CA 94111.

John Markoff is a senior technical editor at BYTE's *West Coast bureau. He can be contacted at* McGraw-Hill, 1000 Elwell Court, Palo Alto, CA 94303.

AT A GLANCE

Name
Framework

Type
Windowing integrated software package with macro command language

Applications Supported
Word processing, spreadsheet, database manager, business graphics, communications, and outline processing

Manufacturer
Ashton-Tate
10150 W. Jefferson Blvd.
Culver City, CA 90230
(213) 204-5570

Developer
Forefront Corp.
Mountain View, CA

Price
$695

Language
C

Computers
IBM PC and compatibles with two 360K-byte floppy-disk drives and a minimum of 256K bytes of RAM

Audience
Business professionals

Photo 1: *The Framework desktop in its initial state. Menus along the top edge can be accessed by holding down the control key and the first letter of the menu title.*

Framework cannot control all the screen-handling routines employed by an external program, it may not be possible to run it within a partial-screen Framework window—the program itself might grab the whole screen. The basic DOS commands (CHKDSK, DIR, etc.), though, can be run in a small corner of the Framework display.

Understanding Frames and Outlines

The underlying principle of Framework is really quite simple. You create "frames" (roughly equivalent to subfiles appearing in separate windows on the screen) containing text, graphics, database, or spreadsheet data. Each frame can hold a maximum of 32,000 characters, but that is not a limitation on file size; the trick to using this product is to start seeing your data as smaller blocks that can be linked together when it comes time for output.

Framework's opening display consists of a blank central workspace (dubbed the "desktop"), a line of one-word menu titles across the top of the screen, and a status area at the bottom for various messages. You can pull down menus for operations that remain consistent throughout Framework (such as frame creation and on-screen formatting) by pointing to the appropriate title with the cursor. This menu line is always displayed, and you're never more than a couple of keystrokes away from accessing its commands. Most of your actual work is done in windows on the desktop; formulas and macro commands are usually entered and displayed in the status area. On-line help is available with the touch of a function key. This arrangement should be familiar to the users of spreadsheets or some of the newer word-processing packages.

Using the menus, you begin by first deciding whether you want to work on text, a database, a spreadsheet, or an outline (more on that later) and then opening a window on the screen. Suddenly, a box appears that's appropriate to its function (e.g., a spreadsheet frame set up with letters across the top to indicate columns and numbers down the left side to indicate rows). This window is the basic operational unit, the frame. Using the function keys, you can size it for your needs and drag it around the screen to a convenient position. It's initially untitled, but you can enter a name for it along its top border. With the plus-sign and minus-sign keys on the right edge of the cursor/numeric keypad, you can "zoom"

(2a)

(2b)

Photo 2: *There are two ways to begin working with Framework: either start a brand new frame by selecting its type from the Create menu (2a) or call in an existing file from one of your disk drives by using the Disk menu (2b). The Disk menu also includes options for closing files and cleaning up the desktop.*

in from the desktop to the frame title, in to the frame, and back out again. The bottommost zoom position blows up the frame to occupy the entire desktop. You can have a large collection of frames open on the desktop at any one time; you aren't required to close up and put away any of them until you're done. Though Framework is memory-bound—that is, it works entirely in available RAM (random-access read/write memory)—the program uses data-compression algorithms to temporarily squeeze open frames that haven't been used for a long time. While it's conceivable that you'll hit the upper limit of your system—by trying to recalculate an enormous spreadsheet, for example—it's unlikely that you'll have to close frames in order to continue to work. Warning messages signal if you push your luck.

Framework departs from other windowing environments in how it keeps track of frames: it ties them together in an outline that is essentially hierarchical. Frames are ordered as you would rank them in an indented outline. Though frames may be given the same weight and treated as independent files, all frames are not necessarily created equal; a frame can have one or many subframes, and those, in turn, can also have "descendants." In fact, you can open a new frame at any point within an existing frame or build a new frame around an old one. Even a frame title or a spreadsheet data cell can become an entire frame that you can zoom in to. Framework keeps an account of this structure by building an index of frame titles that looks like a standard outline.

You have two ways to deal with this system, and you can toggle between them with a few keystrokes. First, you can simply create frames one at a time and build the hierarchy as you go along. In this case, opening a view of Framework's outline processor is merely a method of providing yourself with a map of how you've organized your data. Using the second method, you can open an "outline frame," which is set up displaying a simple indented form, empty at the outset, into which you can enter short points that can then be used as frame titles. You don't have to open frames for every point if you don't want to, and it isn't necessary to put anything at all into an open frame on the desktop. Framework's power and flexibility become evident as you learn how to move back and forth between these two outline-processing modes.

Furthermore, you can use an outline frame to create just

(continued on page 370)

Photo 3: *The stack of "trays" (bracketed titles) to the lower right shows all frames available on the desktop in the order in which they were created or opened.*

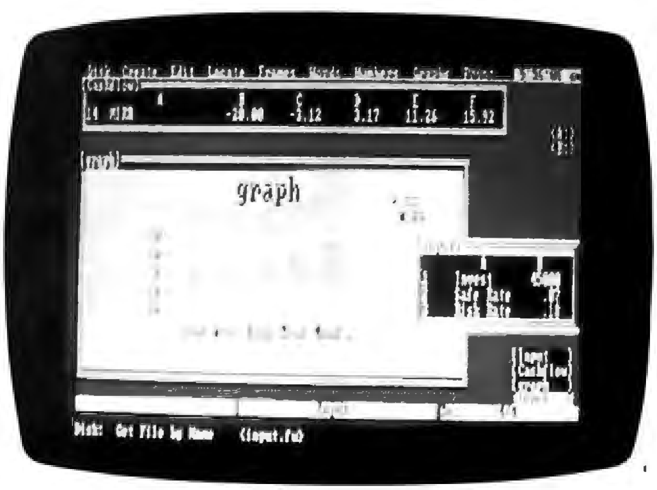


Photo 4: *Two simple spreadsheet examples and a graph generated from one of them. Were the graph to be zoomed to full-screen dimensions, it would appear in color.*

THE 65816 MICROPROCESSOR

PART 1: SOFTWARE

An 8-/16-bit successor to the 6502

WITH SEMICONDUCTOR memory prices falling, microcomputer systems are boldly going where no micros have gone before. Systems with 64K-byte main memories are common, and those with a megabyte or more are just around the corner. Since such old 8-bit standbys as the 6502, 6800, and Z80 can directly address only 64K bytes, their days as the backbone of general-purpose systems may be numbered. Indeed, the increasing number of personal computers, like Apple and Atari, using bank switching and disk simulation to expand their semiconductor memory access shows the growing severity of the address-space pinch.

Designed to relieve the constraints of limited memory, a new branch of the 6502 family directly addresses up to 16 megabytes while bringing the simplicity and execution speed of this time-tested microprocessor to 16-bit systems. The main representative of this new group is the W65SC816, which I refer to hereafter as the 65816. In emulation mode, it is pin- and software-compatible with the 6502, and toggling a single flag bit converts it to a complete 16-bit processor. In part 1 of this article I cover

(continued)

Steven P. Hendrix, an instructor pilot for the U.S. Air Force, has a B.S. in computer science and mathematics from the USAF Academy. He can be reached at Route 8, Box 81E, New Braunfels, TX 78130. His hobbies include computers and astronomy.

BY STEVEN P. HENDRIX

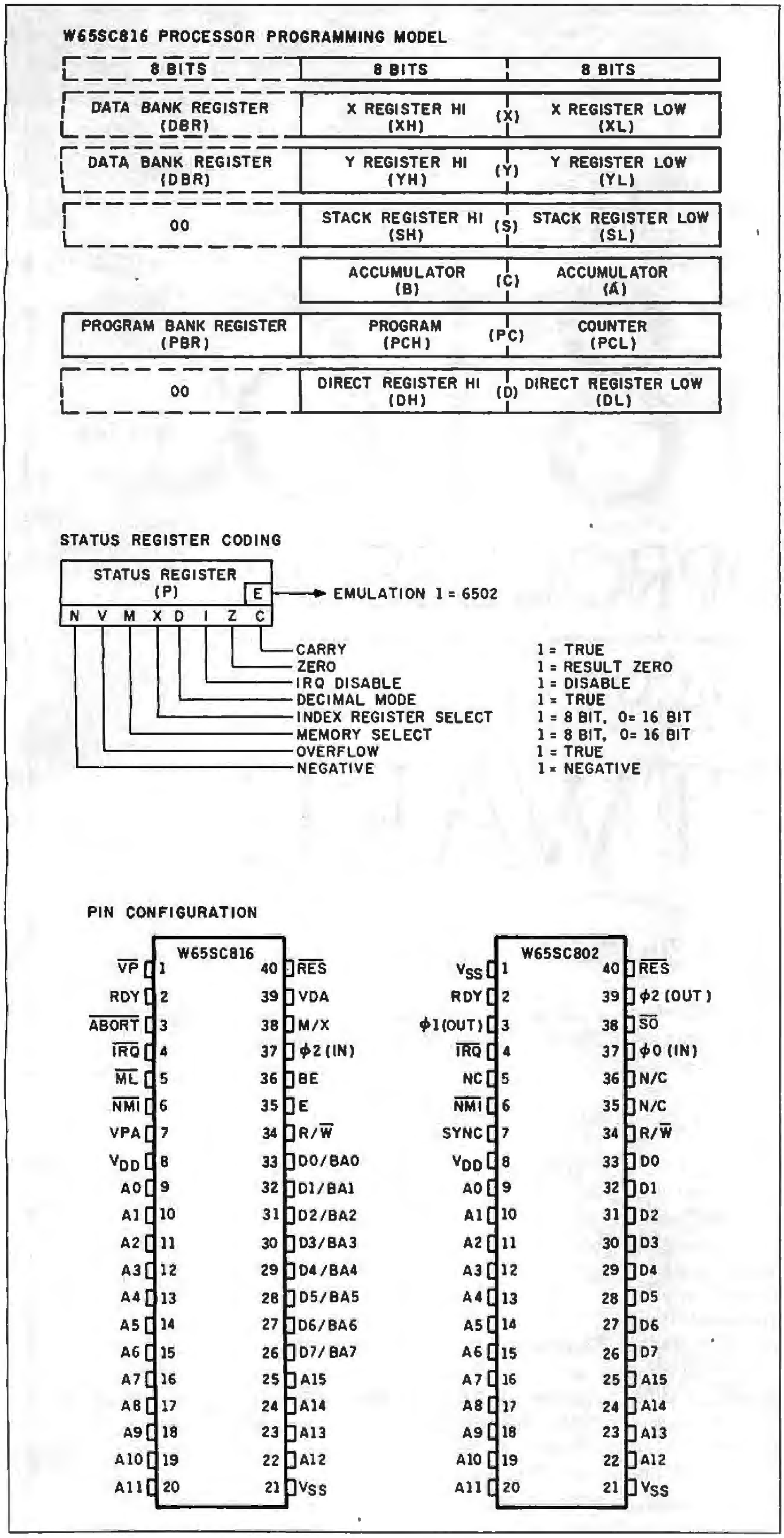


Figure 1: *The programming model for the 65816 shows that the 6502's 8-bit registers have been expanded, the program counter extended, unused bits filled, and a new register (the direct register) added.*

some of the software considerations for this processor. Next month, part 2 will address some hardware considerations. Throughout, the term "page" refers to a 256-byte memory area wherein individual location addresses differ in only the low-order 8 bits, just as for the 6502. "Bank" refers to a 64K-byte memory area with address locations that differ in the low-order 16 bits, with the upper 8 bits identical.

OVERVIEW

Figure 1 shows the programming model for the 65816. Close examination reveals the 6502 registers with extensions, plus one additional 16-bit register formerly not present (the direct register) and two 8-bit bank registers. The 8-bit registers of the 6502 have been extended to 16 bits, the 6502's 16-bit program counter has been effectively extended to 24 bits, and the previously unused bits in the status register have been filled (with an extra bit added). The accumulator and index registers still can be treated optionally as 8-bit registers by setting the appropriate status register bits. Except for the accumulator, the full 16-bit registers retain the original 8-bit names. Each half of each register uses the same original name, and they are distinguished from one another by an "H" or "L" suffix for the high- and low-order bytes, respectively. The 16-bit accumulator is newly designated as "C." The high- and low-order bytes of the accumulator are referred to as "B" and "A."

The six status register flags matching those of the 6502 retain the same meanings. The seventh 6502 flag, "B,"

(continued on page 385)

E = 1 (6502 Emulation)

00FFFE,F—IRQ/BRK	Hardware/Software
00FFFC,D—RESET	Hardware
00FFFA,B—NMI	Hardware
00FFF8,9—ABORT	Hardware
00FFF6,7— —	—
00FFF4,5—COP	Software

E = 0 (16-Bit Operation)

00FFFE,F—IRQ	Hardware
00FFFC,D—RESET	Hardware
00FFFA,B—NMI	Hardware
00FFF8,9—ABORT	Hardware
00FFF6,7—BRK	Software
00FFF4,5—COP	Software

Figure 2: *When the 65816 is not emulating a 6502, it has a separate vector that defines the software interrupt's location and relieves the routine from having to determine which type of interrupt invoked it.*

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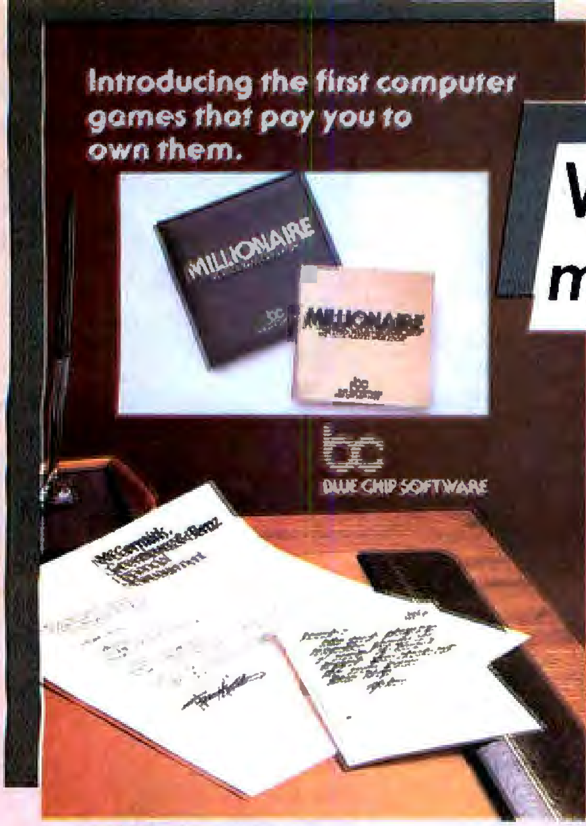

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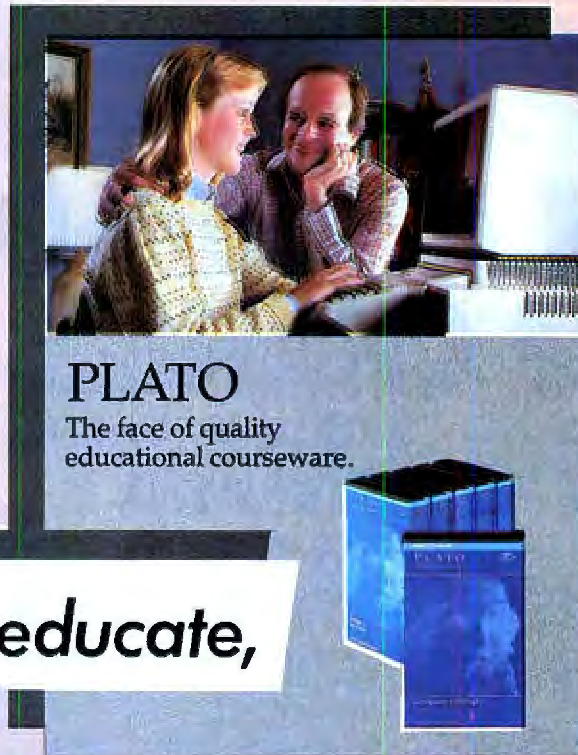

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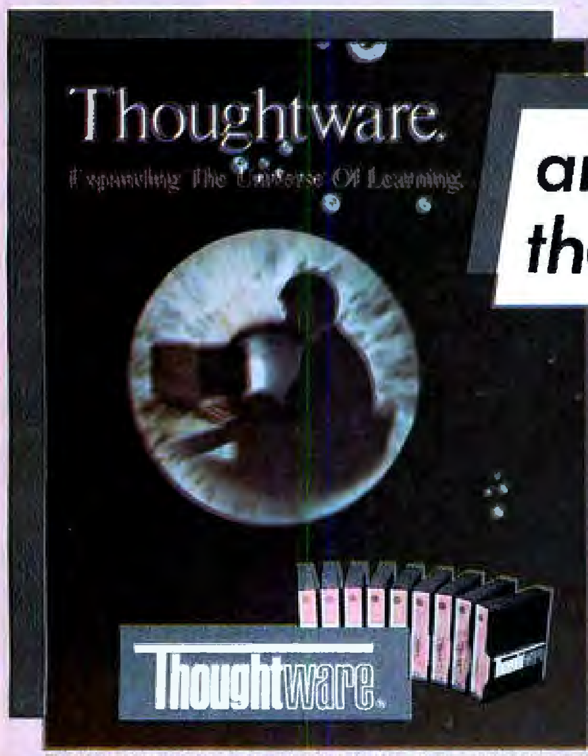

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Circuit Cellar Feedback

Steve answers some letters about past projects

BY STEVE CIARCIA

One result of writing a design column like the Circuit Cellar is that it produces a lot of mail. While this might be a curse for some authors, I find that receiving many pounds of mail suggests that I'm doing something right.

Generally speaking, reader feedback comes in three forms. The first group includes general computer questions and interfacing problems. A selection of these questions is presented each month in "Ask BYTE."

The other two groups deal specifically with my articles or make project suggestions. There never has been a good vehicle for sharing this correspondence with you. I sometimes insert a few project-related questions in "Ask BYTE" when I think the answer has some broad educational value.

Unfortunately, because most of these project-specific letters are never published, I receive many of the same questions and have to answer them individually. For example, unless you wrote me directly or found it somewhere in BYTE, you probably wouldn't know that there is now an MPX-16 user's group (see page 398), that there is a PAL (phase alternating line) equivalent for the Texas Instruments NTSC (National Television System Committee) graphics chip used in EZ-Color, or that an alternative 300-bps modem chip is available so that the ECM-103 can operate in Europe.

This month, rather than presenting a new project, I'll share some of these project-specific letters with some answers I've been mailing to other readers. The ones I've chosen are just a few of the hundreds I receive each month.

The letters I appreciate most are project ideas and general comments. Many readers take the time to describe their experiences building Circuit Cellar projects and enhancements they have made. While there has been no lack of article ideas on my part, it is hard to ignore a hundred letters asking for a 1200-bps modem or a voice-recognition interface.

Finally, with 450,000 technically educated readers, BYTE is one of the best sources of expertise in the U.S. Many of its readers chart the course of history rather than passively observe it.

I appreciate reader feedback and try not to take anything for granted. Many of today's inventions sound absurd at first disclosure, but, if you've developed a perpetual-motion machine, I'd like to know about it.

—Steve Ciarcia, Consulting Editor

RADIO SPEECH SYNTHESIS

Dear Steve,

I liked your article in the June 1983 BYTE ("Use ADPCM for Highly Intelligible Speech Synthesis," page 35). Could you please send me a new figure 7 (page 42) showing a 12-bit A/D converter in it?

I know the circuit sends out TTL-level parallel data; could you recommend a circuit addition that will let me send out this audio data in a serial bit stream? I may send this data over a short radio link (citizens band radio) to be received by a friend having a serial-to-parallel converter and then plug the converter into the circuit in figure 10 (page 49). It is a one-way data link. I might want to modulate this serial data stream and elevate the entire stream by 16, 32, or 40 kHz in an upper-carrier fashion and demodulate at the receiving end. Does this sound like FM carrier modulation?

STEVE ABRAITIS
Cleveland, OH

The 12-bit version of the circuit can be found in the applications notes on the ADPCM chip. Contact your local Oki sales representative.

I do not recommend using a serial radio link

(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.

in the manner you describe. This is due to the sheer magnitude of the speed requirements involved. For example, for an 8-bit D/A converter with an 8-kHz sample speed, the data rate is 4K bytes/sec × 11 bps(async) = 44 kbps min. For a 12-bit D/A converter with an 8-kHz sample speed, the data rate is 6K bytes/sec × 11 bps(async) =66 kbps.

You would need a carrier of twice the bit rate, a minimum of approximately 120 kHz, to send this data over the air. This, coupled with the signaling speed requirement, puts the system out of the reach of conventional citizens band transmission.—Steve

NEEDS DISK CONTROLLER

Dear Steve,

I used your book to build a Z80 computer. I am now starting on your Term-Mite ST smart terminal (January, page 37). Now I think I may have reached a dead end.

Do you know of a disk-controller circuit and monitor program that would work with this computer? I haven't seen any. If you can be of any help, I would really appreciate it.

H. G. WOODWARD
San Antonio, TX

My ZAP computer was designed to be software and peripheral compatible with the Digital Group computer system. Any peripheral that can run with the DG system can be used with the ZAP, once the bus signals are lined up. A disk controller and DOS (disk operating system) are available for the DG machine. The DG system is being supported by Aeon Electronics, Suite MSB, 1855 South Pearl, Denver, CO 80210, (303) 777-2366.

Because the ZAP uses a Z80, the TRS-80 disk controller could also be used as well as the Tarbell, Morrow, and Godbout boards. Use of the last three boards would mean setting up the ZAP bus to the S-100 standard, which would make many other S-100 boards available for your use.—Steve

WHERE'S THE TRANSFORMER?

Dear Steve,

I recently bought your fine book *Build Your Own Z80 Computer*. I want to construct the computer and have started to gather parts. So far, I cannot find the 10-V, 6-A transformer. Also, what prototyping board was used?

I enjoy your articles in BYTE. I would like to see construction and other articles on the TI-99/4A. It is a good computer.

PAT ROBERTSON
Virginia Beach, VA

You can use a transformer with a higher current rating or with a slightly higher voltage output (11.6 or so). Keep in mind that this will strain the regulators a bit more, and they may have to be heat-sinked and cooled. A 10-V, 6-A transformer is a moderately rare item, but you can order the Stancor Model P-8655 from Sterling Electronics, POB 7790, Richmond, VA 23231. The cost is $18.45 (shipping additional). This unit provides the desired specifications in a center-tapped configuration.

For the prototype board, you can use an S-100 card produced by Vector Electronic Company. These are carried by Jameco, Priority One Electronics, and many other companies that advertise in BYTE.

I have played around with the TI-99/4A and was frankly amazed at the power and completeness of its BASIC. The full-size keyboard was nicer to type on than the keyboards found on many inexpensive units today. I did not like the way TI used function keys to logically shift the keyboard characters, however. Although the 99/4A has been discontinued, I'll keep an eye on the mail to see if projects for this machine are warranted.—Steve

SIMPLIFY THE ZAP

Dear Steve,

I am studying your book *Build Your Own Z80 Computer*, and I have several questions.

Has the state of the art changed significantly since you wrote the book that would simplify your computer? Is there reading material that would give me more information? I've noticed a TMM2016, 2048 by 8-bit RAM (random-access read/write memory) that looks like an attractive replacement for the 2114, 1024 by 4-bit RAM. Can these be exchanged without modifications to the circuitry? Can you tie $\overline{\text{MCS0}}$ and $\overline{\text{MCS1}}$ together to access this replaced RAM?

I also have a question about the lead $\overline{\text{IORQ}}$ that feeds two NAND gates that determine whether a read or a write operation is to be performed (figure 4.24 on page 109). Shouldn't this lead be IORQ rather than $\overline{\text{IORQ}}$, since a high when active control signal is desired to AND the respective NAND gate to generate a low out on $\overline{\text{IORD}}$ or $\overline{\text{IOWR}}$?

Any help you can give me will be appreciated.

DAVE SCHAFER
Omaha, NE

Several new chips are available that would simplify the ZAP computer. However, one of the underlying concepts behind the computer and the book was to make the circuits understandable to novice builders. The use of LSI (large-scale integration) multifunction components would have made the building simpler but the understanding harder. This is why discrete SSI (small-scale integration) and MSI (medium-scale integration) components were used.

BYTE Books and Hayden Press offer many fine books on computer peripheral design. Many examples of circuits that employ LSI devices are found in these books.

The TMM2016 memory part could easily be used in place of two 2114 parts. No circuit modifications are necessary, except for the $\overline{\text{MCS0}}$ and $\overline{\text{MCS1}}$ lines. Tying these together would damage the decoder IC. Line $\overline{\text{MCS0}}$ addresses the 2708 EPROM (erasable programmable read-only memory), which has an 8-bit data bus. Lines $\overline{\text{MCS1}}$ and $\overline{\text{MCS2}}$ each drive two 2114s. The 2114s have a 4-bit data bus, which is why two are driven together. The 2016 part, with its 8-bit bus, replaces two of the 2114s and is driven by either $\overline{\text{MCS1}}$ or $\overline{\text{MCS2}}$.

Your comment on the $\overline{\text{IORQ}}$ line is correct. The positive true signal is the one that should have been shown on the schematic. This same problem occurs on figure 4.26.—Steve

QUESTIONS ABOUT LINE CONDITIONING

Dear Steve,

Thank you for the article on line conditioning ("Keep Power-Line Pollution Out of Your Computer") in the December 1983 BYTE (page 36). I've built an eight-outlet conditioned power bar with surge and EMI (electromagnetic interference) protection; I have three questions on this project.

Why are three MOVs required instead of two? Won't the function of the third be assumed by two acting together?

Radio Shack's EMI filter (part number 273-100) is rated only to 5A; to achieve a 10-A rating for the total system, I wired two of these units in parallel. Will this have any consequences on the EMI attenuation specs for the system?

(continued on page 392)


That power cord may look innocent. But it could suddenly turn against your PC.
It could, for example, hurl a power spike from static or lightning into its delicate circuitry. Wiping out its memory. Or destroying a defenseless component.
Don't risk it. Get a 6-outlet Wire Tree Plus™ surge protector from NETWORX.™ It guards against spikes. Filters out RF interference. And it's the only device with two phone jacks to protect modems against surges.
Other unique features include separate switches for the CPU and peripherals and a bracket that mounts under the front of the workstation. The illuminated switches are easy to reach, and yet recessed, so you can't accidentally shut down power and lose data.
If you don't need 6 outlets, pick up our 4-outlet Wire Tree.™ Or our single-outlet Wire Cube™ that's ideal for portable computers.
That'll take care of power surges. But what if your foot gets tangled in a power cord? Prevent this potential disaster with the Wire Away.™ It stores up to four 18-gauge wires and ends the hazardous mess of dangling cords.
All our products are backed by a 5-year warranty. So when you shop for a PC, ask for NETWORX computer station accessories. And don't go home without them.
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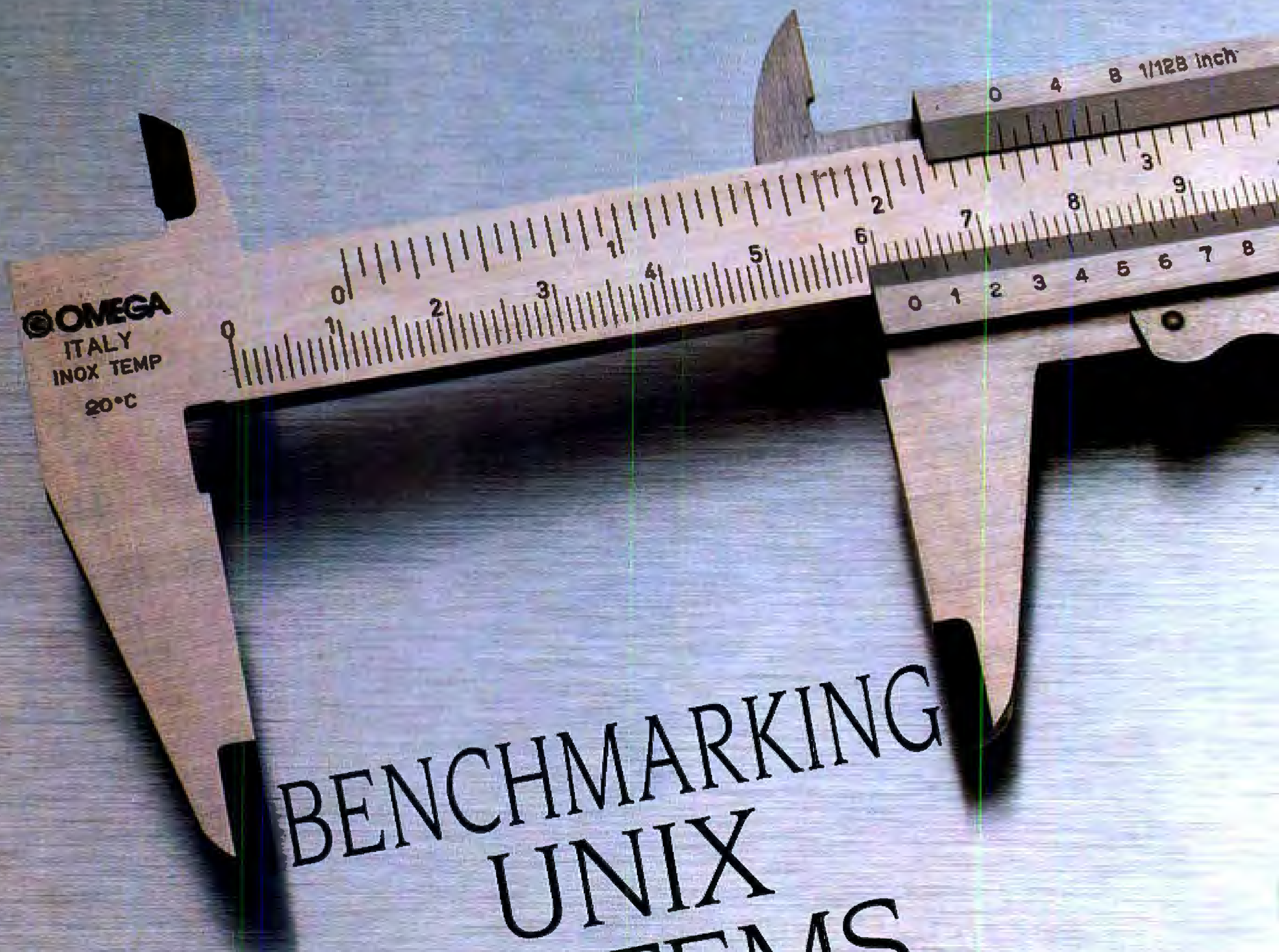


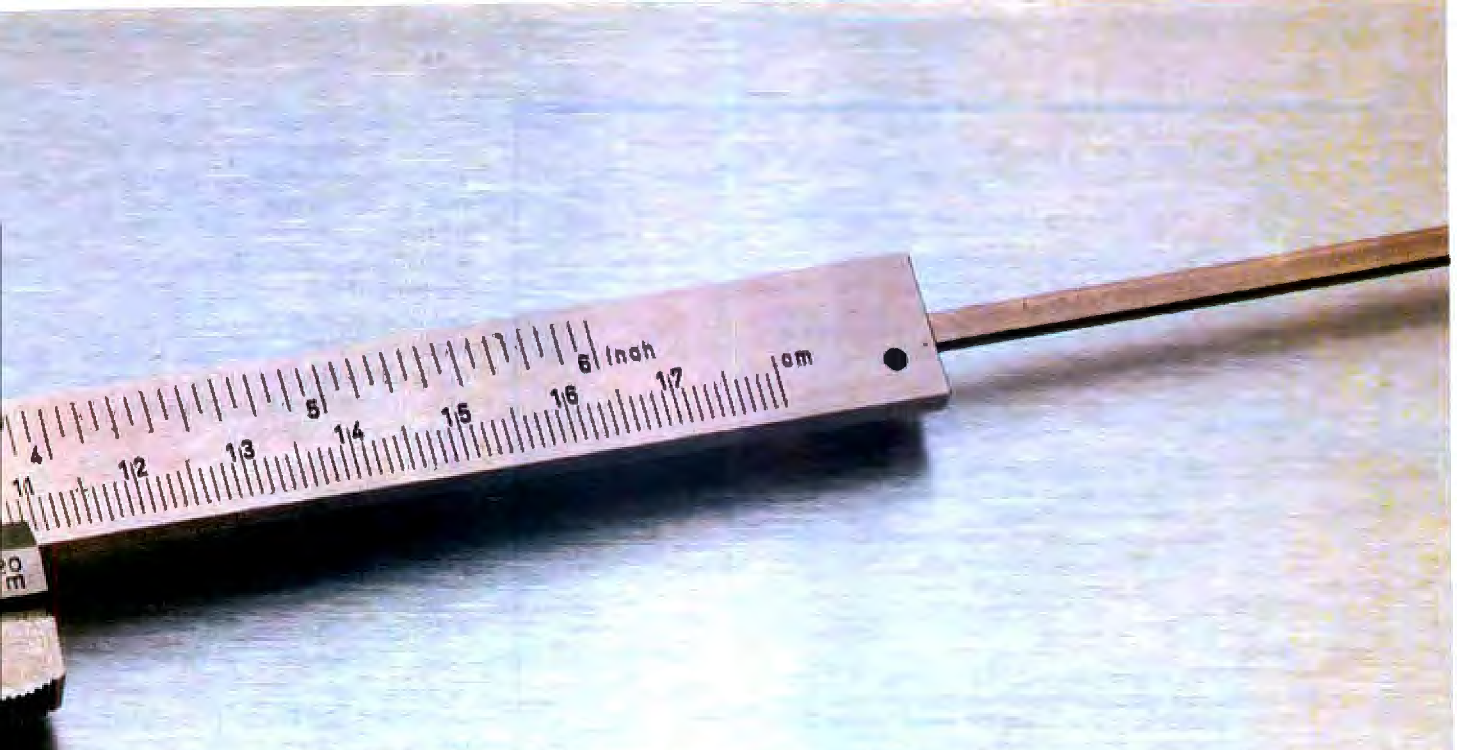
BENCHMARKING UNIX SYSTEMS

UNIX *performance on microcomputers and minicomputers*

BY DAVID F. HINNANT

WITH THE ADVENT of inexpensive but powerful 16- and 32-bit microprocessors, the multiuser, multitasking UNIX operating system is available on many new microcomputers. Because UNIX is becoming a standard multiuser operating system, this article presents benchmarks for several microcomputer UNIX implementations and shows how they perform when compared to minicomputer versions of UNIX.

Almost every week, new versions of UNIX for popular microcomputers or new UNIX-based microcomputers are being announced. They come from everyone from AT&T (UNIX was developed at Bell Laboratories) and IBM down to previously unknown companies who license UNIX from AT&T and then implement, or port, it for new hardware configurations. For some UNIX implementations on microcomputers, you need additional hardware (at least a hard-disk system for the megabytes of



utilities and programs that come with UNIX), while some implementations run by just inserting a disk and booting up the run-time operating system.

Quite a few releases of UNIX software are also available, including Version 6, Version 7, System III, and System V (AT&T's new standard) from Bell Labs; the 4.1 BSD and 4.2 BSD UNIX extensions from the University of California, Berkeley; XENIX, an enhanced UNIX Version 7 from Microsoft; VENIX, a finely tuned UNIX with real-time capabilities; Uniplus+, an enhanced UNIX System III from Unisoft; also, many systems claim to be "UNIX-like." Do all these UNIX implementations look and work alike? What do you look for in determining which is the better UNIX-based machine? Some will be faster than others because of hardware constraints, but how can you tell if you're getting the best system for your operating conditions? That's usually the bottom line. Enter the UNIX benchmarks.

Just what is a benchmark? For our purposes, a benchmark is a set of instructions that measures how well the hardware and software of a computer system perform together. Benchmarks can either exercise singular, specific functions of a compiler or operating system (e.g., function-call overhead or system-call overhead) or they can test the general performance of the machine by exercising a number of operations (e.g., looping, searching, etc.). In both cases, these timings are compared to results on other machines.

Benchmarking an operating system is much more complex than benchmarking a compiler. However, since UNIX and its language compilers are written in the high-level language C, compiler implementation is just as important, as we will see. What should an operating-system benchmark do?

The purist approach tests only well-defined individual functions of the operating system (e.g., pipe implementation, disk throughput, system-call overhead, and context switching). This is difficult to do, as any program that exercises one particular operating-system function inadvertently includes statements that are not related to the function under scrutiny. We must reconcile ourselves to a benchmark that includes as little superfluous code as possible. Since this unwanted overhead varies from program to program, in most cases, the execution-time results cannot be manipulated in an arithmetic fashion to produce true timings of a particular operating-system function. They can, however, be compared to timings on other machines.

The practical approach tests overall system performance by performing many typical functions (e.g., sorts; compilations; and creating, listing, and deleting files) but in a controlled fashion. Again, these timings are compared with timings on other UNIX machines.

Both approaches have merit, and examples of both will be presented here.

Some Benchmark Guidelines

Let's develop some guidelines for benchmarking operating systems in general and apply them specifically to UNIX. In order to benchmark any operating system, as many environmental variables as possible should be eliminated:

- The benchmarks should be run in a multiuser environment so that any normal operating-system overhead (e.g., context switching between processes and other operating-system housekeeping) is taken into account. (Most UNIX implementations offer a single-user mode as well as a multiuser mode.)
- The benchmarks should be taken more than once and averaged to compensate for any system-level background processes that repeatedly sleep awhile and work awhile. (A good UNIX example is the routine update that wakes up every 30 seconds and, among other things, flushes buffers and in-core tables to disk.)
- The benchmarks should be performed while the system is otherwise idle so that the timings are as true as possible. On microcomputers, even one additional user can distort benchmark results significantly; depending, of course, on what is being done.
- All available optimizations should be used. Implementations that take advantage of the hardware con-

(continued)

David Hinnant (2017 Hunterfield Lane, Raleigh, NC 27609) holds a B.S. degree in physics and is a UNIX systems programmer with ITT Telecom in Raleigh. He is coauthor of a book on UNIX microcomputers soon to be published by Robert J. Brady Co. His UNIX UUCP address is ...ucbvax!decvax!ittvax!ittral!hinnant. Machine-readable copies of the benchmark suite are available upon request to the UUCP address. Benchmark results from UNIX systems not mentioned in this article are welcome.

PHOTOGRAPHED BY PAUL AVIS

Listing 1: *The* UNIX *pipe benchmark.*

```
/*
 *                    UNIX Operating System Implementation Test #1
 *
 * This program evaluates pipe efficiency and implementation.
 * Since pipes are commonly used in UNIX, pipe performance is often a
 * decisive factor in overall system performance, and says a lot about
 * the UNIX implementation. Here we test pipe implementation by
 * cramming 0.5 MB through a pipe as fast as possible.
 *
 * Instructions:
 *    Compile by:              cc -O -s -o pipes pipes.c
 *
 *            The -O option says to use the optimizer.
 *            The -s option says to strip the namelist from the
 *               object file after linking.
 *            The -o option says to place the object file in the file
 *               specified by the next argument.
 *
 *    Time by:                 /bin/time pipes
 *
 *    Results:
 *         Since pipes usually use the disk as a buffer, real time is
 *         important, but can be misleading if the disk is very slow.
 *         Of greater importance here is the 'system' time, as it is
 *         a direct measurement of kernel efficiency. The 'user' time
 *         is of little importance.
 *
 */

#define BLOCKS 1024

        /* the buffer */
char buffer[512];
        /* file descriptor for pipe */
int fid[2];

main()
{
                /* want to test pipe implementation; not arithmetic */
        register int i;
                /* initialize the pipe */
        pipe(fid);
                /* fork the child process */
        if ( fork() ) {
                        /* parent process writes to pipe in 512 byte chunks */
                for (i = 0; i < BLOCKS; i++)
                        if (write(fid[1], buffer, 512) < 0)
                                        /* if there is a problem, say so */
                                printf("Error in writing; i=%d\n", i);
                        /* close the pipe when we're done */
                if (close(fid[1]) != 0)
                        printf("Error in parent closing\n");
        }
        else {
                        /* close, since we aren't writing */
                if (close(fid[1]) != 0)
                        printf("Error in child closing\n");
                        /* child process reads the pipe until EOF */
                for (;;)
                        if (read(fid[0], buffer, 512) == 0) {
                                break;
                        }
        }
}
```

figuration are generally better to begin with. If a compiler option for object-code optimization is available, it should be used. If the hardware can support fast (register in the case of C) variables, they should be used. In the benchmarks discussed here, all variables that can be of the register type will be declared as such. In reality, the number of registers available for use by register variables varies widely because of hardware differences between microprocessors. Remember, our goal here is not to develop benchmarks that determine which UNIX machine is the best under a given set of requirements but to develop a general set of benchmarks to aid the consumer in determining which hardware/software implementation gives the most performance for the money.

- The benchmarks should be *exactly* the same on all machines tested and portable enough to run on all the machines. Some may argue that if a particular software option is available, it should be used as an optimization is used (a binary-tree search function, for example). Keep in mind that extensions are not optimizations. Although the distinction can become cloudy, an extension is probably not used as routinely as an optimization.
- Some of the benchmarks developed should be able to exercise specific, known functions of operating-system and compiler implementation.
- The benchmarks developed should also contain tests of overall performance by simulating typical user activities. This should include executing background processes concurrently with foreground processes (if possible) to see how the system responds under a multitasking load.
- The benchmark timings should be made using a consistent and accurate method. A stopwatch just won't do. Fortunately, UNIX has a standard timing mechanism that reports elapsed (real) and processor times used by a process. The processor time is further divided into user and system times.

User time is the amount of time the process spent executing nonprivileged instructions (e.g., arithmetic calculations, sorting, searching, calling user-level functions, etc.).

System time is the time the process spent executing privileged (kernel) commands (i.e., system calls) plus some system-level overhead (e.g. context switching between processes).

The elapsed time is just that. And it is often not the sum of the user and system times. The majority of the missing time is spent waiting for I/O (input/output) operations to complete, waiting for a signal from another process, sleeping, or swapped out on disk while another program is running. It is unfortunate that in some implementations of UNIX the elapsed time reported by this timing mechanism is given only to the second. Thus, the sum of the system and user times can on occasion be greater

Table 1: *The results of UNIX benchmarks for some common microcomputers and minicomputers. The table is sorted on the fastest execution (real) time for the shell benchmark in listing 6a.*

System			Time in Seconds						
			1. Pipe			2. System Call			3. Function Call
No.	Machine	Version	real	user	sys	real	user	sys	real
1	VAX-11/780	4.1 BSD	3.2	0.1	1.2	4.8	1.4	4.0	1.0
2	Masscomp	Sys III+	5.7	0.0	2.8	6.3	0.4	5.8	0.9
3	Sun-2/120	4.2 BSD	7.6	0.1	3.7	6.8	1.1	5.6	0.8
4	VAX-11/750	4.1 BSD	4.6	0.2	2.1	7.0	0.9	6.2	1.7
5	PDP-11/70	2.8 BSD	8.1	0.0	3.4	8.0	0.2	7.5	1.0
6	Altos 986	XENIX	6.0	0.1	2.8	11.0	0.8	10.3	0.4
7	IBM PC XT	PC/IX	16.6	0.1	7.6	39.8	2.9	35.6	4.7
8	PDP-11/23	VENIX	30.0	0.1	9.5	24.0	3.2	20.4	3.3
9	IBM PC XT %	VENIX/86	18.0	0.1	7.3	20.5	2.3	17.8	2.8
10	SCI-1000 ˆ	Sys III+	9.3	0.0	3.1	26.2	0.7	24.2	1.2
11	Omnibyte	Idris •$	32.0	0.1	30.4	21.3	2.5	18.4	1.7
12	TRS-80 16B	XENIX	8.0	0.1	3.4	15.0	1.5	12.7	1.4
13	PDP-11/23	V7	23.0	0.1	10.7	36.5	0.9	33.7	3.6
14	DEC Pro/350	VENIX	26.0	0.5	13.8	33.3	5.8	26.5	3.5
15	Apple Lisa	Sys III+	8.1	0.0	3.0	10.5	0.2	9.1	1.3

System			Time in Seconds											
			4. Sieve			5a. Disk Write	5b. Disk Read	6a. Shell			7. Loop		
No.	Machine	Version	real	user	sys	real	real	real	user	sys	real	user	sys
1	VAX-11/780	4.1 BSD	1.7	1.5	0.1	2.0	8.0	3.3	0.3	1.3	2.6	2.5	0.1
2	Masscomp	Sys III+	2.8	2.5	0.1	1.7	–	3.5	0.4	1.4	6.6	6.3	0.1
3	Sun-2/120	4.2 BSD	5.1	2.8	0.4	1.8	4.9	3.5	0.3	2.0	7.4	7.0	0.1
4	VAX-11/750	4.1 BSD	2.4	2.7	0.1	3.0	8.0	3.8	0.4	1.5	5.1	4.9	0.1
5	PDP-11/70	2.8 BSD	2.3	1.6	0.1	4.0	9.5	4.0	0.2	1.7	7.9	7.1	0.2
6	Altos 986	XENIX	3.3	3.0	0.0	3.5	7.3	7.0	0.4	1.6	13.3	13.0	0.1
7	IBM PC XT	PC/IX	8.2	7.8	0.3	11.6	20.7	8.5	1.1	3.2	32.2	31.5	0.3
8	PDP-11/23	VENIX	5.5	5.1	0.1	8.0	33.7	12.0	0.7	4.8	26.0	25.2	0.1
9	IBM PC XT %	VENIX/86	9.0	8.2	0.3	7.0	25.6	13.0	0.8	4.2	32.7	31.4	0.3
10	SCI-1000 ˆ	Sys III+	4.4	3.6	0.1	4.3	9.1	13.6	0.5	1.9	14.5	13.6	0.2
11	Omnibyte	Idris •$	7.0	5.4	0.4	12.3	$	17.6	0.3	16.1	17.0	16.1	0.4
12	TRS-80 16B	XENIX	6.0	4.8	0.3	8.0	22.0	18.0	0.4	2.6	14.0	12.5	0.5
13	PDP-11/23	V7	5.8	5.3	0.1	22.0	32.7	20.4	0.8	8.5	27.4	25.9	0.3
14	DEC Pro/350	VENIX	6.3	5.1	0.1	7.7	28.0	27.0	0.8	4.7	26.7	25.3	0.1
15	Apple Lisa	Sys III+	6.1	5.3	0.1	20.8	44.5	37.6	0.4	3.2	14.0	12.0	0.2

\+ Indicates UNIX System III plus some Berkeley enhancements.
• The benchmark in listing 1 had to be modified slightly to run under Idris 2.1, perhaps explaining the large times that resulted.
$ Idris 2.1 is a Version 6-based UNIX system, and hence did not have the rand() system call. Thus, the benchmark could not be run.
– Unfortunately, this time was not available at the time of publication.
ˆ The SCI-1000 benchmarked was a preproduction 80186 system with debugging code in the kernel and compiler.
% For some reason, the C compiler optimizer caused the operating system to crash, so these results are with nonoptimized benchmarks.

System Configuration:

1 — 4-megabyte RAM, two 256-megabyte disk drives
2 — 2-megabyte RAM, one 50-megabyte disk drive
3 — 2-megabyte RAM, one 42-megabyte disk drive
4 — 2-megabyte RAM, one 121-megabyte disk drive
5 — 1.5-megabyte RAM, 400 megabytes of disk drives
6 — 1-megabyte RAM, one 40-megabyte disk drive
7 — 512K-byte RAM, one 10-megabyte disk drive
8 — 256K-byte RAM, two 5-megabyte disk drives
9 — 512K-byte RAM, one 40-megabyte disk drive
10 — 640K-byte RAM, one 10-megabyte disk drive
11 — 384K-byte RAM, one 20-megabyte disk drive
12 — 384K-byte RAM, one 15-megabyte disk drive
13 — 256K-byte RAM, two 10-megabyte disk drives
14 — 256K-byte RAM, one 5-megabyte disk drive
15 — 1-megabyte RAM, one 5-megabyte disk drive

than the elapsed time.

This mechanism is the **time** command, which is invoked explicitly by

/bin/time *filename*

where *filename* is the program to be timed. Under UNIX, *filename* can be either an object file or a text file of shell commands. Of course, some overhead is in the **time** command itself, since it has to start *filename* executing, but it is small and can be neglected because all our benchmarks will be timed this way. The results are compared to other UNIX machines timed in the same manner.

THE UNIX BENCHMARK SUITE

How can we apply these guidelines to the UNIX operating system and its most important language, the C compiler? What should we test? That question can be answered by answering the question, "What does UNIX do most often?"

UNIX has a number of unique and powerful features that are used quite heavily. If implemented efficiently, these

(continued on page 400)

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FORTH-83: EVOLUTION CONTINUES

BY C. KEVIN MCCABE

A new standard corrects some problems, but FORTH is still a language in flux

All FORTH words in this article, and in the tables, are in **boldface** *type. Italics is used to designate numeric values that are treated in a specific way. Italicized terms in angle brackets* (**< >**) *are unspecified word names.*

The evolution of FORTH from a radio-telescope control language to an acclaimed software tool can hardly be termed usual—or entirely peaceful. Perhaps because the language is attractive to software hackers, new versions of FORTH appear with a frequency quite unlike more established languages. Proponents of various dialects tend to splinter into groups, with heated debates over mono-addressing, threaded versus direct code, and other esoteric matters.

The latest standardization attempt may only add to a continuing controversy over which version is the "real" FORTH. FORTH-83, accepted almost unanimously by the FORTH Standards Team, includes numerous differences from the earlier FORTH-79 standard. FORTH-79, in turn, differs greatly from FIG-FORTH, the public-domain version developed by the FORTH Interest Group (FIG), FORTH Inc.'s commercial versions of FORTH, and several earlier proposed standards. Major changes in virtually all areas almost insure that FORTH-79 programs will not be compatible with the new standard.

THE CHANGES

Eleven FORTH-79 "words" (named ex-

(continued)

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Table 1: *FORTH-79 words not included in the FORTH-83 required word set.*

FORTH-79 Word	Remarks
79-STANDARD	new word **FORTH-83** fulfills same function
?	use equivalent sequence **@ .** instead
CONTEXT	moved to new system-extension word set
CURRENT	moved to new system-extension word set
EMPTY-BUFFERS	moved to controlled-reference word set
LIST	moved to controlled-reference word set
MOVE	moved to uncontrolled-reference word set
QUERY	moved to controlled-reference word set
SCR	moved to controlled-reference word set
U*	use **UM*** instead
U/MOD	use **UM/MOD**, but note floored division

ecution procedures) have been renamed or removed entirely from the standard's required word set (see table 1). Twenty new words have been added to the required word set. Major changes in FORTH-83 definitions affect integer arithmetic, control structures, relational operations, use of mass storage, stack manipulations, I/O (input/output), compilation of new definitions, and vocabulary usage. Required words that have undergone significant changes in definition are listed in table 3. Both the assembly-language and the double-number extension word sets have been revised, and a new system-extension word set has been added as an option; the additions and changes in meaning are shown in tables 4, 5, and 6.

FORTH-83 division operations use "floored" integer arithmetic, with the quotient z rounded to the greatest integer less than or equal to z, i.e., toward negative infinity. This provides symmetry with respect to 0 on the number line but is incompatible with FORTH-79's simpler rounding toward 0. FORTH-83 division operations also are defined to force error conditions if a divisor is 0 or a quotient lies outside the permissible operand range.

The DO . . . LOOP and DO . . . +LOOP control structures have been revised considerably. For positive increments, termination of a FORTH-79 loop occurs when the new index value equals or exceeds the limit; for negative increments, +LOOP terminates only when the new index is less than (but not equal to) the limit. FORTH-79 loop parameters are also restricted to signed single-precision numbers.

Both characteristics have changed in FORTH-83. The new versions permit loop parameters to be any signed or unsigned single-precision value (values between −32,768 and 65,535; see table 7). FORTH-83 loops terminate when the index is incremented across the boundary between limit−1 and limit; code to detect the transition is easily implemented for any processor with an overflow bit. Use of the transition detection rather than FORTH-79's direct comparison means that a limit equal to the initial index will no longer terminate the loop after one pass; instead, the index is handled on a continuous "number circle" using 2's complement arithmetic.

(continued on page 412)

Table 2: *Modifications to, and clarifications of, stack parameter manipulations under the proposed FORTH-83 standard. Stack diagrams show value(s) on the parameter stack before and after the execution or compilation of the indicated FORTH word. For an explanation of the abbreviations used for stack values, see table 7.*

Word	Word Set	Stack Diagram(s)
!	required	(16b addr —)
#>	required	(32b — addr +n)
*	required	(w1 w2 — w3)
+	required	(w1 w2 — w3)
+!	required	(w1 addr —)
,	required	(16b —)
−	required	(w1 w2 — w3)
-TRAILING	required	(addr +n1 — addr +n2)
1+	required	(w1 — w2)
1−	required	(w1 — w2)
2!	double	(32b addr —)
2+	required	(w1 — w2)
2−	required	(w1 — w2)
2@	double	(addr — 32b)
2DROP	double	(32b —)
2DUP	double	(32b — 32b 32b)
2OVER	double	(32b1 32b2 — 32b1 32b2 32b1)
2ROT	double	(32b1 32b2 32b3 — 32b2 32b3 32b1)
2SWAP	double	(32b1 32b2 — 32b2 32b1)
;	required	(—) (sys —) (compiling)
>R	required	(16b)
@	required	(addr — 16b)
ABS	required	(n — u)
ALLOT	required	(w —)
AND	required	(16b1 16b2 — 16b3)
BEGIN	required	(—) (— sys) (compiling)
C!	required	(16b addr —)
C@	required	(addr — 8b)
CMOVE	required	(addr1 addr2 u —)
CONVERT	required	(+d1 addr1 — +d2 addr2)
COUNT	required	(addr1 — addr2 +n)
D+	required and double	(wd1 wd2 — wd3)
D−	double	(wd1 wd2 — wd3)
DEPTH	required	(— +n)
DROP	required	(16b —)
DUP	required	(16b — 16b 16b)
ELSE	required	(—) (sys1 — sys2) (compiling)
FILL	required	(addr u 8b —)
I	required	(—w)
IF	required	(flag —) (— sys) (compiling)
J	required	(— w)
LOAD	required	(u —)
OR	required	(16b1 16b2 — 16b3)
OVER	required	(16b1 16b2 — 16b1 16b2 16b1)
R>	required	(— 16b)
R@	required	(— 16b)
REPEAT	required	(—) (sys —) (compiling)
ROT	required	(16b1 16b2 16b3 — 16b2 16b3 16b1)
SPACES	required	(+n —)
SWAP	required	(16b1 16b2 — 16b2 16b1)
THEN	required	(—) (sys —) (compiling)
TYPE	required	(addr +n —)
UNTIL	required	(flag —) (sys —) (compiling)
WHILE	required	(flag —) (sys1 — sys2) (compiling)
XOR	required	(16b1 16b2 — 16b3)
[	required	(—) (—) (compiling)
[COMPILE]	required	(—) (—) (compiling)
]	required	(—)

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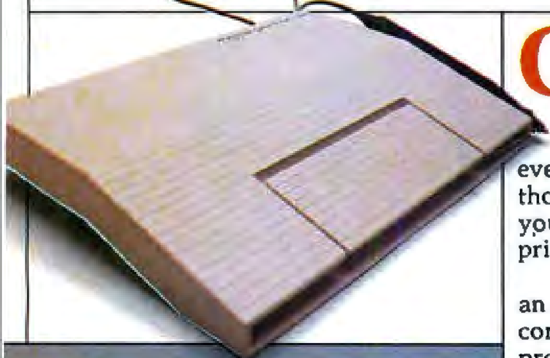

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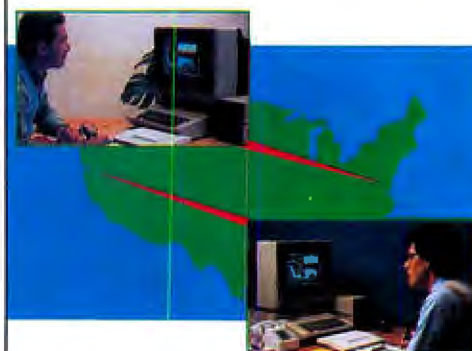

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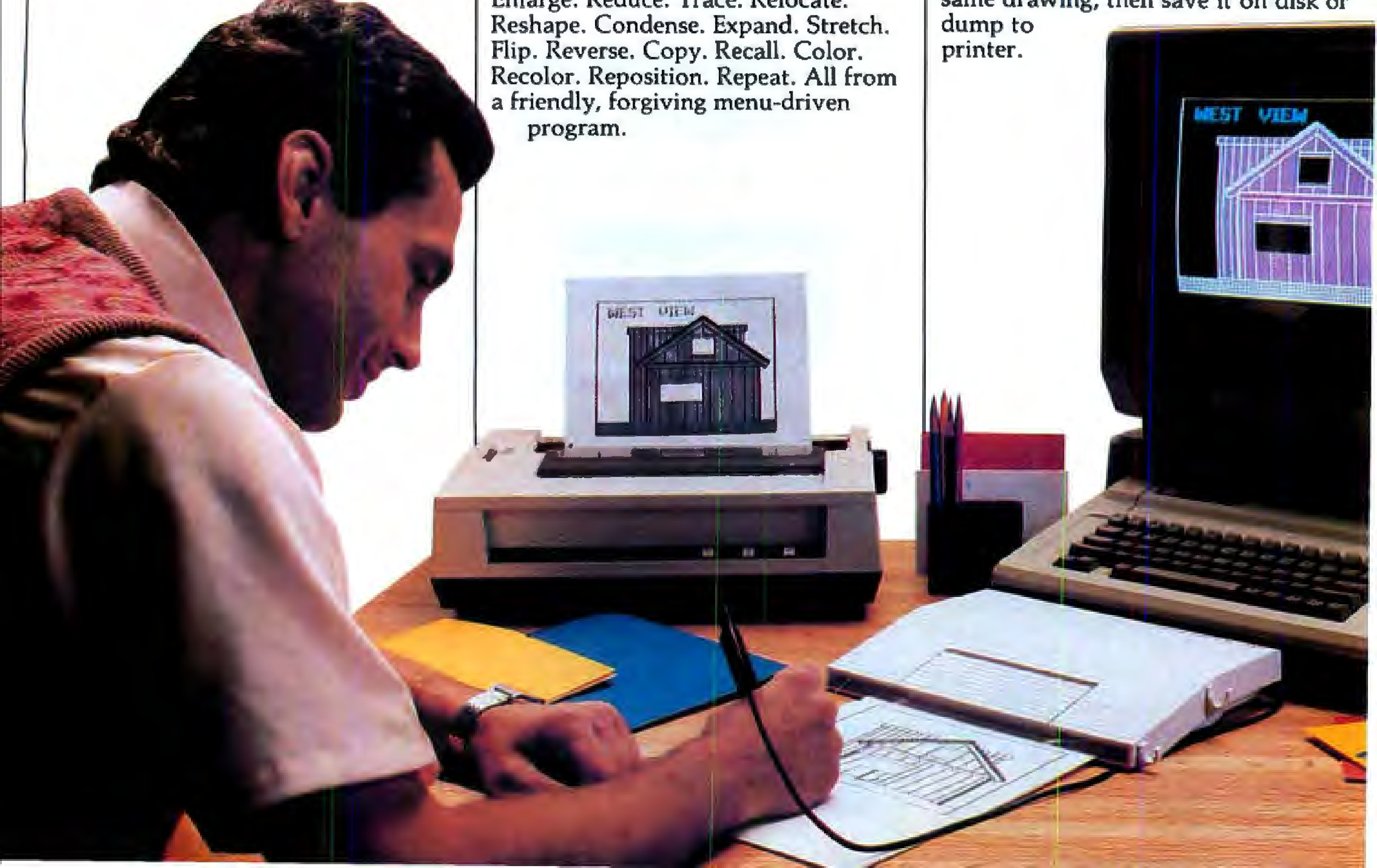

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Modula-2

A PIECE OF FOLK WISDOM on computer programs says, "Write two and throw the first one away." We all know that completing a program gives us insight into how we should have done it in the first place, as does subsequent real-world experience using it. The same is true of programming languages. Dr. Niklaus Wirth of the Institut für Informatik research institute of ETH (Switzerland's equivalent to MIT) invented Pascal in 1968—largely as a hypothetical language to teach programming—and had a working implementation by 1970. Wirth started on the design of Modula-2 in 1977, but only after he had written another language, Modula, and learned from it as well. (Modula was an experimental language concerned with multiprogramming; it contributed its name, syntax, and the concepts of multiprogramming and modules to Modula-2.)

After using Pascal for several years in academic and commercial situations, Wirth and many users of the language found shortcomings and defects in it, most notably its awkwardness when used for large programs, the many nonstandard extensions, and problems that occurred when a programmer wanted to use Pascal to manipulate the computer's memory and peripherals directly. Wirth was sensitive to the last criterion. In the preface to his book, *Programming in Modula-2* (Berlin: Springer-Verlag, 1982), Wirth says:

> In 1977, a research project with the goal to design a computer system (hardware *and* software) in an integrated approach, was launched at the Institut für Informatik of ETH Zürich. This system (later to be called Lilith) *was to be programmed in a single high-level language* [italics mine], which therefore had to satisfy requirements of high-level system design as well as those of low-level programming of parts that closely interact with the given hardware.

Note that this means that all the software in the Lilith machine—operating system, windowing facilities, text editor, system utilities, and everything else—is written in Modula-2.

Other key features of Modula-2 include the concepts of the module (which separates the definition and implementation of related code and makes the language more suited to large projects that require a team of programmers) and the process (used to implement multiprogramming), an improved syntax (allowing programmers to learn the language faster and make fewer syntax errors), and the ability to use procedure and array names as subroutine arguments (both of which make programs potentially more versatile).

This issue contains a variety of Modula-related articles. There are introductory articles by Wirth and one of his colleagues, Dr. Jurg Gutknecht, a description of the Lilith machine by one of its designers, an introduction to Modula-2 for Pascal programmers, and a comparison of Modula-2 with Pascal and Ada.

Even before we announced this issue, we found a lot of people already excited about the language. Several implementations of Modula-2 are already available, and a lower-cost version of the Lilith machine may be available within a year. We hope that this issue will contribute to the ground swell of interest in Modula-2.

—*Gregg Williams, Senior Technical Editor*

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Expanding Microcomputing

HISTORY AND GOALS OF MODULA-2

BY NIKLAUS WIRTH

The module comes of age

BY 1977 THE concept of high-level language, and with it Pascal, had gained popularity. To a major degree this was due to the recognition that mastering the art of programming is based on the understanding of its underlying concepts, and that therefore it is essential to use a notation that displays the concepts in a lucid manner and emphasizes the need for orderly structures. Equally widespread, however, was the belief that the price for this gain in structure and lucidity was unduly high, and that it was well worth paying it in the classroom but not in the competitive world of industry. This amounted to nothing less than the relegation of modern programming tools to the world of ivory towers and toys.

Naturally, this claim was more than a belief; it could be proven. Even worse: it didn't have to be proven, it was evident. The same algorithm expressed in FORTRAN would run twice as fast as when expressed in Pascal or PL/I. And it was widely known that a clever programmer using an assembler could even enlarge this factor. In the same vein, the code generated by a high-level language compiler was considerably larger than the one constructed by the clever coder at a lower level.

The numbers, although measured, proven, and therefore true, were based on a misunderstanding caused by many people's inability to distinguish between a programming language and its implementation. A programming language is a *formalism* suitable for expressing algorithms and data structures, based on a concise and formal definition of its constructs and their meaning. (From this it follows that the term *language* is actually most unfortunate and misleading.) An *implementation* is a mechanism for the interpretation of programs expressed in the formalism. I am afraid that even today many professionals, including teachers and writers, fail to make this fundamental distinction.

I was then fully aware that the claimed loss in effectiveness was not inherent in the concept of the high-level, structured language, but in the inadequacy of the present implementations. Consequently, in our efforts to develop a compiler for Pascal we paid much attention to achieving an efficient compiler, i.e., a compiler that compiled fast and also generated dense and effective code. Eventually, our second Pascal compiler for the CDC Cyber computer, completed in 1974, generated code whose efficiency was genuinely comparable with that of a good FORTRAN compiler.

Ironically, however, the breakthrough of Pascal did not come from our valiant efforts to measure up to FORTRAN production compilers. It rather came from our so-called portable Pascal p-compiler, where efficiency was a very minor concern. In San Diego, Ken Bowles had the insight and courage to write p-code interpreters for various microprocessors that had just appeared on the market with loud fanfare. He introduced Pascal to the world of computer users and fans, where the efficiency of the programming process was often much more relevant than that of the resulting programs. Even more important, these users were seldom compelled to remain

(continued)

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Modula-2 grew out of Pascal and incorporates a few major and some minor improvements.

compatible with their past; they were less likely to adhere to the widespread misconception that their software libraries were so valuable, merely because their development had cost so much.

The success of Pascal implementations for microcomputers, however, has not eliminated the value of good compilers. To the contrary, it has increased the motivation to produce high-quality implementations.

The Project Lilith

An implementation does not consist of the compiler alone but includes the interpreting computer. Our efforts in constructing a good Pascal implementation were bounded by the suitability of the target computer. In fact, we spent a large amount of energy to conceal and make up for the inadequacy of the underlying computer. We had learned a lot about compiler design, but I also recognized that a truly satisfactory design would have to encompass programming language, compiler, and computer, all properly matched.

My visit to the Xerox Palo Alto Research Center (PARC) in 1976/1977, and my confrontation with its powerful personal workstation, the Alto, provided the incentive to undertake a new research project encompassing all these aspects. I was intrigued by the Alto's singularly simple design concept and the resulting flexibility for the programmer. Thus, I embarked on learning about hardware design and, upon returning to Switzerland, started the project that resulted in the computer Lilith, a personal workstation based on a powerful processor (Am 2901), a bitmapped display, a mouse as input device, and an architecture tailored to the needs of a compiler. With a staff of six part-time assistants this seemed to be an overly ambitious goal, a project almost certainly doomed to failure. Nevertheless, after two years, two prototypes of Lilith were operational, together with a compiler, an operating system, an advanced full-screen mouse-driven text editor, an interactive line-drawing editor, and elementary utility programs.

Apart from the motivation and competence of the team members, the feasibility of the ambitious task rested on three fixed constraints that I had postulated at the start: (1) we would implement a *single language*, and all software would be written in that language, without exception whatsoever; (2) the operating system would be designed for a *single user*, thus avoiding difficult problems of scheduling, protection, resource management, and accounting; (3) the computer would have a *single processor*, powerful enough to execute programs and to perform the raster operations on the displayed bit map.

Indeed, considering that Lilith was to be a personal workstation, there were no advantages to be gained by deviating from these constraints, in spite of widespread popular trends to develop multiprocessor, multilanguage, multiuser systems.

The first constraint required a language equally suitable for expressing algorithms on a high level of abstraction and for expressing operations directly accessing machine facilities, equally suitable for formulating a database system as for programming a disk driver. Evidently, Pascal was not capable enough, and I did not favor the common escape of embellishing it with a few "desirable extensions." Modula, a small language that I had designed in the preceding years to experiment with the concepts of multiprogramming, clearly did not suffice either. But it featured a facility to partition programs into modules with explicitly specified interfaces. This was precisely the facility needed to allow the introduction of so-called low-level facilities in the high-level language, because it allowed you to encapsulate them and to constrain their dangerousness to clearly delineated parts of a program. Hence, the choice for the new language was Pascal, augmented by the module and a few other facilities, and regularized by a more systematic syntax. Thus was born Modula-2.

Modula-2

The language was defined in 1978 (10 years after Pascal) and implemented by L. Geissmann, S.E. Knudsen, and C. Jacobi on the PDP-11. Its small store of available memory (28,000 16-bit words or 56K bytes) caused many obstacles and was the reason for the first compiler's five-pass structure. In the summer of 1979, the compiler was completed, and at the same time, the first Lilith prototype became operational. The operating system Medos-2 had been constructed by S.E. Knudsen concurrently, and together with the compiler it was transported from the PDP-11 to Lilith within three weeks. This was in itself an encouraging feat in software engineering and proof of Modula-2's usefulness as a system-implementation language. After a year's in-house use, I published the report on Modula-2 and we released the Modula-2 compiler to interested parties (March 1980). The defining report is included in the tutorial book *Programming in Modula-2* (N. Wirth, New York: Springer-Verlag, 1982) which I prepared up to the camera-ready stage with the aid of Lilith and a document-formatting system that I programmed, of course, in Modula-2.

As mentioned already, Modula-2 grew out of Pascal and incorporates a few major and a fair number of minor improvements. The single most outstanding added facility is the module structure. Basically, this facility allows you to partition programs into units with relatively well-defined interfaces. More specifically, it allows you to control the visibility of declared objects and to hide them from places where they better remain unknown. Since it plays such an important role, we shall now look briefly into the history of Modula-2's development.

Although the principle of information hiding was much discussed in the early 1970s, it is perhaps Modula's merit to place it consistently into the framework of a clearly defined language. To the best of my knowledge, it was David Parnas who first coined the expression *information hiding*. Both Tony Hoare and Per Brinch Hansen gave it form by connecting it to the class facility of the programming language Simula. This is essentially, in terms of Pascal, a record type; the set of instantiations of this type forms what Simula terminology calls a *class*. In contrast to Pascal records, the Simula class allows you to associate

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procedures with the data represented by the field identifiers. Hoare and Brinch Hansen then postulated that while the names of the procedures would normally be visible, those of the data would remain hidden except within the associated procedures. This feature was implemented in Brinch Hansen's Concurrent Pascal and embodied the principle of information hiding, which in the meantime (1975) had been promoted to that of *data abstraction*. The example in listing 1 serves to exemplify the issue: we use a liberal Pascal notation ("N" is a constant):

In a program using this class (type), one might declare variables

q0,q1: queue

and thereafter access them by statements like

q0.put(13.7)   q1.get(v)

but statements like "q0.n := 237" or "q1.in := q0.out," which evidently interfere with the presented implementation of the abstraction of a queue, would be disallowed. More importantly, they would be prevented by the compiler, which does not "see" the field identifiers "n," "in," and "out" that are hidden inside the class (record) declaration.

Unfortunately, these proposals intertwined several independent concepts like visibility, instantiation, indirection of access, concurrency, and mutual exclusion. Both authors had actually postulated these kinds of classes to embody areas of mutual exclusion in multiprocessing systems, and the facility became more widely known as a *monitor* (in which the HALT statements are replaced by synchronization operations).

In the development of the experimental multiprogramming language Modula-1, I strived for clarity of concept and was convinced that a substantial disentangling of the various intertwined concepts was mandatory. Together with H. Sandmayr we found a possible solution in the structure then called module that would concern the aspect of visibility only. This, I believe, was the major breakthrough, because in all other languages the visibility issue had always remained intimately connected with that of existence. In particular, it was now possible to declare sets of static, global objects that were visible from selected parts of the program only. This is typically desirable to encapsulate certain permanent parts of a system (like device drivers, storage allocators, window handlers, etc.). I enhanced this module facility with so-called *import* and *export* lists that allow the explicit control of visibility across the "module wall" of each individual object. Furthermore, true to Algol and Pascal tradition, modules can be nested. An export now signifies the extension of visibility to the outside, and import signifies its extension to the inside (see figure 1).

Separation of Specification and Implementation

During my aforementioned stay at PARC in 1976, I became acquainted with the language Mesa, a Pascal offspring specifically designed to meet the needs of large system development. Mesa also incorporated an information-hiding feature. It also allowed you to encapsulate program parts into modules but lacked the ability to control the visibility of individual objects, and it entangled the facility once again with another feature, namely that of *separate compilation*, a facility of implementation. Its noteworthy contribution was the separation of the declarations of the exported objects from that of the ones to remain hidden. The former is called the *definition part*, the latter is the *implementation part*, which contains all those details that are relevant to the realization of the exported mechanisms, but not to their functional definition.

The combination of Mesa's module facility with split definition and implementation parts, and the (nestable) Modula-1 modules with controllable import and export resulted in Modula-2.

The facility of separate compilation posed some nontrivial problems. The key idea is that the compilation of a definition part results in a (compiled) symbol table (represented as a file). The file contains all information relevant to importers (clients) of that module. If, at a later time, another module imports objects from, say, modules M1 and M2, then the compiler accesses the previously generated symbol files of M1 and M2. Thus, the rules of type consistency are observed across module boundaries as well. This makes separate compilation genuinely helpful and safe, in contrast to *independent compilation* as known from assemblers and FORTRAN compilers, which is a misleading pitfall when used with high-level, data-typed languages.

It is noteworthy that Ada incorporates this form of module in almost identical form, although under the name *package*. We can attest that this is one of the more essential features of any system language because we have made extensive use of it for the last five years. Regrettably, Ada designers have failed to restrict separate compilability to global modules.

Using Modules Effectively

During the last five years, we have seen that postulating and providing a new facility is one thing, and learning to make good use of it is another. The more intricate and sophisticated a facility is, the smaller is the chance that it will be used wisely. In fact, finding the appropriate structure for the data and

(continued)

Listing 1: *Sample queue routine in Pascal.*

```
TYPE queue =
RECORD n, in, out: INTEGER;
        (*n = no. of filled slots; initially 0*)
        buffer: ARRAY [0 .. N-1] OF REAL;

        PROCEDURE Put(x:REAL);
        BEGIN IF n = N THEN HALT (*full*);
                buffer[in]:=x; in:=(in+1)MOD N;n:=n+1
        END;

        PROCEDURE get(VAR x: REAL);
        BEGIN if N = 0 THEN HALT (*empty*)
                x:=buffer[out]; out:=(out+1) MOD N;n:= n-1
        END
END
```

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program is the key to successful programming. With the module we have added another level of granularity in program structuring. The difficulties of finding a good partitioning—I carefully avoid the word "optimal"—are cumulated at this level, because often the modules are the units that are constructed by different programmers. Their contracts, in fact, are the definition parts of their modules. The definition parts establish the interfaces, which constitute the first task in a system's design process. Lucky are those who hit a good solution at the outset, for any change affects all participants. If a definition module A has been changed in any way, then all modules that import A must be adapted (and at least be recompiled). This is not the case, however, if only the implementation part of A had been modified. Hence, a fair degree of decoupling is established. Extreme examples are the primary utility modules of an operating system, because they are used by virtually every program. The system may well be modified without hampering the users. However, the slightest change in a definition module will require the recompilation of all clients.

The first rule to be observed when you deal with modules is that the interfaces must be considered before implementations are attempted. The terser they are, the smaller the chance for mistakes and the need for changes. Interfaces should, by their very definition, be "thin."

A second observation is that a module usually hides a set of data and provides a set of operators to manipulate this data. By forcing the client to access this data via the offered procedures, the module's designer may guarantee that certain consistency conditions are always observed, i.e., always remain invariant. In the queue model shown in listing 1, it is guaranteed that the counter n truly reflects the number of elements contained in the buffer and that their order of coming out of the queue is the same as that of going in.

As a consequence, a module is typically chosen as the collection of routines that operate on a set of data, which can be seen by the client as an abstraction defined by the accessible set of procedures.

Often, a module is also chosen as the collection of procedures that constitute a level of abstraction of data that is residing elsewhere. For example, a module containing a set of input and output routines such as

ReadInteger(f,x) and WriteReal(f,x)

will allow you to think in terms of the abstract concept of a sequence of integers and real numbers, and to ignore the details of its implementation in terms of bits, bytes, buffers, files, disk sectors, etc.

Consequently, such a module is chosen in order to establish a new level of abstraction. The success of such an abstraction crucially depends on its rigorous definition and your willingness to genuinely ignore its implementation. Please don't misunderstand! I do not say to remain ignorant of its implementations, but rather only use an implementation's properties that are defined in terms of the abstraction. To cite a well-known example: if you think in terms of integers, it does not make sense to ask for the value of an integer's last bit, even if you know that it is represented as a sequence of bits. Instead you should ask whether the integer is odd.

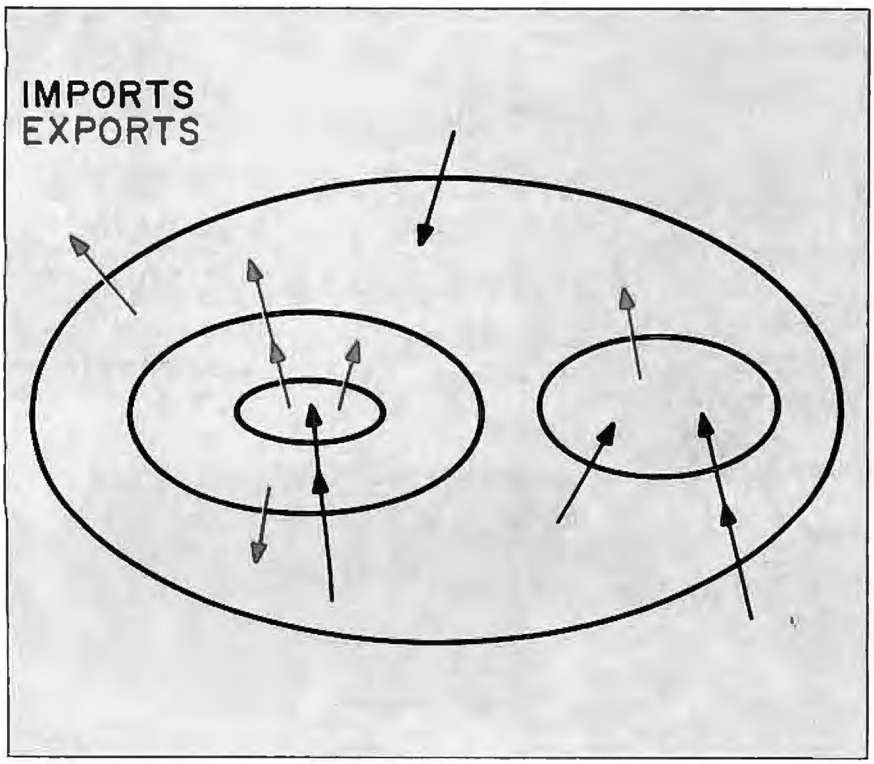

Figure 1: *Crucial to the structure of Modula-2 is the concept of the module, which may be nested inside other modules. Within each module, the visibility of objects to other modules may be controlled via the* IMPORT *and* EXPORT *functions.*

Computers, Languages, and Commercialism

It is precisely the ability to think in terms of proper abstractions that is the hallmark of a competent programmer. Even more, he or she is expected to be able to jump from one level to another without mixing them up. A structured language is enormously helpful in this endeavor, but it does not do it for you. It is like with a horse: you may guide it to the water, but it has to do the drinking itself. I am afraid that this simple truth is in stark contrast to the numerous lulling advertisements being published in such abundance. They cleverly reinforce themselves with slogans like *Switching to Pascal solves all your (programming) problems* and *Our Computer speaks Pascal*, and, in fact, represent nothing more than an extremely aggressive sales campaign.

Sooner or later, people will, through

(continued)

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harsh experiences, realize that they have become victims of slogans and fads, and that owning the best of tools is worthless unless that tool is thoroughly understood. I am afraid that the modern trend of overselling can become counterproductive. I have seen progressive teachers proudly offering their students the chance to learn structured Pascal, and I quickly realized that the students had no inkling of what structure meant. And I have seen professional programmers proudly present Pascal programs abounding with neatly indented structures, comments (for documentation, of course), and lots of procedures and sophisticated data types. Upon closer inspection, however, the baroque nomenclatures and structures revealed themselves as deadweight. Sometimes, redesigning these programs led to drastic, even tenfold, reduction in their size and complexity. I sadly realized that a high-level programming language could not only be used to design beautiful programs with much less effort, but also to hide incompetence underneath an impressive coating of glamour and frills. The analogy to literature became all too evident. We must do our best to avoid the misuse of modern programming languages for the selling of lousy contents through enticing packaging. Style may be essential to achieve a good design, but ultimately it is the design, and not the style, that counts.

Let me emphasize the point: neither owning a computer nor programming in a modern language will itself solve any problems, not even yours. But it may be instrumental. Predominantly, I have noticed, more effort is spent on obtaining those instrumental tools than on mastering them. And this is a grave mistake. Perhaps the most effective precaution against it is this rule: Know what the tool is to achieve and what you are going to use it for before you acquire it. This holds for language as well as computers—the more sophisticated it is, the more effort you will need for its mastery, the bigger will be the chance for its misuse, but, presumably, the higher the ultimate reward. I hope that this reward is not only measured in terms of problems solved and dollars earned, but also in the learners' satisfaction of having gained understanding, ability, and genuine insight. ■

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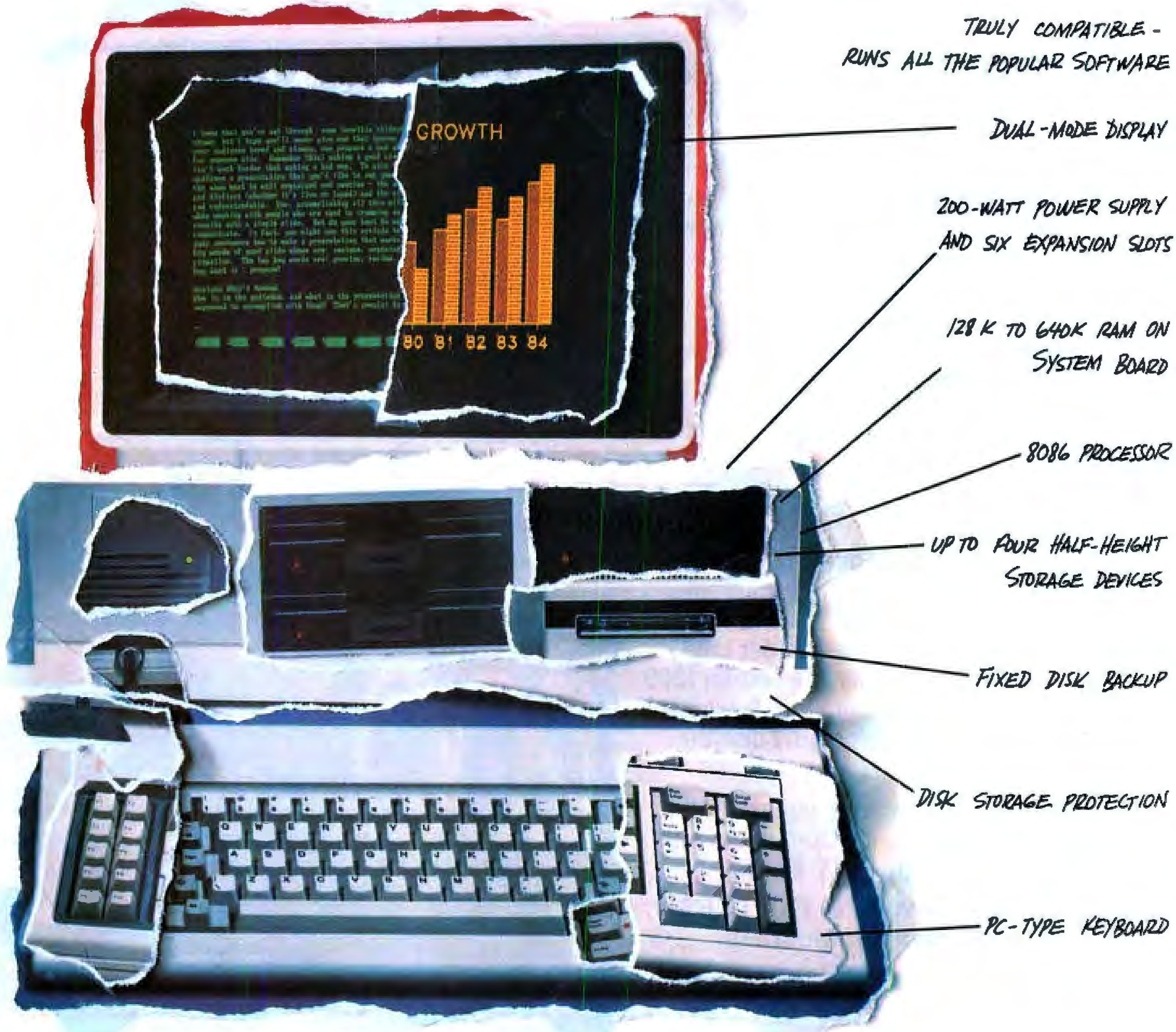

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TUTORIAL ON MODULA-2

BY JURG GUTKNECHT

A structured programming language based upon the concept of autonomous modules

MODULA-2 INTRODUCES the module into the world of systems engineering. It is a basic constituent of Modula-2 programs, appears in a variety of formats, and is comparable to that of procedures brought in by ALGOL and Pascal for structuring programs.

One module may combine a set of logically connected procedures; a second module may hide a complex data structure and provide operations to influence this structure; a third module may define the fundamental data types in a large program. Modules are either autonomous or embedded, as submodules, into larger modules. The autonomous are said to be embedded into the universe.

The module is essentially a separate program part, with an infrastructure that is similar to the infrastructure of a Pascal program. Types, constants, variables, and procedures declared within the module are generally not visible outside the module, and objects defined outside the module are not accessible from within.

The module technique has turned out to be surprisingly difficult to master. We have been involved with Modula-2 at the Institut für Informatik and our experience shows that it is easier to misuse the module than to use it profitably. Nevertheless, we find it to be indispensable. This tutorial may help you in developing a good eye for appropriate program modularization.

Let us define some integral concepts. The nature of permanency is common to all types of modules. The lifetime of the module and its objects equals that of the whole program. This is in contrast to the temporary character of procedures. In fact, the notion of a module is more closely related to the notion of *record* than to that of *procedure*.

We define a module as active at a given moment if statements of the module are executed. The first time a module becomes active is when it has been loaded. The module body (also called initialization part) is then executed as a subroutine of the program loader. The last module loaded is the main module and its initialization part is the main program. A module is reactivated whenever one of its exported procedures has been called.

AN EXAMPLE

To get firm ground under our feet, we will develop a Modula-2 sample program—a text formatter. For this example, assume that the text must be printed on sheets of paper in adjusted and multicolumn form. Assume further that this text is available in an ordinary text file that consists of lines of text (see figure 1a). Let us define a paragraph as a sequence of lines that is terminated by an empty line. Thus, from our text formatter's point of view, line terminators (hereafter referred to as EOL characters) are equivalent to space characters, except when they terminate an empty line, which concludes a nonempty sequence of lines.

The crucial thing for our formatter to do is to convert the text from "straight text" representation into "columnar text" representation. We shall organize our program so that it creates a new text file, which contains the text in its new format. A standard utility program may later produce the desired printout.

The overall dynamic structure of our program now suggests itself: read text lines from the input file in sequence, and build up the text pagewise in its new format. Completed pages should be written immediately into the output file to make way for the next page in the memory. Clearly, the events of reading lines and writing pages are asynchronous.

An appropriate program structure should certainly reflect the described situation. We could regard the input handler as the main, and therefore con-

(continued)

Dr. Jurg Gutknecht (Institut für Informatik, ETH—Zentrum (Clausiusstrasse), CH-8092, Zürich, Switzerland) is actively involved in the use of Modula-2.

trolling, part of the program. Alternately, we might structure the output formatter as the translation controller that periodically demands a new text portion from the input routine. From our experience, the former point of view is superior to the latter, particularly if the input stream includes control information.

Further, we propose to encapsulate the formatter into a submodule. Let us now develop the interface to this submodule that we shall call *Layout*. Essentially, communications will consist of a single operation: formatting an appropriate piece of text. We shall therefore call this procedure Format. Format accepts and formats a paragraph. The paragraph is handed over in the form of a pointer *lim* (end of text) into a

(continued)

1a

```
Lara is a document processing program consisting of an interactive editor (lara)
and a printer companion (laraprint) producing hardcopies of Lara documents on
the laser printer.
Lara introduces several new concepts.
We shall roughly outline the most important of them in this memo.
The memo also includes basic rules and guidelines for working with Lara.
We shall expect the reader to be familiar with the program editor and the
text editor Andra.

Concepts of Lara:
Self-Consistency:
Each Lara document completely describes itself, i.e. it does not refer to any
other information such as styles and user profiles.
Thus, the values of all formatting attributes occuring within the document
are included in the (header of the) document file.

Hierarchical document structure:
A Lara document is structured as a sequence of so called chapters.
Each chapter starts on a new page and is made up of a sequence of paragraphs.
Each paragraph starts on a new line and consists of a sequence of characters.  A
chapter, resp. paragraph, is created by typing a form-feed (CTRL L), resp.
line-feed (CTRL J).
In the case of adjusted paragraphs, RETURN is equivalent to line-feed.

Document, Chapter, Paragraph, Character
are the structural units of which a Lara document consists.
Each structural unit is connected with a set of formatting attributes
(applicable to instances of that structure, see table below).
A structural unit of higher level is selected by a multiple click of the
select button pointing at the same location.
Each clicking increases the selection menu by one.
For a selection to be successful, the beginning and end of the respective
structural unit must be displayed.
An unsuccessful level may be skipped by simply clicking again.
```

1b

```
Lara  is a document processing
program   consisting   of   an
interactive editor  (lara) and
a     printer       companion
(laraprint)         producing
hardcopies  of  Lara documents
on the  laser  printer.   Lara
introduces     several     new
concepts.   We  shall  roughly
outline  the most important of
them in this  memo.   The memo
also includes basic rules  and
guidelines  for  working  with
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Concepts        of       Lara:
Self-Consistency:    Each Lara
document  completely describes
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Thus,   the   values   of  all
formatting attributes occuring
within   the   document    are
included  in  the  (header  of
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structure:  A Lara document is
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starts  on  a  new page and is
made  up  of   a  sequence  of
paragraphs.    Each  paragraph
starts  on  a  new  line   and
consists   of  a  sequence  of
characters.   A chapter, resp.
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typing a form-feed  (CTRL  L),
resp.  line-feed (CTRL J).  In
the   case    of     adjusted
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Document,  Chapter, Paragraph,
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location.       Each  clicking
increases  the  selection menu
by one.   For a selection to be
successful, the  beginning and
end   of    the    respective
structural   unit    must   be
displayed.    An  unsuccessful
level may be skipped by simply
clicking again.
```

Figure 1: *The test file (1a) prior to being converted into 3-column format (1b).*

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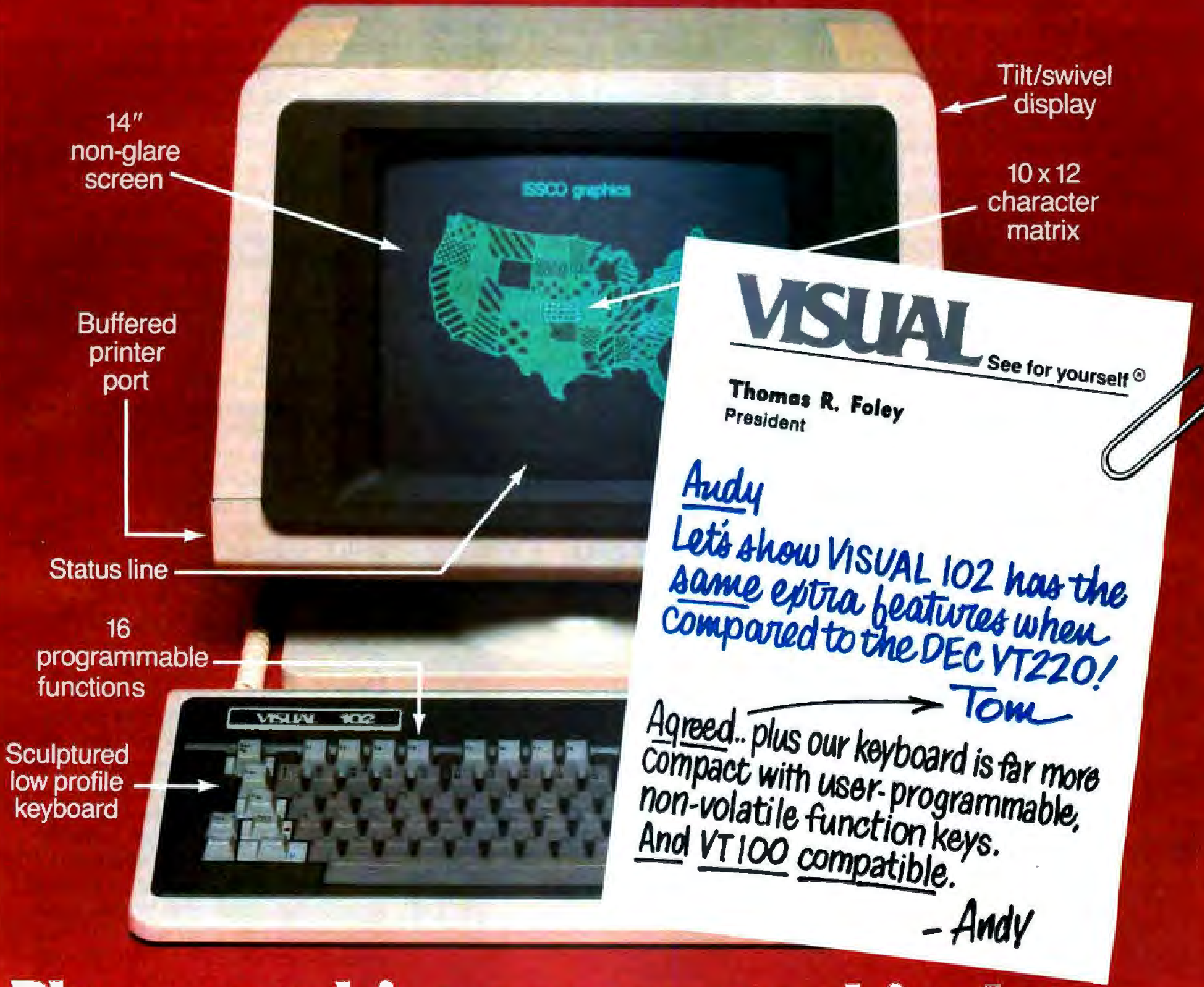

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character buffer *buf* (see listing 1).

A few explanations on this program fragment are in order. Although similar to Pascal, some conspicuous differences can be detected:

Import lists: these refer to separate standard modules, namely *FileSystem* and *InOut*, members of the basic module library. We shall discuss the library concept later. The entries in the import lists designate objects declared in and exported from the library modules. Apart from *File*, which is a type, all listed objects are procedures. Note that *File* is a record type, as can be seen from the statement WHILE NOT IN.EOF DO . . . . Fields of imported records (such as *eof*) are implicitly imported together. In Modula-2's syntax, WHILE and IF statements are never initiated with a BEGIN but are always terminated by a keyword (UNTIL or END). This rule lets nested statements appear more elegant than their counterparts in Pascal. Also, the ambiguities that arise in Pascal with nested IF. . .THEN. . .ELSE statements have been eliminated.

Type *Cardinal*: this is a new standard type describing natural numbers. Repetition of names: the module name has to be repeated at the end of the module. (This repetition convention also applies to procedures.) Character constants: *nC* designates the character with octal ordinal number *n*. Abbreviations: # is equivalent to < > and & is an abbreviation for *AND*.

In our program fragment, we could have used the standard Modula-2 procedure *INC* for incrementing *lim* (i.e., *INC(lim)* is equivalent to *lim:= lim* + 1).

Let us now examine the imported procedures ReadString and WriteString. They accept as their parameter an array of characters of arbitrary length. The corresponding formal parameter is a so-called *dynamic* or *open* array:

```
PROCEDURE ReadString(VAR s:
  ARRAY OF CHAR);
```

Listing 1: A *program fragment written in Modula-2 designed to format text into columns.*

```
MODULE Formatter;
  FROM FileSystem IMPORT File, Lookup, Close, ReadChar, WriteChar;
  FROM InOut IMPORT ReadString, WriteString, Write;
  CONST EOL = 36C;
  VAR in, out: File;
    name: ARRAY [0..31] OF CHAR;
      ch: CHAR;
      buf: ARRAY [0..1000] OF CHAR;
      lim: CARDINAL;
BEGIN
  WriteString("in> "); ReadString(name); Write(EOL);
  Lookup(in, name, FALSE);
  WriteString("out> "); ReadString(name); Write(EOL);
  Lookup(out, name, TRUE);
  lim := 0; ReadChar(in, ch);
  WHILE NOT in.eof DO
    WHILE ch # EOL DO
      lim := lim + 1; buf[lim] := ch; ReadChar(in, ch)
    END;
    lim := lim + 1; buf[lim] := " "; ReadChar(in, ch);
    IF ch = EOL THEN Format; lim := 0; ReadChar(in, ch) END
  END;
  Close(in); Close(out)
END Formatter.
```

Listing 2: A *procedure used to return the length of a given string within an array of characters.*

```
PROCEDURE Len(VAR s: ARRAY OF CHAR): CARDINAL;
  VAR l: CARDINAL;
BEGIN l := 0;
  WHILE (l <= HIGH(s)) & (s[l] # 0C) DO l := l + 1 END;
  RETURN l
END Len;
```

Dynamic arrays are of major importance in Modula-2. The index type of dynamic arrays is always *CARDINAL*, and the low boundary is 0. The boundary of the actual array parameter can be obtained by *HIGH(s)* using the standard function *HIGH*. Dynamic arrays can only be used as formal parameters.

Next, let us look at strings (i.e., sequences of characters). Assume that a function procedure had to be developed that returns the actual length of a string. A string within an array of characters is terminated by *OC* or by the upper array boundary, whichever comes first. Consider the procedure declaration in listing 2.

In Modula-2, functions differ from ordinary procedures solely by the supplement of a result type. The result is returned by the RETURN statement. We point out the amazing simplicity of this algorithm. It has its roots in the conditional evaluation of the test in the WHILE statement. If *l* <= *HIGH(s)* is false, then the second part of the expression is ignored rather than evaluated. Thus, an index out-of-range error cannot occur.

Laying Out Layout

Let our attention now turn to the submodule *Layout*. We know that *Layout* exports the procedure Format, which formats a paragraph that is stored in the global buffer *buf*. Therefore, the wall around *Layout* has to be transparent for this variable: *buf* must be imported. But how should Format record its results? An obvious solution is to introduce the two-dimensional array *form* that represents a text page. By successively calling the formatting procedure, a map of the current text page will be built up. The variables *row* and *col* indicate the current status of the formatting process. Of course, these variables have to survive the procedure Format. On the other hand, the significance of the variables *form*, *row*, and *col* is strictly related to the specific implementation of Format. They have no meaning outside the submodule. They are, in fact, invisible outside the module as they are not exported. We shall say that these variables constitute the private data structure of the (sub)module.

We have seen that the procedure Format operates on the status variables *row*

(continued)

and *col*. How are these variables initialized? Remember the initialization part mentioned above. The Modula-2 linking loader guarantees that the statement sequence in the module body has been executed whenever an exported procedure is called from the outside. So introducing the initialization statements in the module body solves our problem.

So far we have disregarded the output. Clearly, a page should be written line by line into the output text file each time the page is completed. Format calls procedure OutPage when *row* and *col* have reached their maximum. Is this the only situation in which a page has to be written? It is likely that the last page of the text is only partially filled, so that the variables *row* and *col* won't reach their maximum values. So OutPage should also be called from the main program as termination procedure immediately before closing the files. We therefore generalize OutPage to include the handling of a partially filled *form* and include it in the export list.

Our submodule, *Layout*, appears in listing 3. Its text has to be included in the declaration part of the main module.

Notice the presence of a new repetitive **LOOP** statement. The loop statement is used whenever a repetition with more than one exit, or no exit at all, has to be programmed. The **LOOP** is left whenever an **EXIT** statement has been encountered within the loop brackets **LOOP** and **END**. It is noteworthy that the loop statement makes a jump statement (like **GOTO**) unnecessary. In our example, the loop is left when either the paragraph is terminated ("emergency exit") or when the current word has no room on the current line ("regular exit").

Constant expressions are another innovation of Modula-2 over Pascal. They are particularly useful for the specification of array bounds such as in [0 . . . *maxRow*-1] and can also be used for the declaration of dependent constants (e.g., *bndRow* = *maxRow* − *len*).

Until now, we have underexploited the possibilities of our submodule *Layout*. In fact, we have fixed the number of columns and the column widths as constants, although the module works correctly for arbitrary (appropriate) values of these quantities. Let us extend the format of input files with an optional header line that is initiated by a *CTLF(6C)*. *CTLF* has to be followed by a digit from 1 to 4 indicating the desired number of text columns.

A second modification concerns the overall program flow. It is not a good idea to terminate the program after having processed a single text file. Instead, the program should be ready to process

(continued)

Listing 3: *The submodule* Layout, *the output formatter, must appear within the main module.*

```
MODULE Layout;
  IMPORT buf, lim, out, WriteChar, EOL;
  EXPORT Format, OutPage;
  CONST len = 30; wid = 33; maxRow = 70;
        maxCol = 3*len; bndCol = maxCol-len;
        FF = 14C; (*form feed*)
  VAR form: ARRAY [0..maxRow-1], [0..maxCol-1] OF CHAR;
      row, col: CARDINAL; (*current coordinates*)

  PROCEDURE OutPage;
    VAR c, r, p: CARDINAL;
  BEGIN r := 0;
    WHILE r # maxRow DO c := 0;
      WHILE c # col DO p := 0;
        WHILE p # len DO WriteChar(out, form[r, c + p]); p := p + 1 END;
        WHILE p # wid DO WriteChar(out, " "); p := p + 1 END;
        c := c + len
      END;
      IF r < row THEN p := 0;
        WHILE p # len DO WriteChar(out, form[r, c + p]); p := p + 1 END
      END;
      WriteChar(out, EOL);
      r := r + 1
    END;
    WriteChar(out, FF)
  END OutPage;

  PROCEDURE Format;
    VAR beg, cur, end, pos, wds, spc, rem: CARDINAL;
  BEGIN
      beg := 0; cur := 0;
      REPEAT cur := cur + 1 UNTIL buf[cur] = " ";
      REPEAT wds := 0; beg := beg + 1;
        LOOP
          wds := wds + 1; end := cur;
          IF end = lim THEN spc := 0; rem := 0; EXIT END;
          REPEAT cur := cur + 1 UNTIL buf[cur] = " ";
          IF cur - beg > len THEN
            IF wds > 1 THEN
              spc := (len + beg - end) DIV (wds - 1);
              rem := (len + beg - end) MOD (wds - 1)
            END;
            EXIT
          END
        END;
        pos := 0;
        WHILE pos # len DO form[row, col + pos] := " "; pos := pos + 1 END;
        pos := 0;
        WHILE beg # end DO
          form[row, col + pos] := buf[beg];
          IF buf[beg] = " " THEN pos := pos + spc;
            IF rem > 0 THEN pos := pos + 1; rem := rem - 1 END
          END;
          pos := pos + 1; beg := beg + 1
        END;
        row := row + 1;
        IF row = maxRow THEN
          IF col = bndCol THEN OutPage; col := 0 ELSE col := col + len END;
          row := 0
        END;
      UNTIL end = lim
    END Format;

BEGIN col := 0; row := 0
END Layout;
```

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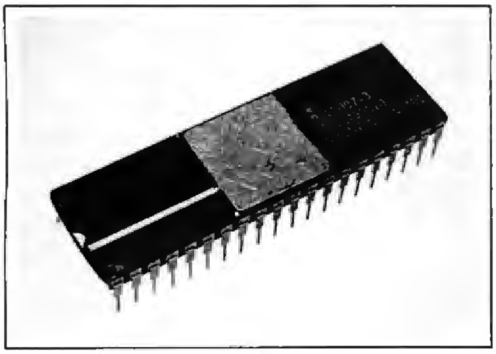

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Structuring elements allow and invite software designers to group declarations and procedures into distinct modules.

another file. Hence, we embed our previous main program into a WHILE statement. We shall specify that entering *ESC(33C)* instead of a filename will bring the process to an end. Module *InOut* exports a variable *termCH* containing the termination character of the string read by *ReadString*. Of course, this variable is exported for inspection only. See listing 4 for our extended main program.

In listing 4 we find yet another new Modula-2 statement. The IF statement from Pascal has been extended by the *ELSIF* clause. The meaning and possible application of this clause should be obvious from our example.

In contrast to our earlier solution, the submodule *Layout* may need to be initialized several times (i.e., each time new text is to be processed). The way to master this problem is to introduce an explicit initialization procedure; in our case, this procedure is called InitForm, which replaces (and extends) the previous submodule body. The body of the new submodule is empty.

With that, however, the responsibility for the correct sequence of module initialization has passed over from the Modula-2 loader to the programmer.

Divide and Conquer

Since the late 1960s serious programmers have based their software development on structured programming. This means that they have structured the dynamic flow of their programs such that a procedure call corresponds to each action in the formulation of the respective algorithm. Thereby, the question of where to program all these procedures has not been raised or answered "in the declaration section of the program." This is the point where Modula-2 intervenes. As we have already seen in the previous section, Modula-2's structuring elements allow and even invite the software designer to divide and logically group the set of declarations and procedures into distinct units called modules.

The consequences of this division reach further than expected. Separate compilation is one new aspect. It is a small step from encapsulating a program part within a main module to completely removing this part from its environment and defining it as autonomous. In fact, the Modula-2 compiler accepts autonomous modules as compilation units and performs full compatibility checking across module boundaries.

But Modula-2 goes one step further: separate modules can be split up into a definition and an implementation part. The definition part defines the module from a functional point of view, while its implementation companion lays down the methods used to realize these functions or to represent data. The definition part can be regarded as a separately stated (and compiled), extended export list.

This concept clearly opens a new door for software engineers. They may define centrally the components of large software systems in a concise and unified way and leave the implementation to a team of programmers.

It is crucial to separate compilation that imports must always refer to definition (parts of) modules. An important consequence of this is that recompilation of an implementation (part of a) module does not influence the module's clients. However, the recompilation of a (modified) definition part can trigger a chain reaction of which the extent is determined by the number of importations in dependent definition modules. It is therefore a good idea to minimize imports in definition modules.

Let us illustrate all that by two examples: a compiler and an editor. Think of the compiler as being designed according to the method of recursive descent. The different parts in recursive-descent compilers are known to be closely interwoven. On the other hand, we have seen that modularization essentially amounts to a textual splitting of the program. Hence, modularizing a compiler has to be a difficult undertaking. Nevertheless, some functional units can be extracted: lexical analysis (scanner), syntactical analysis (parser), generating of the symbol table, and type checking and code generation. We shall assign each of these functional units to a separate module.

These modules are obviously tightly

(continued)

Listing 4: *The main program that has been extended to* a) *use variables for the number of columns and column widths, and* b) *request a new text file to process after completing file output.*

```
BEGIN
    WriteString("in> "); ReadString(name); Write(EOL);
    WHILE termCH # ESC DO
      Lookup(in, name, FALSE);
      WriteString("out> "); ReadString(name); Write(EOL);
      Lookup(out, name, TRUE);
      lim := 0; ReadChar(in, ch);
      IF ch = CTLF THEN ReadChar(in, ch);
        IF ch = "1" THEN InitForm(96, 96, 70, 0)
          ELSIF ch = "2" THEN InitForm(46, 49, 70, 1)
          ELSIF ch = "3" THEN InitForm(30, 33, 70, 2)
          ELSIF ch = "4" THEN InitForm(22, 24, 70, 3)
          ELSE InitForm(96, 96, 70, 0)
        END;
        REPEAT ReadChar(in, ch) UNTIL ch = EOL;
        ReadChar(in, ch)
      ELSE InitForm(96, 96, 70, 0)
      END;
      WHILE NOT in.eof DO
        WHILE ch # EOL DO lim := lim + 1; buf[lim] := ch; ReadChar(in, ch) END;
        lim := lim + 1; buf[lim] := " "; ReadChar(in, ch);
        IF ch = EOL THEN Format; lim := 0; ReadChar(in, ch) END
      END;
      OutPage;
      Close(in); Close(out);
      WriteString("in> "); ReadString(name); Write(EOL)
    END
  END Formatter.
```

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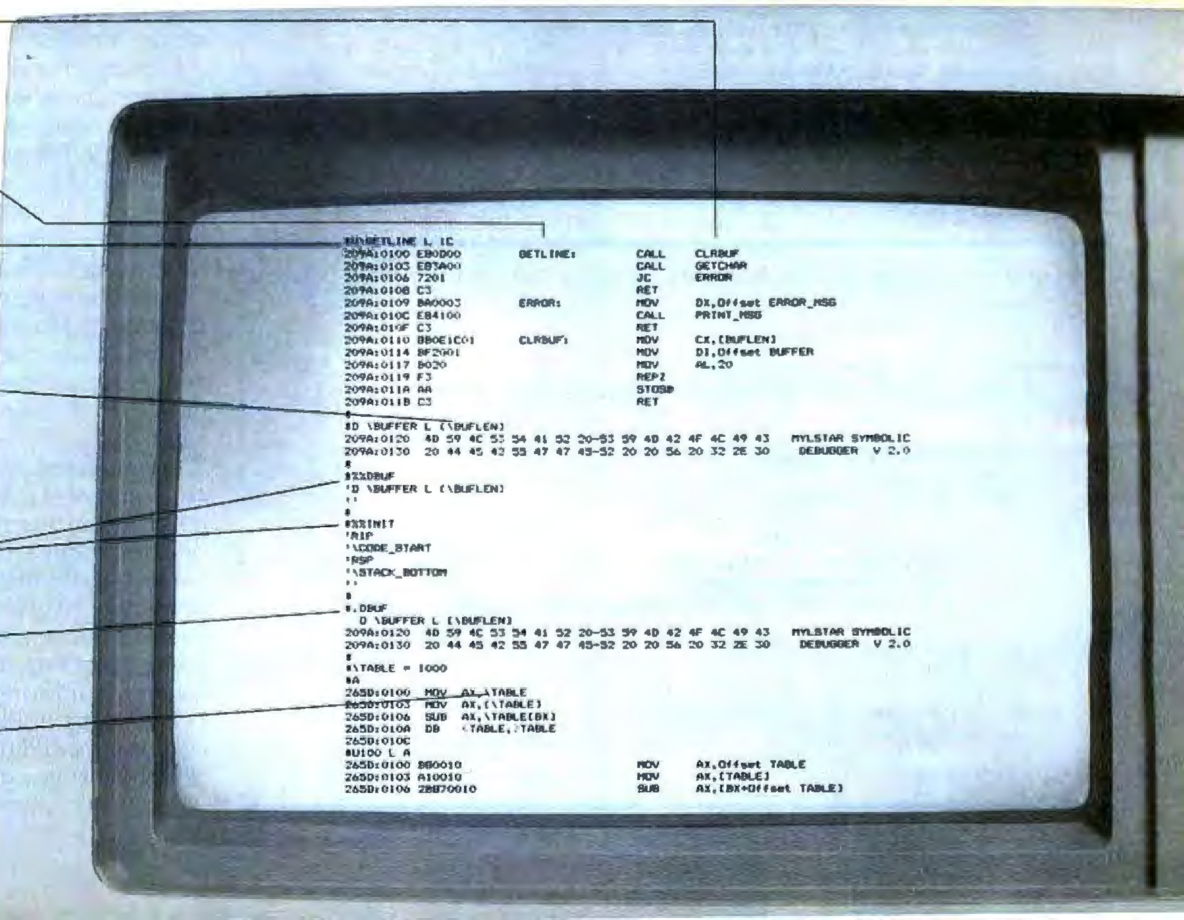

coupled. They all rely on a central and dynamic data structure: the symbol table. How can this common data structure (i.e., the respective data types) be presented to the different modules? The solution is to place the description of the data structure itself into a module, a so-called data-type module. This data module constitutes a common base that must be imported by any module that participates in the handling of the symbol table. Notice the contrast to our first example: there, a public procedure operated on a private and hidden data structure. Here, private and public procedures operate on a common and public data structure.

What can be hidden at all in our compiler modules? Methods is the answer. Consider, for example, the symbol-table generator. Listing 5 is an excerpt from its definition module.

ObjPtr, *ObjClass*, *StrPtr*, and *StrForm* are data types which are imported from the data module. *NewScope* and *CloseScope* open and close scopes, and *NewObj* and *NewStr* are procedures to create new entries in the symbol table. *Find* and *FindField* search for objects with a given name. *InitTableHandler* initializes explicitly the table handler, and *EndTableHandler* is the termination procedure for this module. We emphasize that no information is given about methods. It is left open, for example, which strategy is applied and whether a certain object is searched with a linear or a binary search.

Only the implementation module in listing 6 lifts the veil of secrecy.

Listing 5: TableHandler, *the definition module from a symbol-table generator.*

```
DEFINITION MODULE TableHandler;
  FROM DataTypes IMPORT ObjPtr, ObjClass, StrPtr, StrForm;
  EXPORT QUALIFIED Scope,
    NewScope, CloseScope, NewObj, NewStr, Find, FindField,
    InitTableHandler, EndTableHandler;

  VAR Scope: ObjPtr; (*header of scope located by Find*)

  PROCEDURE NewScope(kind: ObjClass): ObjPtr;
  PROCEDURE CloseScope;
  PROCEDURE NewObj(id: CARDINAL; class: ObjClass): ObjPtr;
  PROCEDURE NewStr(form: StrForm): StrPtr;
  PROCEDURE Find(id: CARDINAL): ObjPtr;
  PROCEDURE FindField(id: CARDINAL; rec: StrPtr): ObjPtr;
  PROCEDURE InitTableHandler;
  PROCEDURE EndTableHandler;
END TableHandler.
```

Listing 6: TableHandler, *the implementation module that contains the logic (see also listing 5).*

```
IMPLEMENTATION MODULE TableHandler;
  FROM Data IMPORT ObjPtr, Object, ObjClass, StrPtr, Structure, StrForm;
    ...

    PROCEDURE Find(id: CARDINAL): ObjPtr;
      VAR objx: ObjPtr;
    BEGIN Scope := topScope;
          LOOP objx := FindInScope(id, Scope);
          IF objx # NIL THEN EXIT
          ELSIF Scope↑.kind = Module THEN
            objx := FindImport(id, Scope);
            IF objx = NIL THEN objx := FindInScope(id, universe) END ;
            EXIT
          ELSE Scope := Scope↑.base
          END
        END;
        RETURN objx
      END Find;
  ...
END TableHandler.
```

Figure 2 shows the modular structure of our compiler in graphical representation. An arrow from module "M" to module "N" indicates that "N" imports "M" (i.e., "N" depends on the definition module of "M").

It is noteworthy that most multipass compilers show, from the point of view of time, a similar structure—first pass, lexical and syntactical analysis; second pass, table generating; third pass, type checking; and fourth pass, code generating. However, the spatial and temporal structures must not be mixed up (see figure 3).

Our second example of separate compilation is a text editor. In contrast to compilers, editors are interactive programs. Their dynamic flow is typically action oriented. Actions influence the text document's contents and, therefore, its representation on the display. This knowledge may result in the attempt of a modularization seen in figure 4.

But the display handler has to rely on the document handler. In fact, the document handler can be regarded as an abstract file system delivering a stream of characters and formatting information to the display. So we have mutual imports between the document and display handler.

Although this situation does not lead to a conflict as long as mutual import doesn't occur between definition modules, it indicates that the coupling of the two modules is too tight. A fundamental rule states that the "thinner" the interface between modules, the better the modularization.

In our example, we shall remedy the situation by eliminating the arrow from the display to the document handler and replacing it with an arrow from the display to the command interpreter (see figure 5).

This modification has some desirable consequences. First, the command interpreter can directly pass over display-oriented commands—such as scrolling the text—to the display handler without primarily involving the document handler. The second consequence is of even greater importance: the document handler is now freed from its dependence on the display. Therefore, it can also be imported by modules that process the text in a different way, say, by

(continued)

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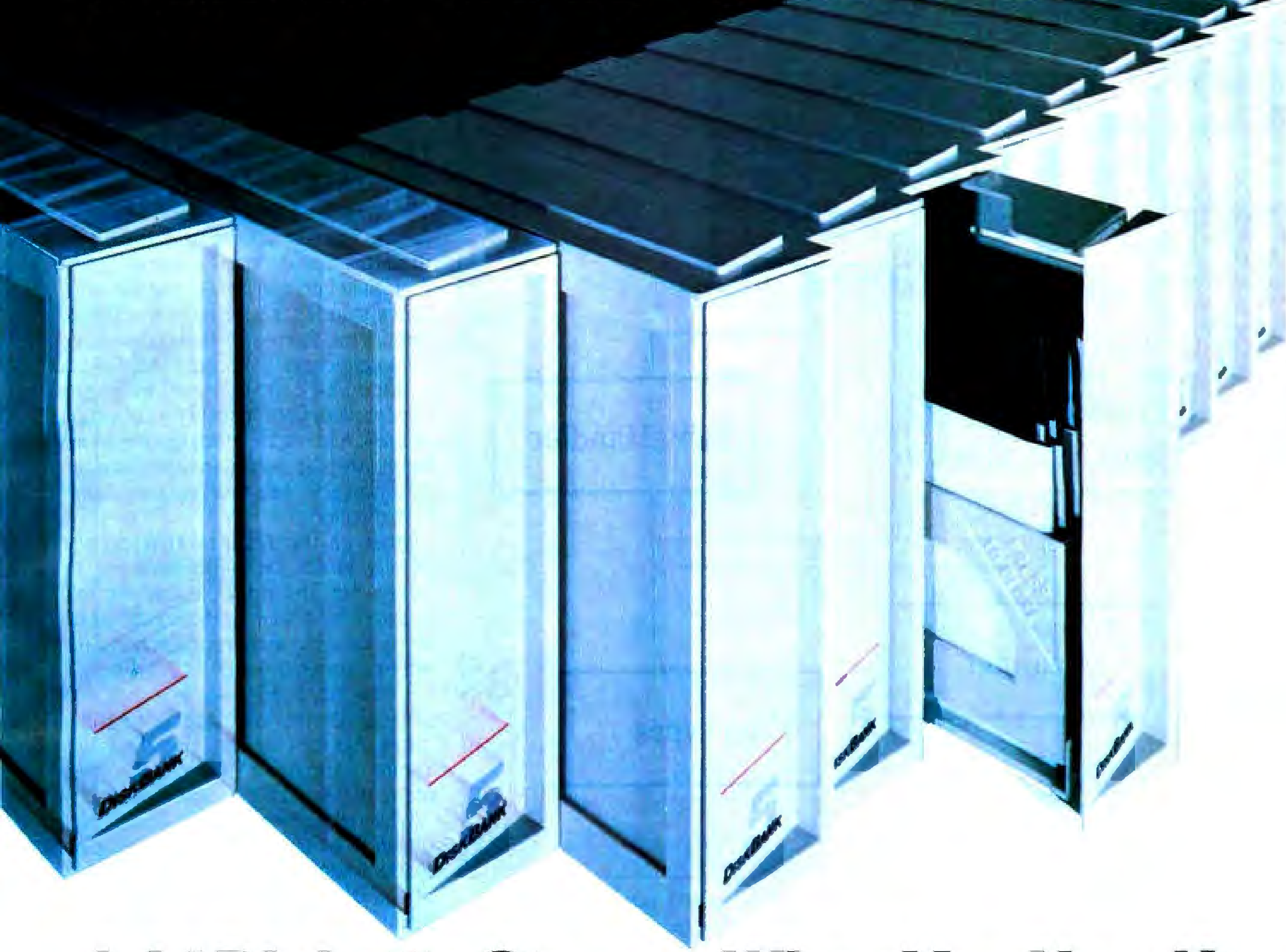

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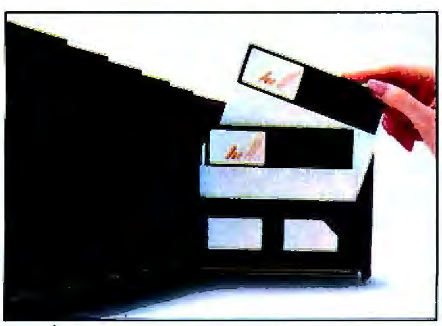

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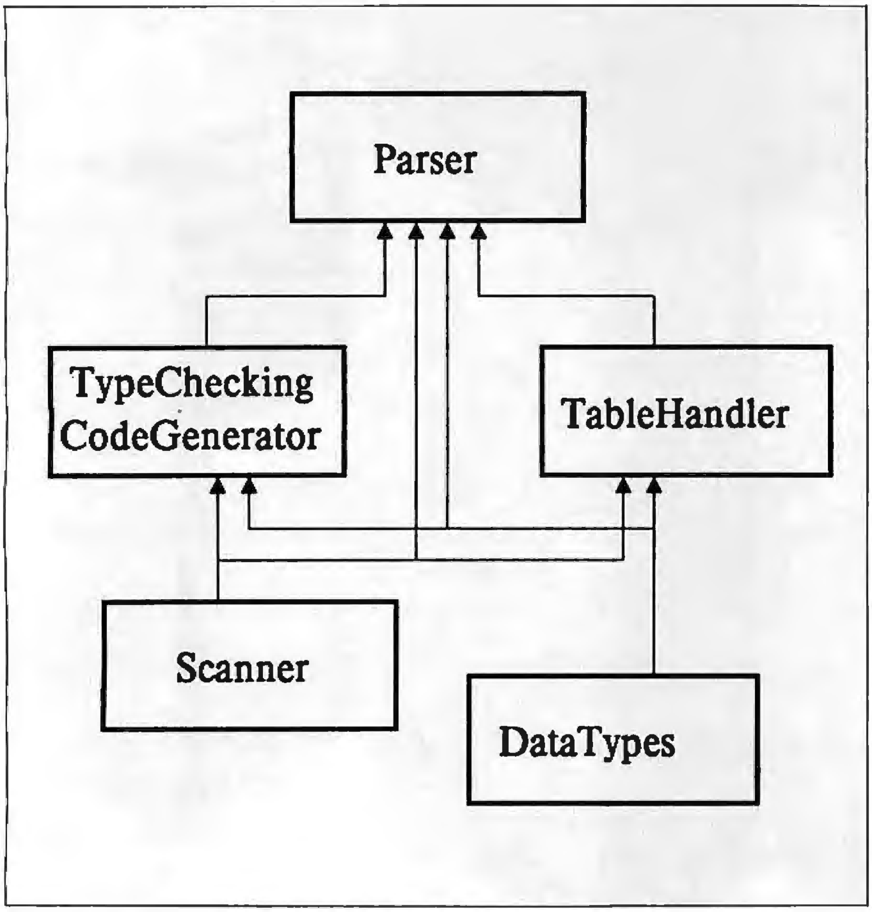

Figure 2: A *representation of the modular structure of the compiler example. The arrows from one module to another indicate that the latter imports the former.*

3a

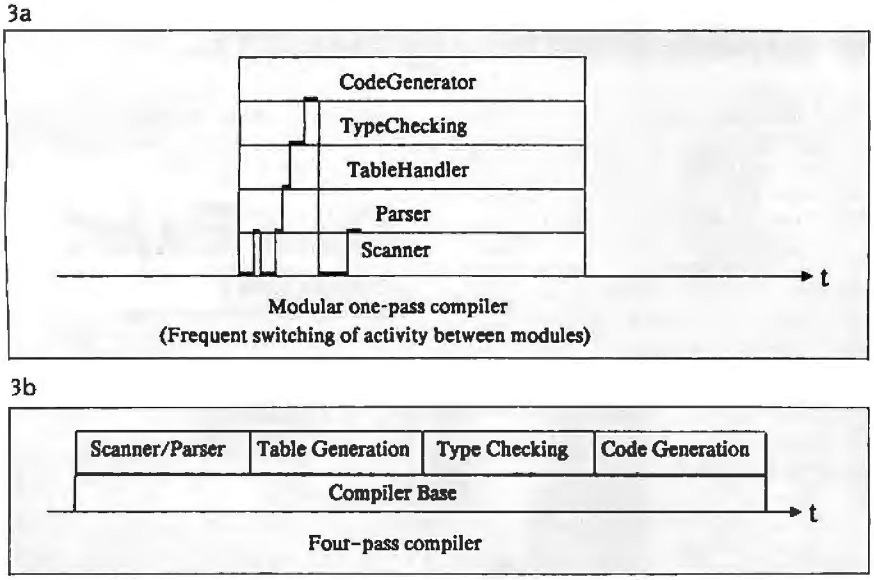

Figure 3: A *one-pass compiler (3a) as contrasted to a four-pass compiler (3b) over* t *time.*

a printing program or by an off-line statistics program.

From Program Components to Library Modules

We have seen that a specific module can be used by different programs. This thought naturally leads to the notion of a module library. The fact that the word *library* stands for a collection of books tempts me to create the word *modulary* for a collection of modules. Actually, in a Modula-2 environment even the operating system is simply a collection of basic and usable modules. The sharp boundary that separates system and application software thus becomes even less distinct.

Most of the features that do not belong directly to the programming language but are indispensable for real programming, such as I/O (input/output) string handling and process scheduling, are transferred to modules in Modula-2. On one hand this relieves, and also generalizes, the language and, on the other hand, increases its flexibility. Figure 6 shows an example of a hierarchy of Modula-2 library modules.

When designing a library module, the question of which facilities should be made available is paramount. If the set of offered procedures is too complicated, then most users will create their own modules; if the procedures are too simplistic, they are again dissatisfied. Our goal is to find the "golden mean."

We can summarize our experience relating to this quest in the following guidelines. We recommend that the library-module designer obey these rules.

Guideline 1

Do not export complex procedures from your library module (i.e., procedures with a large number of explicit or—even worse—implicit parameters and assumptions). Instead, export the atoms of complex operations as individua. This gives the user of your module the chance to "tailor" the operation as a whole to his requests.

For example, assume that a mouse-handling module offers a procedure TrackMouse to track the mouse until a mouse button has been pressed or a character typed. This procedure would

(continued)

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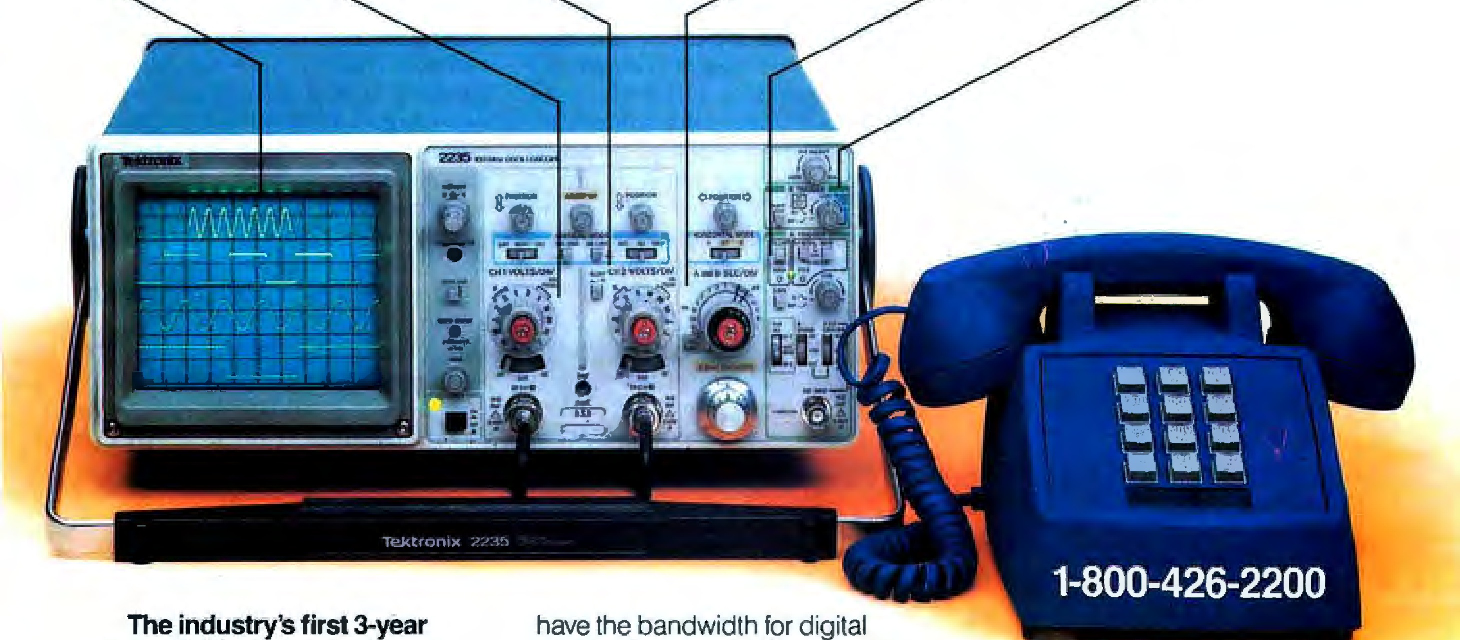

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satisfy all users *N* who agree to use this termination condition and to give away program control during the tracking loop.

But what about user *A* who wants the loop to stop when the left mouse button has been pressed, or user *B* who wishes to keep the cursor on a grid, or user *C* who wants to make the shape of the cursor depend on its location on the display? (See listing 7 for the general and specific cases of "mouse tracking.")

They would prefer two exported procedures, GetMouse and DrawCursor.

GUIDELINE 2

If complex objects are to be handled by your module, divide it up into several physical modules or groups of modules, each of them operating on the objects at a different level of abstraction ("distributed processing"). This enables your module's client not only to import a suitably restricted set of operations, but also to select the entry level to the module set, i.e., the level of abstraction on which he wants to have the objects handled.

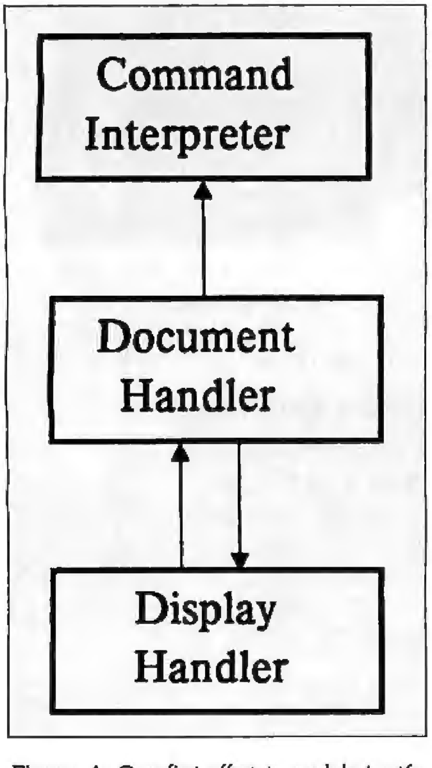

Figure 4: *Our first effort to modularize the text editor leads to mutual imports between the document and display handler modules.*

Moreover, later modifications in the definition can be restricted to individual modules in the set, thus reducing the number of user modules that have to be recompiled.

For example, the window handler base *Windows* (see figure 6) handles windows as a whole. It merely operates on the graph of their global overlapping hierarchy and completely disregards contents. By contrast, module *TextWindows* exports procedures to write text into the windows.

GUIDELINE 3

Assume again that your library module handles complex objects. If the maximum number of objects to be simultaneously handled is sufficiently small, identify each object by a number; for instance, define a subrange as object type. Thus, each user may store that information about the objects that is relevant for his sphere of activity in a private table that is indexed by the data type (distributed data).

Alternatively, a pointer type could have been chosen as object type. In such a case, each object points to its descriptor record. As the object descriptors are public, they cannot be effectively protected. This somehow contradicts the module concept. In fact, Modula-2 offers the possibility of hiding a type. A hidden (or abstract) type is defined in the definition module without structure indication and declared in the corresponding implementation module (normally as a pointer). But hidden object types restrict the handling of the objects strictly to the module.

In the case under discussion, the subrange is preferable to a pointer type (be it hidden or not) as the latter demands fixing the descriptor record once and for all (see listing 8).

GUIDELINE 4

If you design a library module that handles objects of a certain category, you may decide to include a merely restricted set of (universal) operations. If so, make use of the Modula-2 procedure-type parameter mechanism to enable the user to install his own procedures. Thereby, the range of potential users of your module can radically be enlarged without its size and complexity being increased. Procedure-type parameters make it possible to keep away details from a module. Keeping away details is somehow dual to hiding details in the module.

If a default procedure is provided for a certain operation, this procedure should be exported to enable the user to reassign the default whenever required. For example, the procedure OpenWindow in module *Windows* expects as parameter a procedure which, upon calling, restores the contents of the window. The window handler calls this procedure whenever restoration of this window becomes necessary (see listing 9).

(continued)

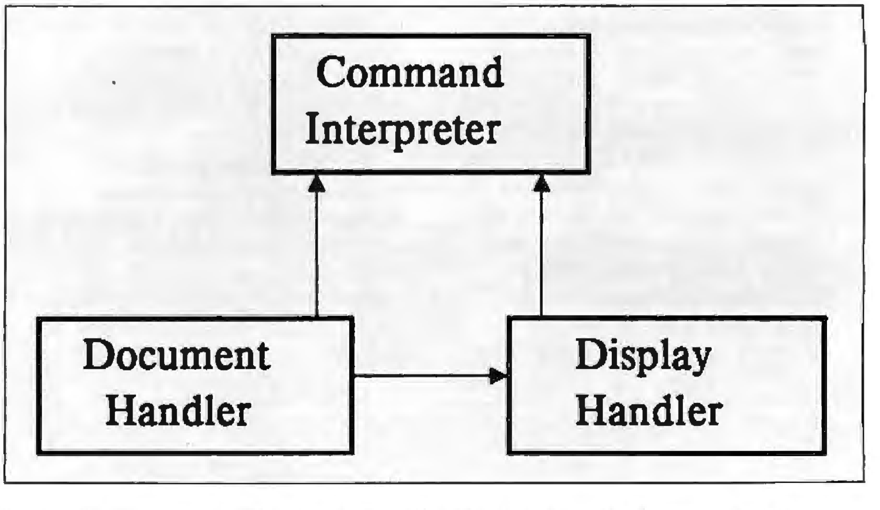

Figure 5: *Our second effort to modularize the text editor frees the document handler from dependence on the display handler.*

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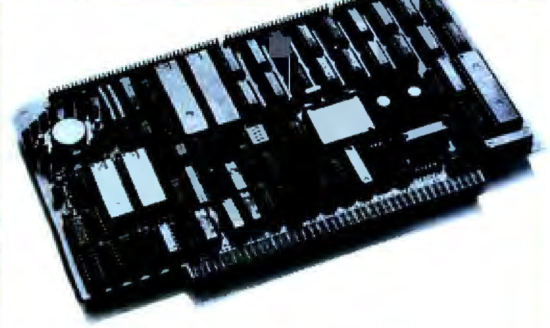

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CONCURRENCY

Concurrent processes have a particular attraction for software engineers. The aspect of *parallelism* opens up the purely sequential world of ordinary programming. We shall distinguish between *genuine* and *logical* concurrency. "Genuine concurrency" implies that several *processors* are available to execute a program; this is not usually the case these days. "Logical concurrency" is of much greater importance. In Modula-2, an autonomously running process is called a *coroutine*.

You can create coroutines in your Modula-2 program using the standard procedure NewProcess. Each coroutine is controlled by a procedure. In a way, a coroutine is an "instantiation" of its

(continued)

Listing 7: *Four types of users and their respective use of the procedures GetMouse and DrawCursor.*

```
User N: REPEAT GetMouse(buttons, x, y);
          DrawCursor(x, y); BusyRead(ch)
          UNTIL (buttons # {}) OR (ch # 0C);

User A: REPEAT GetMouse(buttons, x, y);
          DrawCursor(x, y); BusyRead(ch)
          UNTIL (left IN buttons) OR (ch # 0C);

User B: REPEAT GetMouse(buttons, x, y);
          DrawCursor(x DIV unit*unit, y DIV unit*unit); BusyRead(ch)
          UNTIL (buttons # {}) OR (ch # 0C);

User C:REPEAT GetMouse(buttons, x, y);
         IF x < wid THEN SetPattern(private) ELSE ResetPattern END;
         DrawCursor(x, y); BusyRead(ch)
         UNTIL (buttons # {}) OR (ch # 0C);
```

Listing 8: *An example of a hidden (or abstract) type.*

```
TYPE Window = [0..7]; (*subrange type*)
TYPE Window; (*hidden type*)
```

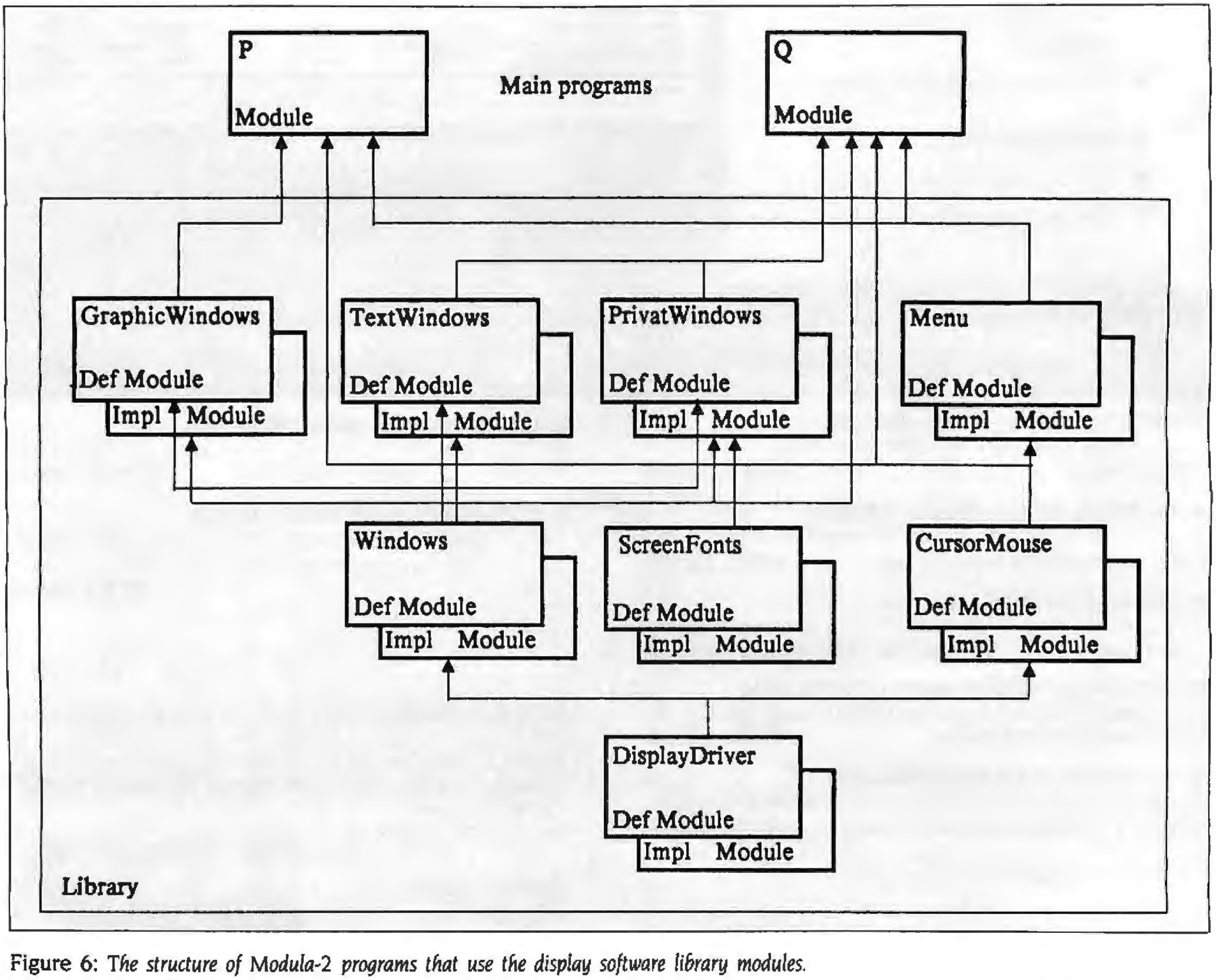

Figure 6: *The structure of Modula-2 programs that use the display software library modules.*

MicroAge franchisees Ernie Venta and Elayne Kalman shown with an IBM Personal Computer.

procedure. The essence of the coroutine concept is that control can be transferred between the different coroutines. When your program calls the standard procedure TRANSFER with parameters *p* and *q* (both of type *PROCESS*), control is passed from *p* to *q*. Thereby, the current state of the coroutine *p* is saved and coroutine *q* is reactivated in the state of its previous interruption.

Whenever a coroutine of a program terminates, i.e., its procedure terminates, then the program itself terminates. Therefore, procedures of auxiliary coroutines are typically embedded into an (infinite) *LOOP. . . END* loop, such that program termination is controlled by the main process, i.e., the coroutine created by the program loader.

Let us elucidate the coroutine with a program that creates reservation lists.

Listing 9: *The default procedure OpenWindow will restore the contents of the window when needed.*

```
TYPE RestoreProc = PROCEDURE(Window);
PROCEDURE OpenWindow(VAR wdw: Window; x,y,w,h: CARDINAL; Repaint: RestoreProc);
```

Listing 10: *Procedure GenList, which creates reservation lists, demonstrates the use of coroutines in Modula-2.*

```
PROCEDURE GenList;
  CONST lim = 20;
  VAR i, j, k, entry: CARDINAL;
      list: ARRAY [0..50] OF RECORD name, next: CARDINAL END;
BEGIN
  list[0].name = 0; list[0].next := 1; (*sentinel*)
  list[1].name := 1; list[1].next := 0; (*sentinel*)
  entry := 2; (*create alphabetic list*)
  LOOP
    IF entry = lim THEN EXIT END;
> GetRegistration;
    IF name = 0 THEN EXIT END;
    list[entry].name := name;
    k := 0; (*insert item*)
    LOOP
      i := list[list[k].next].name; j := name;
      WHILE (buf[i] = buf[j]) & ((buf[i] # 0C) OR (buf[j] # 0C)) DO
        i := i + 1; j := j + 1
      END;
      IF buf[i]> buf[j] THEN EXIT END;
      k := list[k].next
    END;
    list[entry].next := list[k].next; list[k].next := entry;
    entry := entry + 1
END;
IF entry = lim THEN (*create chronological list*)
  LOOP
    > GetRegistration;
    IF name = 0 THEN EXIT END;
    list [entry].name := name;
    entry := entry + 1
  END
END;
  (*print list*)
  k := list[0].next;
  WHILE list[k].next # 0 DO i := list[k].name;
    WHILE buf[i] # 0C DO WriteChar(out, buf[i]); i := i + 1 END;
    WriteChar(out, EOL);
    k := list[k].next
  END;
  WriteChar(out, EOL);
  k := lim;
  WHILE k < entry DO i := list[k].name;
    WHILE buf[i] # 0C DO WriteChar(out, buf[i]); i := i + 1 END;
    WriteChar(out, EOL);
    k := k + 1
  END;
  WriteChar(out, FF)
END GenList;
```

Assume that different courses in informatics with restricted attendance were announced. Students are accepted according to the sequence of their registration.

We shall design the program so that it accepts chronologically ordered reservations stored on a text file *in*. A reservation is a pair of the desired course (0–9) and the student's name. As long as the number of applicants for a course has not yet reached the limit, the name of each new student is alphabetically inserted into the main list of that course. Additionally, our program maintains a standby list for each course containing the names of surplus applicants. Obviously, the standby lists have to be chronologically ordered.

Of course, the process of generating (and printing) the two lists is exactly the same for each course. We shall formulate it as a procedure GenList. Notice that *name* is in fact an index into a name buffer *buf* and that *name* = 0 signals termination. See listing 10.

Let us emphasize again that this procedure describes the whole process of generating and printing the two lists of an individual course in a very coherent way. Hence, we should try to find a formulation that does not force us to split up the procedure—for technical reasons—into smaller portions.

In fact, assigning a coroutine to each course—with GenList as controlling procedure—is an elegant way of formulating our program. The main process shall activate the respective coroutine whenever it has read a new reservation item from the input file. The coroutine will transfer control back to the main process when it is ready to accept a new registration.

You can obtain the final form of GenList by simply embedding the procedure body into a *LOOP. . . END* loop and replacing *GetRegistration* (marked with a >) by TRANSFER (*handler[cur]*, *main*).

The crucial thing for the main process to do is reading reservations from the input file, one after the other, and passing control to the appropriate course handler (see listing 11).

Notice that all process-oriented types and procedures stem from a standard module *SYSTEM*. This module can be regarded as the interface between

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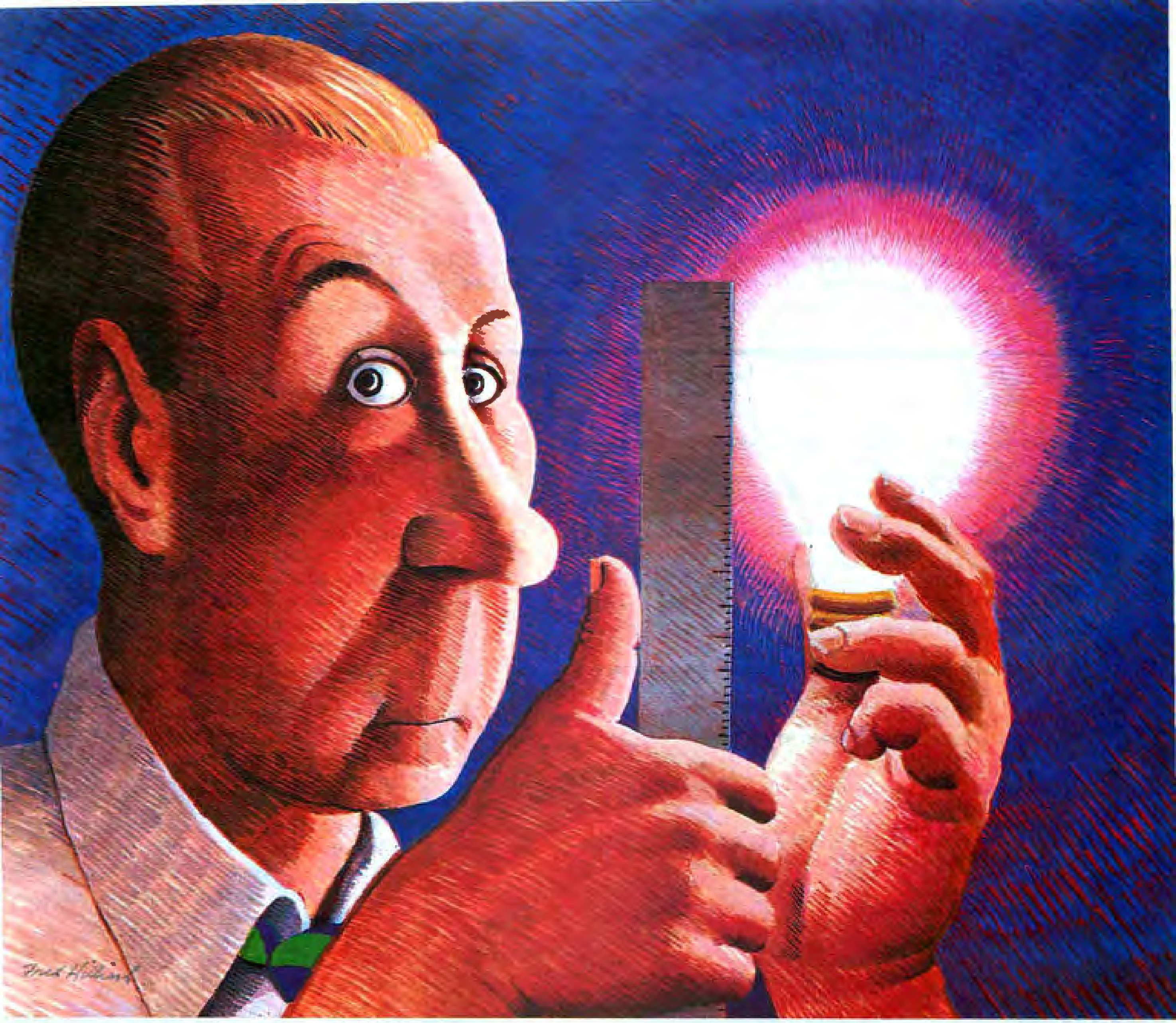

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Modula-2 and the system. *SYSTEM* also exports a type *ADDRESS*. An object of type *ADDRESS* is a pointer to a memory-word. (The type *WORD* is also exported from *SYSTEM*.)

Each coroutine is connected with a memory section where its variables are allocated. Beginning and size of this section have to be specified as parameters of *NEWPROCESS* at the time of creating the coroutine. In our example, we have called procedure AllocateHeap of another low-level module *Program* to reserve the desired amount of storage (400 bytes).

Notice finally that the standard function *CAP* returns the uppercase variant of its character argument.

Listing 11: *Module* Lists *reads a reservation item from the input file and then invokes the respective coroutine* handler.

```
MODULE Lists;
  FROM SYSTEM IMPORT ADDRESS, PROCESS, NEWPROCESS, TRANSFER;
  FROM Program IMPORT AllocateHeap;
  FROM FileSystem IMPORT File, Lookup, Close, ReadChar, WriteChar;
  FROM InOut IMPORT ReadString, Write, WriteString;

  CONST EOL = 36C; FF = 14C; (*form-feed*)
  VAR buf: ARRAY [0..10000] OF CHAR;
    name, i, cur: CARDINAL; ch: CHAR; A: ADDRESS;
    main: PROCESS; handler: ARRAY [0..9] OF PROCESS;
    in, out: File; fname: ARRAY [0..31] OF CHAR;
BEGIN
  buf[0] := 0C; buf[1] := 255C; buf[2] := 0C; i := 3;
  FOR cur := 0 TO 9 DO
    A := AllocateHeap(400); NEWPROCESS(GenList, A, 400, handler[cur])
  END;
  WriteString("in> "); ReadString(fname); Write(EOL);
  Lookup(in, fname, FALSE);
  WriteString("out> "); ReadString(fname); Write(EOL);
  Lookup(out, fname, TRUE);
  ReadChar(in, ch);
  WHILE (ch >= "0") & (ch <= "9") DO
    cur := ORD(ch) - ORD("0"); name := i;
    ReadChar(in, ch); ReadChar(in, ch);
    WHILE (CAP(ch) >= "A") & (CAP(ch) <= "Z") DO
      buf[i] := ch; i := i + 1; ReadChar(in, ch)
    END;
    buf[i] := 0C; i := i + 1;
    TRANSFER(main, handler[cur]);
    ReadChar(in, ch)
  END;
  name := 0;
  FOR cur := 0 TO 9 DO TRANSFER(main, handler[cur]) END;
  Close(in); Close(out)
END Lists.
```

SUMMARY

Modula-2 is a modern programming language invented for the development of large software systems. The module is a new structuring tool, comparable in its relevance with the procedure and locality introduced by ALGOL and Pascal. Although conceptually simple, the module has proven to be surprisingly difficult to master. On the other hand, the modular way of thinking has far-reaching and unexpected consequences, even for the design of operating systems and for computer architecture.

The coroutine concept of Modula-2 allows processes to be coherently formulated as procedures. Coroutines are a kind of dynamic counterpart to modules. In contrast to modules, procedures can be instantiated. Thus, thanks to a mechanism to transfer control between coroutines, different instances of the same procedure may simultaneously be alive. ■

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LILITH AND MODULA-2

BY RICHARD OHRAN

A case study of high-level-language processor design

THE LILITH IS a specialized computer (called an engine) designed specifically to execute Modula-2 programs. Its specialization makes it fast and efficient with Modula-2. It would not be particularly effective as an engine for programming in other high-level languages, such as FORTRAN or BASIC.

The Lilith achieves its exceptional performance through a combination of an efficient architecture specifically tailored to Modula-2 and a hardware implementation of that architecture that further enhances performance of the system.

THE HISTORY OF THE LILITH COMPUTER

The driving force behind Modula-2 and the Lilith computer was Niklaus Wirth, the designer of Pascal. Wirth's own account of the development of Modula-2 and the Lilith appears in this issue (see "History and Goals of Modula-2," page 145).

After the Modula-2 language had been defined, the team's hardware engineers began work on the computing engine that was to support Modula-2: the Lilith computer. Two overriding goals shaped the design of the Lilith:

- to provide efficient support for the programming language Modula-2
- to provide a flexible and advanced user interface so that the computer would be an effective single-user workstation

As it turned out, these two goals were compatible.

The efforts to design a machine that was particularly suited for Modula-2 were based upon earlier, similar projects. Early in Pascal's history, efforts at the ETH (the Swiss Federal Institute of Technology) in Zürich to transport Pascal from Control Data systems to other computers led to the development of the P-machine architecture. (Ken Bowles, then at the University of California at San Diego, took a version of the P-machine compiler and added an operating system to it to make the UCSD p-System.)

The P-machine was a specialized architecture particularly well suited for Pascal. This architecture has been widely used as a mechanism for producing portable code, which is then interpreted by the host processor. The P-machine perhaps should have been given a more glamorous name; as it stood, it was never widely accepted as the elegant machine architecture that it was.

The architecture designed for Modula-2 (called the M-machine) is similar to this idealized Pascal architecture, except that the M-machine is specifically designed for high-performance execution of Modula-2 programs. Only those instructions that would be useful to the Modula-2 compiler have been included in its instruction set. Instructions that would benefit only the assembly-language programmer have been left out—no excess baggage.

Another important part of the Lilith's performance is its user interface, on which the greatest influence was Wirth's experience with the Xerox Alto during a sabbatical spent at Xerox's Palo Alto Research Center. The Alto computer had a bit-mapped display and used a mouse for rapid cursor positioning. These strong features of the Alto, with some improvements that support the display without sacrificing performance, help make the Lilith an effective and flexible workstation.

M-CODE: LILITH'S INSTRUCTION SET

One of the advantages the Lilith has over other computer systems that support Modula-2 is the carefully designed instruction set of the M-machine. The effectiveness of any computer processor

(continued)

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depends in large measure upon its instruction set. If the instructions are inadequate for the job, performance is poor. Conversely, if there are many instructions that are not used by the compiler, performance is likely to be poor because extra instructions mean extra bits, which must be moved and tested. The Lilith engine has only 256 carefully chosen instructions: the language constructs of Modula-2 map neatly to the Lilith's instruction set, without extra instructions to add fat to the processor.

The size of an object-code program is a good measure of its execution speed. (For this reason, whenever a benchmark test is done, the size of the program object code is usually listed along with the execution times.) Note that the size of the code is a relative measure of the number of instructions required to execute a certain program.

M-code, the Lilith's instruction set, is dense; few instructions are required for each Modula-2 language statement. PDP-11 code for a Modula-2 program is typically three times the size of M-code for the same Modula-2 program. With other aspects equal (i.e., clock speed, memory cycle), Lilith would be faster than the PDP-11 because fewer instruction executions would be required to accomplish the same task. The Lilith's high code density is achieved through use of an expression evaluation stack, several addressing schemes, and short instructions for performing sophisticated high-level operations.

Stack Architecture

One reason for the Lilith's high code density is that the M-machine is a stack machine. The elegance and simplicity of stack architectures for higher-level-language programs is well known (see reference 1). Effectively implemented stack machines are faster than register-based machines because stack machines need fewer instructions.

The Lilith engine has an expression stack used for calculations and also organizes its main memory as a stack. Using an expression stack eliminates the need for user-accessible registers because stack operations simply pop operands off the stack and push the result back on the stack. Of course, no address is associated with the expression-stack operations for the same reason. This means that operations on the expression stack use only single-byte instructions and are, therefore, fast. The stack organization of main memory efficiently supports procedures and block structure. The result of the Lilith engine's stack organization is a reduction in the number of instructions needed to support the constructs of the Modula-2 language.

M-machine Addressing Schemes

To keep data addresses as short as possible, the M-machine uses several addressing modes, depending upon the type of data being referenced. In general, data is referenced by very short addresses (4 or 8 bits). The arithmetic and logical instructions require no address because they reference the expression evaluation stack. Only in the case of indirect reference and external data (from another module) does the M-machine use a 16-bit address. The result of using several addressing modes depending upon the needs of the instruction is that the most commonly used instructions are the shortest and the less commonly used instructions are longer.

Because of the frequent use of short addresses (see the text box, "The 4-bit Constant"), the average length of the M-instructions in a typical program, including op code and data address, is only 10 bits. The overwhelming majority of M-codes in a typical program are only 1 byte long. It takes only a small number of bits to instruct the Lilith

(continued)

The 4-bit Constant

One of the unique features of the Lilith's instruction set is its use of 4-bit constants embedded in a byte along with a 4-bit op code. It may seem that a constant of only 4 bits is so small that it would be useless. In fact, because a single byte with an embedded 4-bit constant can often be made to serve instead of a 2-byte instruction, the use of 4-bit constants reduces code size. The ability of the Lilith engine to effectively use 4-bit constants is partly responsible for the Lilith engine's compact code.

Four-bit embedded constants are used in at least four ways: 1) for loading a constant value onto the stack; 2) for loading and storing a procedure's local variables; 3) for calling procedures within a given module; and 4) for referencing fields within a record. In each case, using a 4-bit constant embedded in the same byte with the instruction allows something that would normally require at least 2 instruction bytes to be accomplished with only 1 instruction byte.

Of course, 4-bit constants are limited to values within the range 0 to 15. However, consider how useful it is to be able to load a small value onto the stack with a single-byte instruction. Such small constant values are often used for incrementing and comparisons.

When employed as the address of a local variable, a 4-bit value can be used to access the first 12 local variables in a procedure (the number is 12 rather than 16 because the four-word procedure activation record described in the text occupies words 0 to 3). Procedures often have 12 or fewer items of local data. For such procedures, the Lilith engine can load and store all local data within that procedure with single-byte instructions!

In a similar way, a 4-bit value can be used to select one of the first 16 procedures in a module. Often, modules have fewer than 16 procedures. As with manipulating local data, embedded 4-bit constants make most procedure calls on the Lilith unusually concise.

When a structured variable is used in Modula-2, it is frequently referenced through the use of a pointer address loaded onto the expression evaluation stack. For subfields of a record so addressed, Lilith offers a selection of short instructions with embedded 4-bit offsets to provide quick and efficient access. Many other situations in Modula-2 programming also use this technique.

The Lilith's use of the 4-bit constant is partly responsible for the fact that over 70 percent of the instructions in a typical Lilith program are only 1 byte long. This means that the code for a Modula-2 program on the Lilith is short and also fast.

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engine (see reference 3).

One of the ways the Lilith engine achieves such short addresses is that the M-machine does not use absolute addressing (see table 1). Both local and global data are addressed by offsets to base registers. Indirect addressing is done by adding an offset to the top of stack, and external addressing (for data in other modules) is done by adding an offset to a pointer to the appropriate module's data space. Using offsets instead of absolute addresses means that instructions usually need only 8 address bits (rather than 16). While many computers make use of base registers and offsets to calculate actual addresses, the Lilith engine automatically updates the base registers whenever the context is changed. This means that the addressing schemes are both short and efficient.

Short Addresses Speed Processing

The advantage of the Lilith engine's multiple addressing modes is that there is no need to supply insignificant address bits as part of an instruction as would be the case if there were only one long address used at all times. Because the most common instructions use either no address (because they address the stack) or only a 4-bit address, M-code is unusually concise. This means that the processor spends more time doing useful work because it does not have to fetch as many bits for its instructions as most computing engines.

High-Level Instructions

The Lilith engine provides a number of sophisticated, high-level instructions, which speed the execution of some of the syntactic constructs of Modula-2. These instructions include context switching (transferring to a coprocess), FOR and CASE statements, and procedure calls.

As an example, let's consider the procedure call. Procedure calls in Modula-2 are more complicated than procedure calls in FORTRAN, for instance. Rather than simply saving the address to return to when the procedure terminates, Modula-2 requires the creation of an activation record whenever a procedure is called. This record includes not only the return address, but also information about where the procedure call came from, a link to global data accessible from inside the called procedure (this is determined by Modula-2's scope rules), and the priority of the module containing the procedure (this is important when handling interrupts).

In order to effectively support Modula-2, any processing engine must provide this relatively complex activation record for each procedure call. If the M-machine needed many instructions to perform all the operations associated with building a procedure activation record, procedure calls would be slow. However, the Lilith engine builds the activation record with a single 1-byte instruction. The processor takes care of all the associated memory references and data manipulations without the need for detailed instructions. By comparison, the 8088 processor used in the IBM PC would require perhaps a dozen bytes of instructions to perform the same task.

Perhaps the crowning example in the Lilith of a concise instruction for performing a sophisticated task is the coroutine transfer. Coroutine transfers are the basis for multiprogramming. In a coroutine transfer, one process (program) is suspended at some point and another process is started. Such a transfer involves a complete change of context. The Lilith engine accomplishes a coroutine transfer with a 2-byte instruction.

Table 1: *M-machine instruction formats. The Lilith takes advantage of proven principles of stack architecture and addressing from base registers. The Lilith engine uses six different instruction formats to ensure that instructions are never longer than necessary (see reference 4).*

Class	Size	Format	Location of Data
Implicit	1 byte	op	Expression Stack
Immediate	1 byte	op : n	n is data or offset to data
Local	2 bytes	op | n	Data at L-register + n
Global	2 bytes	op | n	Data at G-register + n
Indirect	3 bytes	op | n	Data at Top Of Stack + n
External	3 bytes	op | m | n	At Frame table m offset n

Hardware Performance Enhancement

The Lilith computer is more than an implementation of a well-conceived architecture. It is effective hardware that makes the most of its architecture. I present here five crucial elements of the Lilith implementation of the M-machine, which improve the overall performance of the system significantly: the implementation of the expression stack, masking the data portion from a 1-byte immediate-type instruction, an unusual memory configuration, a special instruction fetch unit, and a special barrel shifter.

Bipolar Expression Stack

In the past, stack machines often used a reserved part of main memory for evaluating expressions. This type of implementation has been considered slower than using registers (even though stack machines use fewer instructions) because it requires many references to main memory, and main memory is much slower than registers. In order to get around this speed problem, the Lilith (like the Burroughs and Hewlett-Packard stack machines) uses a small array of fast bipolar registers to implement its expression stack.

Because the Lilith implements the M-machine's expression stack with very fast registers that are connected to the 2901 bit-slice processors so that the top two operands on the stack are always accessible, all basic stack operations are performed in a single microcycle (150 nanoseconds). Basic stack operations include PUSH, POP, AND, OR, addition, and subtraction. The M-machine uses an expression stack to reduce the number of instructions needed to support the Modula-2 language; the hardware implementation of the M-machine stack makes the most of the architecture by making stack operations very fast indeed.

While the Lilith is much like the Burroughs and Hewlett-Packard stack machines, the Lilith has an additional advantage. The Burroughs and HP stack machines constantly test to ensure that

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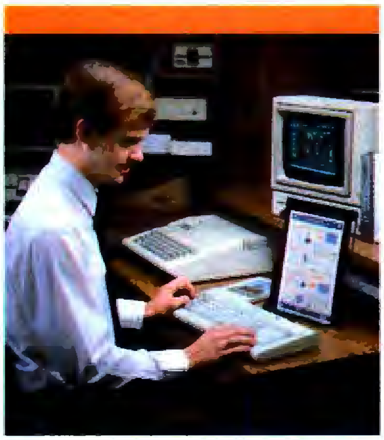

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Why Stack Architecture?

The Lilith engine is a stack machine because stack structures effectively support high-level, block-structured programs. The important fact about a stack is that it is inherently dynamic. As operations that place new operands on the stack occur, the stack grows accordingly; as operands are removed from the stack, the stack shrinks accordingly. Moreover, stack operations use no address; operations always address the top of the stack. This means that stack operations are both elegant and efficient.

Consider the following Modula-2 expression:

((4 + 3) * 5) DIV 16

The evaluation of this expression on a stack proceeds as follows:

Operation	Stack
PUSH 4	4
PUSH 3	3 4
ADD	7

(removes top two operands, adds them, and places the result on the stack).

Operation	Stack
PUSH 5	5 7
MULT	35
PUSH 16	16 35
DIV	2

Notice that at the end of the sequence, the final value is all that remains on the stack. In addition, notice how the stack grows and shrinks as needed. If the same expression were calculated using registers, more bits of instructions would almost certainly be needed (Lilith requires only 8 bytes for each of the above operations). Typically, a register machine would leave at least one useless intermediate result in one register and the value of the expression in another. When the expression is calculated on a stack, there is no possibility of ambiguity (now which register holds the right value?). You are left with only the result—the intermediate values are gone. (An important benefit of this is that there is no need to have separate load and store instructions for each register. Code for stack operations is concise.)

The same technique works effectively on a larger scale. Whenever a procedure is called, space must be allocated for its local data. Because local data is defined only within a procedure, once the procedure terminates, the space allocated to the local data should be recovered. Using a stack to organize procedure calls and their local data performs the necessary allocation and deallocation without extra bother (i.e., with fewer instructions and with greater speed).

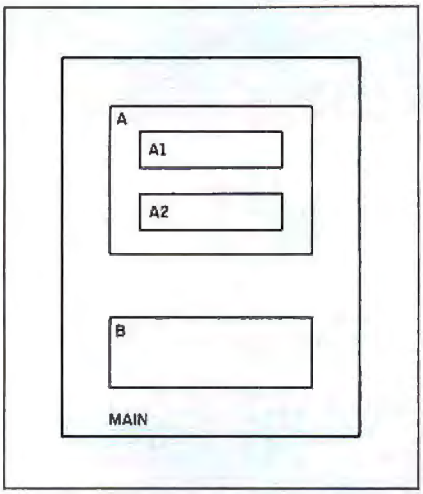

Figure 1: *The schematic representation of a simple program.*

Consider the schematic representation of a simple program in figure 1. The program consists of the main routine, which calls two procedures A and B. A has two local procedures A1 and A2. A2 is a recursive procedure. A typical execution of this program might proceed as shown in table 2.

At each call, the local data of the called procedure is pushed onto the stack. In the return operation, the terminating procedure's local data is popped off the stack. In particular, notice how elegantly recursion occurs. At each invocation of the recursive procedure, another instance of its local data is pushed onto the stack. As the program "backs out" of the recursive calls, the data from each instance of the procedure is removed from the stack.

Of course, a register-based machine architecture could allocate storage to procedures and recover that storage upon termination of the procedure. The key point is that a stack-based machine naturally communicates via the stack. Parameters and local values are pushed onto the stack and popped off when the procedure terminates.

Because this necessary allocation and deallocation occurs as a natural consequence of stack architecture, stack machines are efficient. While any high-level-language processor has to perform the same kinds of tasks, a stack machine can perform them with fewer instructions because the stack structure is inherently dynamic and requires only short addresses.

Table 2: *A typical execution of the program from figure 2.*

Program Calls	Stack Activity
Main called by host system	Push A's data onto stack
Main calls A	Push A1's data onto stack
A calls A1	Push A2's data onto stack
A1 calls A2	Push A2's data onto stack
A2 calls A2	Push A2's data onto stack
A2 calls A2	Pop A2's data off stack
A2 returns	Pop A2's data off stack
A2 returns	Pop A2's data off stack
A1 returns	Pop A's data off stack
A returns	
Main calls B	Push B's data onto stack
B returns	Pop B's data off stack
Main terminates	

the stack does not overflow or underflow. In these two machines, when an operation causes an overflow/underflow, part of the stack is automatically written into main memory. In the Lilith engine, use of the expression stack is limited by the compiler to operations in which the compiler can control the number of levels of the stack employed. Operations like function calls are not allowed to use the expression stack

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directly because there is no way to know at the time of the call whether a function (particularly a recursive one) will cause a stack error.

What this means is that the Lilith engine's stack cannot overflow or underflow. The hardware does not even support testing for overflow and underflow in the usual way. (The Lilith engine tests the stack only to see if it is empty when unloading the values on the expression stack into main memory—as might happen in a coroutine transfer.) In effect, the Lilith tests for over/underflow when a program is being compiled rather than when it is running.

If assembly-level programming were to be done on the Lilith, the protection of run-time testing would have to be built into all stack operations. But because expression stack use is controlled by the compiler, errors that could arise in assembly-language programming cannot occur. For example, it is not possible for a program to attempt to pop an operand off the stack when there is nothing in the stack (causing an underflow). Because the Lilith is specialized as a Modula-2 engine, control of expression stack size can be conveniently entrusted to the compiler. This makes the stack operations run faster than they would otherwise, because it eliminates the overhead of run-time testing.

Masking Constants from Op Codes

It was mentioned above that the Lilith engine saves on instruction size by embedding 4-bit constants in the same byte with a 4-bit op code. While this means that the Lilith does not have to move 2 bytes when 1 will do (see the text box if you haven't already), it also means that the same byte contains both the op code and an operand. Separating the byte into two parts and sending the parts to the appropriate places poses a problem. An innovative solution actually makes these instructions even more efficient.

The instruction fetch unit (the portion of the Lilith engine responsible for supplying the processor with instructions) sends instructions that have embedded operands to two parts of the processor at the same time. Both the microcontrol unit (MCU) and the arithmetic-logic unit (ALU) receive the single byte that contains both the op code and the operand. While the microcontrol unit decodes the machine instruction, the ALU masks the op code out of the byte and prepares the operand for the coming operation.

The use of the dual path for instructions with embedded operands is partly responsible for the fact that more than 60 percent of the instructions in a typical program are executed in three microcycles or less (450 nanoseconds or less). (See figure 2.) Common instructions execute at an average rate of 1.2 million instructions per second, including memory wait time.

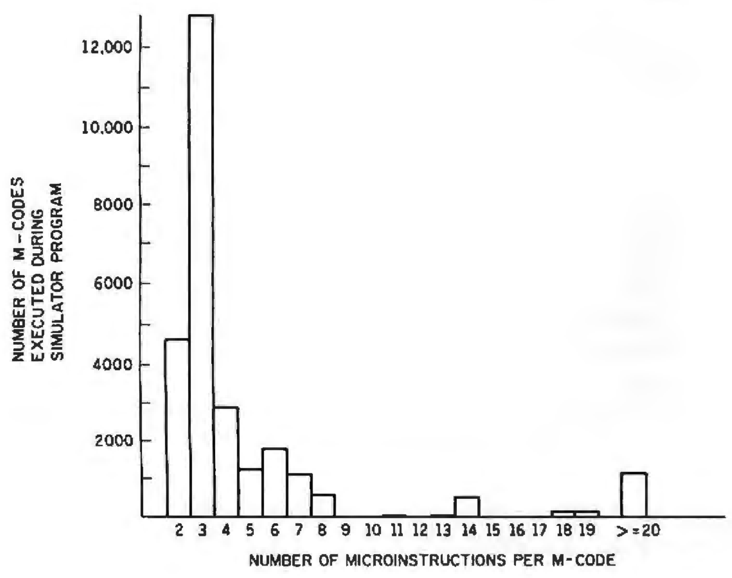

Figure 2: *This microinstruction profile of M-codes shows that the overwhelming majority of op codes in the test program (which attempted to accurately reflect the Lilith's basic performance) require three microcycles or less (450 nanoseconds or less). The conspicuous peak at $\geq$ 20 microinstructions is mainly due to the fact that floating-point operations require many microinstructions.*

Unusual Memory Configuration

As mentioned earlier, the Lilith's large high-resolution bit-mapped display is handled by its main processor with little loss of performance. In contrast, the Xerox Alto (which heavily influenced the Lilith's design) was unable to control the screen without sacrificing overall performance. The Alto used about 50 percent of its power just to drive its screen (see reference 2).

The key factor in the loss of computing power experienced by the Alto was the excessive number of memory cycles required to service the display. To reduce this loss, I chose to expand the memory width and make memory accessible to the main processor via a 64-bit bus. This means that screen refresh requires approximately one memory reference per five microseconds. Only 11 percent of the Lilith's memory time is used to refresh the display, and the memory itself is idle 60 percent of actual operating time. I verified these figures with a measured benchmark: using the Lilith's main processor to control the display causes less than 3 percent overall system degradation. The Lilith engine controls its high-resolution raster display without significantly reducing the general effectiveness of the main processor.

For 16-bit memory read operations, special logic selects the group of 16 bits needed from the full 64-bit memory word. However, it is not practical to write to memory in 64-bit chunks. This would make writing a 16-bit value cumbersome and slow. Therefore, Lilith writes its memory in single word units.

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Lilith spends much more time executing instructions than it does getting them.

16 bits [illegible]me. The rather unusual combin[illegible]of a memory that has a broad r[illegible]bandwidth and a more typical w[illegible]bandwidth allows the Lilith to operate [illegible]s screen effectively without making memory write operations slow.

GETTING INSTRUCTIONS FASTER

Because the Lilith engine can read four words of instructions at a time, but most often may need only a single instruction byte at the time, an extra device, the instruction fetch unit (IFU), is included in the Lilith engine to support the processor. The IFU performs a prefetch of 64 bits of instructions and presents bytes of instructions to the processor as needed. As soon as the IFU sends the last byte of instruction to the processor, the IFU prefetches the next 64 instruction bits. Usually, the IFU is ready with an instruction whenever the processor is ready to accept one. But even at worst, the processor waits only one memory cycle for the IFU to read another 64 bits and deliver the next instruction byte. The IFU then has 7 more bytes waiting to be delivered to the processor without any delay.

What this means for performance is that the Lilith processor spends much more time executing instructions than it does getting them. Most processors have to wait one memory cycle for each instruction. They actually spend more time fetching instructions than they do manipulating data. In contrast, the Lilith can prefetch as many as eight instructions in one memory cycle. One instruction goes directly to the processor, and during the next seven memory cycles, the processor does only useful work. If the IFU were considered a cache memory device, it would have the respectable hit ratio of 84 percent (instructions waiting to be executed versus needing to get an instruction before proceeding). The IFU makes the main processor wait while it gets the next batch of instructions during only 16 percent of the processor's cycles.

In practice, executing typical Modula-2 programs, the Lilith processor spends only 22 percent of its operating time fetching instructions and the remaining 78 percent doing useful work. (Other processors typically use at least 50 percent of their operating time fetching instructions.) This impressive performance is partly due to the ability of the Lilith engine to read its main memory in 64-bit chunks. It is also partly due to the

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The high performance of Lilith and the flexibility of its user interface combine to make it an effective workstation.

fact that the average Lilith instruction is only 10 bits long—that means that the IFU fetches an average of 6.4 instructions each time it is activated.

The Barrel Shifter

Although the full power of the Lilith's processor is available for screen manipulation, moving a portion of the screen image is particularly difficult. Imagine the image of a tiny plane "flying" across the screen. Internally, the movement of the plane's image is actually accomplished by moving the bits that represent the plane. Obviously, these bits must be moved as a unit one bit at a time if the plane's movement is to be smooth (that is, it should appear to move one pixel with each refresh of the screen).

Moving an irregularly organized group of bits (that is, not full words or even bytes) by irregular units (bits rather than words or bytes) is not straightforward. Assume that our plane's image is 32 bits long and it starts out fitting nicely into a column of words. The first move puts 1 bit into the next word and shifts the original two words over by 1 bit and leaves 1 bit of the first word empty. Anyone who has attempted to program animation in assembly language knows how much shifting and masking this involves.

The Lilith employs a special shifting device called a barrel shifter to accomplish the shifting and masking needed for image movement on the screen. A barrel shifter rotates the bits in a given word by one to 15 positions in a single cycle. This allows very fast shifting and masking and, consequently, movement of graphic data in memory. The Lilith can easily move large portions of its screen in real time—ignoring byte and word boundaries.

The use of the barrel shifter allows the Lilith's processor to accomplish complex shifting and masking in a single cycle. This permits the impressive graphic performance the Lilith is noted for and, incidentally, makes operations on Modula-2's type BITSET very fast. The use of the barrel shifter is another example of the hardware implementation of the Lilith engine enhancing the performance of the M-machine architecture.

Lilith as a Workstation

The high performance of the Lilith computer and the flexibility of its user interface make it an effective workstation. When developing programs on the Lilith, the user may take advantage of program-development and diagnostic programs that are specifically designed to make the most of the Lilith's processing power and user interface. The Lilith environment also includes software tools that may be incorporated into user programs (such as multifont character displays; bit-map operations; and window, mouse, and cursor manipulation).

The Lilith processor is also microprogrammable, meaning that special instructions can be added to the instruction set of Lilith to speed up sophisticated tasks. Lilith has been successfully microprogrammed to draw vectors on the display, increase the precision of floating-point operations, and control a laser printer. Such micro-level flexibility in a processing engine can be invaluable.

Conclusion

The Lilith is a specialized engine designed specifically to execute Modula-2 programs. It achieves exceptional performance through a combination of efficient architecture tailored to Modula-2 and an efficient hardware implementation. Although Lilith is a specialized processing engine, compared to other machines in its price class, it is a highly flexible engine for Modula-2 programming. ■

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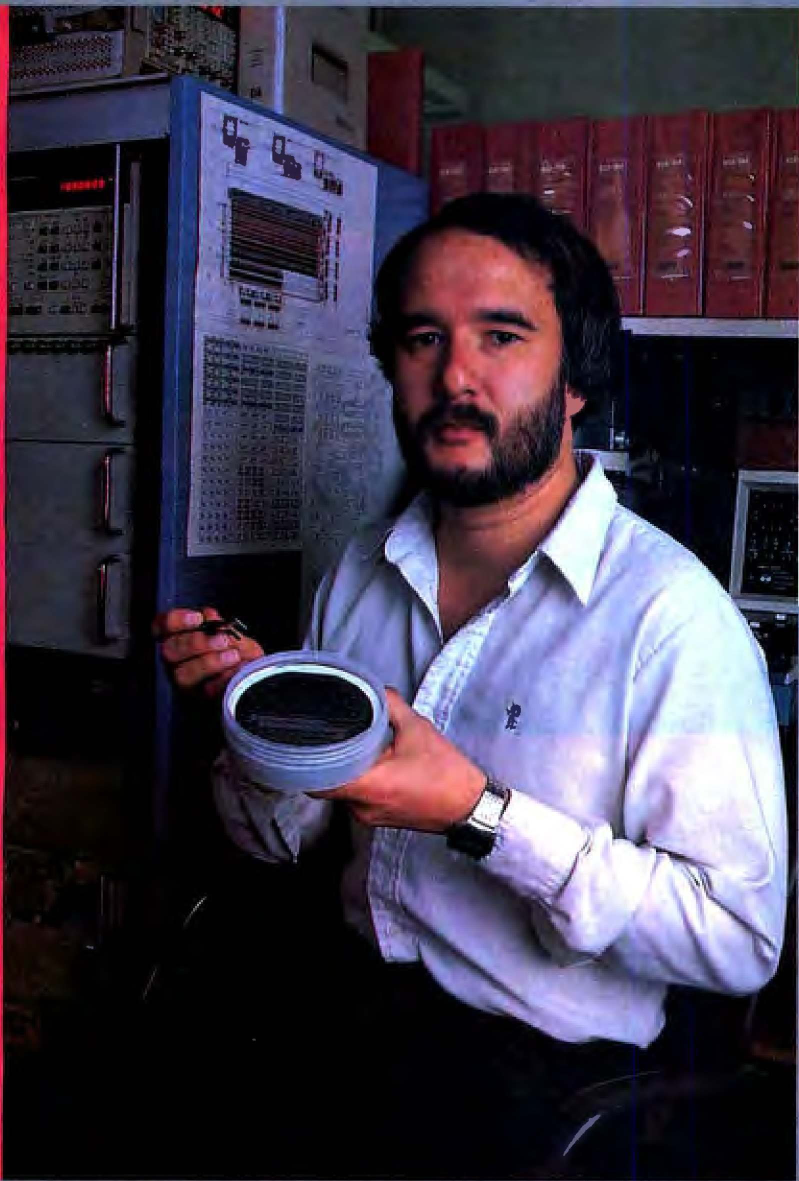

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AN INTRODUCTION TO MODULA-2

BY ROBERT J. PAUL

This new language is a superset of Pascal

IN THIS ARTICLE we'll take a look at the differences in control structure, expressions, and general syntax between Pascal and Modula-2. First, however, I should mention three fundamental philosophical differences between the two languages.

First, the introduction of the module concept in Modula-2 extends the "separate compilation" features that various Pascal implementations have often added. You can build a library of modules that provide standard routines to perform common operations. You can also use the modules to create hidden data structures and to isolate a program from the specific data structures used.

Second, Modula-2 replaces the Pascal I/O (input/output) routines **read** and **write** with the standard module TTIO, a logical change considering the module concept. This module provides the primitive routines **Read** and **Write**, which function one character at a time. Another module, **InOut**, provides more sophisticated routines, including **ReadInt**, to read an integer in character form; **WriteInt** and **WriteCard**, to write integers and cardinals (unsigned integers) in decimal notation; **WriteOct** and **WriteHex**, to write integers or cardinals in octal and hexadecimal notation, respectively; and **WriteString**, to write character strings.

The third major change from Pascal is the addition of concurrency primitives to Modula-2, which lets you write concurrent (multitasking) programs in a standard and portable way. Concurrency can make certain programming tasks easier, and some applications require it. Concurrent variations of many languages (including Pascal) have been developed, but Modula-2 is a standard language in which to write concurrent programs.

COMPARISON TO PASCAL

You can use several criteria to distinguish one programming language from another: program structure, control structure, expressions, and data typing facilities. One language is clearly superior to another, for example, if it ranks higher in all four areas; mixed results, on the other hand, highlight the relative strengths and weaknesses of each one.

Of course, these criteria refer to the language definition alone. Its implementation on a specific machine determines the time required to compile and execute a program. In general, competent implementations of either Pascal or Modula-2 should result in almost identical compile and run times.

PROGRAM STRUCTURE AND PROCEDURES

The main routine in a Modula-2 program is called the "main module." It contains all the sections of a Pascal program as well as features that provide for external subroutines (in other modules). Listing 1 shows a schematic of the main module.

The bulk of any Pascal or Modula-2 program is a collection of procedures or subprograms that perform specific functions. Pascal distinguishes between a function, which returns a value, and a procedure, which does not. Modula-2 offers the same facilities, although the distinction between procedures and functions blurs because the keyword PROCEDURE introduces both of them.

(continued)

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Listing 1: *A schematic representation of the main module. The programmer provides the names in lowercase; the words in uppercase are* Modula-2 *keywords.*

```
MODULE modulename;
FROM librarymodule IMPORT libraryroutine1, libraryroutine2;
FROM librarymodule2 IMPORT libraryroutine3;
CONST                                   (* constant declarations go here *)
  charcount = 80 * 24;                  (* sample constant *)
TYPE                                    (* type declarations go here *)
  type1 = (apple, pear, orange);        (* enumeration type *)
  type2 = [ 1960 .. 1990 ];             (* subrange type *)
  returntype = CARDINAL;                (* unsigned integer *)
VAR                                     (* variable declarations go here *)
  foo: returntype;                      (* declare 1 variable *)

PROCEDURE procedure1(parm1, parm2: type1; VAR parm3: type2);
VAR                                     (* local variables declared here *)
BEGIN                                   (* body of procedure goes here *)
  END procedure1;

PROCEDURE function1(parm1: type1) : returntype;
VAR                                     (* local variables declared here *)
BEGIN                                   (* body of function goes here *)
                         (* to exit with value use the return statement... *)
  RETURN integerexpression;
END function1;
BEGIN                                   (* beginning of main procedure *)
                                        (* body of main program goes here *)
  procedure1(apple,orange,1967);
  foo := function1(pear);
END modulename.
```

Listing 2: *Variable-size array as a procedure parameter of the function* Count-Them. *This example also illustrates the output routines required to write text strings and cardinals and to terminate an output line.*

```
MODULE sample1;
FROM WriteStrings IMPORT WriteString, WriteLn;
FROM TTIO IMPORT WriteCardinal;
CONST
  smallsize = 20;                       (* small sized array *)
  largesize = 35;                       (* large sized array *)
VAR
  i: CARDINAL;
  smallarray: ARRAY [0 .. smallsize] OF CARDINAL;
  largearray: ARRAY [0 .. largesize] OF CARDINAL;
(*
  Procedure: CountThem
  Parameters: one variable size array of CARDINALs (unsigned integers)
  Returns: CARDINAL, sum of the elements in the array
*)
PROCEDURE CountThem( vector: ARRAY OF CARDINAL ) : CARDINAL;
VAR
  i, sum: CARDINAL;
BEGIN
  sum := 0;                             (* initialize sum *)
  FOR i := 0 TO HIGH(vector) DO         (* for all elements *)
    sum := sum + vector[ i ];           (* add to sum *)
  END;                                  (* end of FOR *)
  RETURN sum;                           (* and return value *)
END CountThem;
(*
  Main Program starts here
  Initialize two arrays and call the function CountThem
  once with each of the two arrays.
*)
BEGIN (* main program *)
  FOR i := 0 TO smallsize DO            (* initialize small array *)
    smallarray[i] := i;
```

(continued)

The syntax of a procedure definition is

```
PROCEDURE
  name (<fp>[;<fp>])
  [: return-type];
[CONST (* optional constant
  declarations *)]
[TYPE (* optional type
  declarations *)]
[VAR (* optional variable
  declarations *)]
BEGIN
  statement-sequence
END name;
```

Above, <fp> is shorthand notation for a formal parameter section (an identifier list followed by a colon and a type name).

The two methods of passing parameters in Pascal are the same in Modula-2. "Call by value" means that a copy of the parameter value is sent to the subprogram. This makes it impossible for the subprogram to modify the calling program's copy of the parameter. In the alternative method, "call by reference," the subprogram receives the parameter's address, meaning that changes made to its value by the subprogram also affect its value in the calling program. You can request "call by reference" in Modula-2 by placing the keyword VAR (the same as in Pascal) before the formal parameter section. The default is "call by value."

Modula-2 can also pass variable-size arrays to procedures; Pascal cannot. If you substitute ARRAY OF **typename** for the type name in the formal parameter section, you can pass an array of the specified type to the procedure. The special function HIGH(**arrayname**) returns the upper bound of the array passed (see listing 2).

Statements and Control Structures

The heart of any language is how you control the program-execution flow. Modula-2 provides all the familiar Pascal control structures and a few more to make special programming circumstances easier to handle.

One important change from Pascal is that every control structure in Modula-2 has an explicit termination, usually an END statement. This prevents the ambiguity possible in the following Pascal program sequence:

(continued)

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```
  END;                                                        (* end of FOR *)
  FOR i := 0 TO largesize DO                          (* initialize large array *)
    largearray[i] := i;
  END;                                                        (* end of FOR *)
  WriteString('The sum of the numbers 0 to  ');
  WriteCardinal( smallsize, 5 );
  WriteString(' is ');
  WriteCardinal( CountThem(smallarray), 5 );
  WriteLn;
  WriteString('The sum of the numbers 0 to ');
  WriteCardinal( largesize, 5 );
  WriteString(' is ');
  WriteCardinal( CountThem(largearray), 5 );
  WriteLn;
END sample1.
```

```
IF (oregano IN recipe[1])
  THEN
    IF (thyme IN recipe[1])
      THEN writeln('Use oregano
          and thyme')
  ELSE
    writeln('No oregano');
```

Although the indentation implies that the first message should print if the recipe specifies both oregano and thyme and the second message if it does not specify oregano, this is not how the program executes. In fact, the program matches the ELSE clause with the most recent IF statement, so the second message prints if the recipe does have oregano but does not have thyme.

Modula-2 smooths out this Pascal problem and a few other rough edges. The basic control structure needed to provide conditional execution, the IF-THEN-ELSE statement, is the best example of this improvement.

```
IF expression
  THEN statement sequence
   [ELSIF expression
     THEN statement sequence]
     [ELSE statement sequence]
END
```

You can repeat the ELSIF clause as many times as you wish, providing for a number of mutually exclusive cases. When the program encounters the expression, it can execute only one of the statement sequences; if none of the expressions is true, then the program executes the ELSE clause. You can write the Pascal oregano example in Modula-2 as

```
IF (oregano IN recipe[1])
  THEN
    IF (thyme IN recipe[1])
      THEN
        WriteString('Use oregano
          and thyme')
    END
  ELSE WriteString('No oregano');
END
```

The placement of the END statements tells the compiler which IF statement goes with the ELSE clause.

The CASE statement provides a way to select between mutually exclusive conditions.

```
CASE expression OF
  label1 [,label2, . . .]
    : statement sequence
  | label3 [,label4, . . .]
    : statement sequence
  [ELSE statement sequence]
END
```

The expression is evaluated and compared to the labels; if the program finds a match, it executes the corresponding statement sequence. If it does not find a match, the program executes the ELSE clause. You can place as many labels as you wish before each statement sequence, and you can specify as many statement sequences as you need. The type of the case expression must be INTEGER, CARDINAL, CHAR, BOOLEAN, or an enumeration or subrange type, and you cannot repeat labels. For example, the following program fragment determines what type of character the variable ch contains.

```
CASE ch OF
  '0' . . '9'
    : WriteString("Digit")
| 'a' . . 'z'
    : WriteString("Lowercase
      letter")
| 'A' . . 'Z'
    : WriteString("Uppercase
      letter")
| '+', '-', '*', '/'
    : WriteString("Operator")
ELSE WriteString("Other
      punctuation or symbols")
END
```

The next basic type of control flow is the loop. Modula-2 provides three loop-control statements like Pascal's and one new statement that provides a more general form of loop control.

The FOR statement sets a control variable to some initial value and then executes a statement sequence, varying the control variable through the progression of values specified in the FOR statement.

```
FOR var := expr1 TO expr2
    [ BY expr3 ]
  DO statement sequence
END
```

This initializes the simple variable **var** to the value of the expression **expr1**. If the variable is not greater than the second expression, **expr2**, the program executes the statement sequence and increments the variable by the value of the third expression, **expr3**. This process repeats itself until **var** exceeds the limit in **expr2**. If you omit **expr3**, the default increment is one. If the increment is negative, the repetition continues until **var** is less than **expr2**. Thus, Modula-2 offers greater flexibility through the use of **expr3** while Pascal requires the increment to be either 1 or −1.

In Modula-2 as in Pascal, the WHILE and REPEAT statements provide indefinite looping. These statements have the following forms:

```
WHILE expression
  DO statement sequence
END
```

and

```
REPEAT
  statement sequence
UNTIL expression
```

The WHILE statement evaluates **expression**, and, if it is logically true, executes the statement sequence. The program repeats this process until **expression** is logically false. The REPEAT

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Listing 3: *Examples of the* LOOP *construct. The first example shows proper use of the* LOOP *statement; the second, poor use; and the third, the appropriate corrections to the second.*

```
(*
The following procedure processes keystrokes until it reads the character 'X'. If it reads the com-
mand 'A', 'B', or 'C', the procedure calls the function function1, function2, or function3, respectively. These
functions return a positive integer return code. This routine also demonstrates the proper use of
the LOOP and CASE constructs. Note that this logic is virtually impossible to duplicate in Pascal
without the use of a GOTO statement.
*)
  PROCEDURE ProcessCommand( VAR cmd: CHAR ) : CARDINAL;
  VAR
    rc: CARDINAL;
  BEGIN
    LOOP
      Read(cmd);                                   (* read one character *)
      CASE cmd OF
      'X' : EXIT;                                  (* get out of LOOP stmt *)
      'A' : rc := function1();
      'B' : rc := function2();
      'C' : rc := function3();
      ELSE rc := 0;
      END;                                         (* end of CASE *)
      IF (rc # 0) THEN RETURN rc;
      END;                                         (* end of IF *)
    END;                                           (* end of LOOP *)
(*
If you are here, you must have executed the EXIT statement above
*)
    WriteString('Normal termination');
    RETURN 0;
  END ProcessCommand;
(*
The following procedure illustrates a questionable use of the LOOP construct. It is improper because
the WHILE statement is a more informative way of expressing the logic. This procedure reads an
input file and looks for a match with an already initialized global array, MasterArray. The search
continues until either a match or an end-of-data character, '@', is found. If it finds a match, the
procedure returns the position in the array. If no match is found, it returns a zero.
*)
  PROCEDURE SearchList ( VAR token: CHAR ) : CARDINAL;
  VAR
    index: CARDINAL;
  BEGIN
    LOOP
      Read(token);
      index := 1;
      IF (token = MasterArray[ index ])
        THEN RETURN index;
      END;                                         (* end of IF *)
      index := index + 1;
      IF (index > MaxIndex)
        THEN
          Read(token);
          index := 1;
          IF (token = '@')
            THEN RETURN 0;
          END;                                     (* end of nested IF *)
        END;                                       (* end of outer IF *)
      END;                                         (* end of LOOP *)
  END SearchList;
(*
The better procedure to handle this is . . .
*)
  PROCEDURE SearchList( VAR token: CHAR ) : CARDINAL;
  VAR
    index: CARDINAL;
  BEGIN
    index := 1;
    Read(token);
    WHILE (token # '@') DO
```

(continued)

A new looping statement, appropriately called LOOP, *provides an infinite iteration.*

statement, on the other hand, executes the statement sequence first and then evaluates **expression**. If **expression** is logically false, the process repeats until it is true. The major difference between the two loops is that a WHILE statement executes its statement sequence *zero* or more times, while the REPEAT statement executes its statement sequence at least *once*. Note that the REPEAT statement does not end with the END clause but rather with the UNTIL clause.

The new looping statement is called, strangely enough, LOOP. The syntax is simply

LOOP statement sequence END

and provides for an infinite loop. There are two statements that can terminate this endless loop, EXIT and RETURN. The EXIT statement can appear only within the statement sequence of a LOOP statement; program execution continues at the first statement after the LOOP statement. The RETURN statement, on the other hand, terminates the current procedure and returns control to the calling procedure. If you use this statement in a function, an expression follows the RETURN statement, indicating the value to return. If RETURN appears in a main procedure, it terminates the program. For both good and bad examples of the LOOP statement, see listing 3.

Data Types

The data types available in Modula-2 are almost identical to those of Pascal. The basic data types BOOLEAN, INTEGER, REAL, and CHAR from Pascal are all available, along with the data type CARDINAL, which represents an unsigned (positive) integer. Enumeration types, which permit the programmer to name the acceptable values for the type, and subrange types are also available. Array types, which create a collection of identical data items, and record types, which create a collection

(continued)

For Dealer locations, see pg. 286.→

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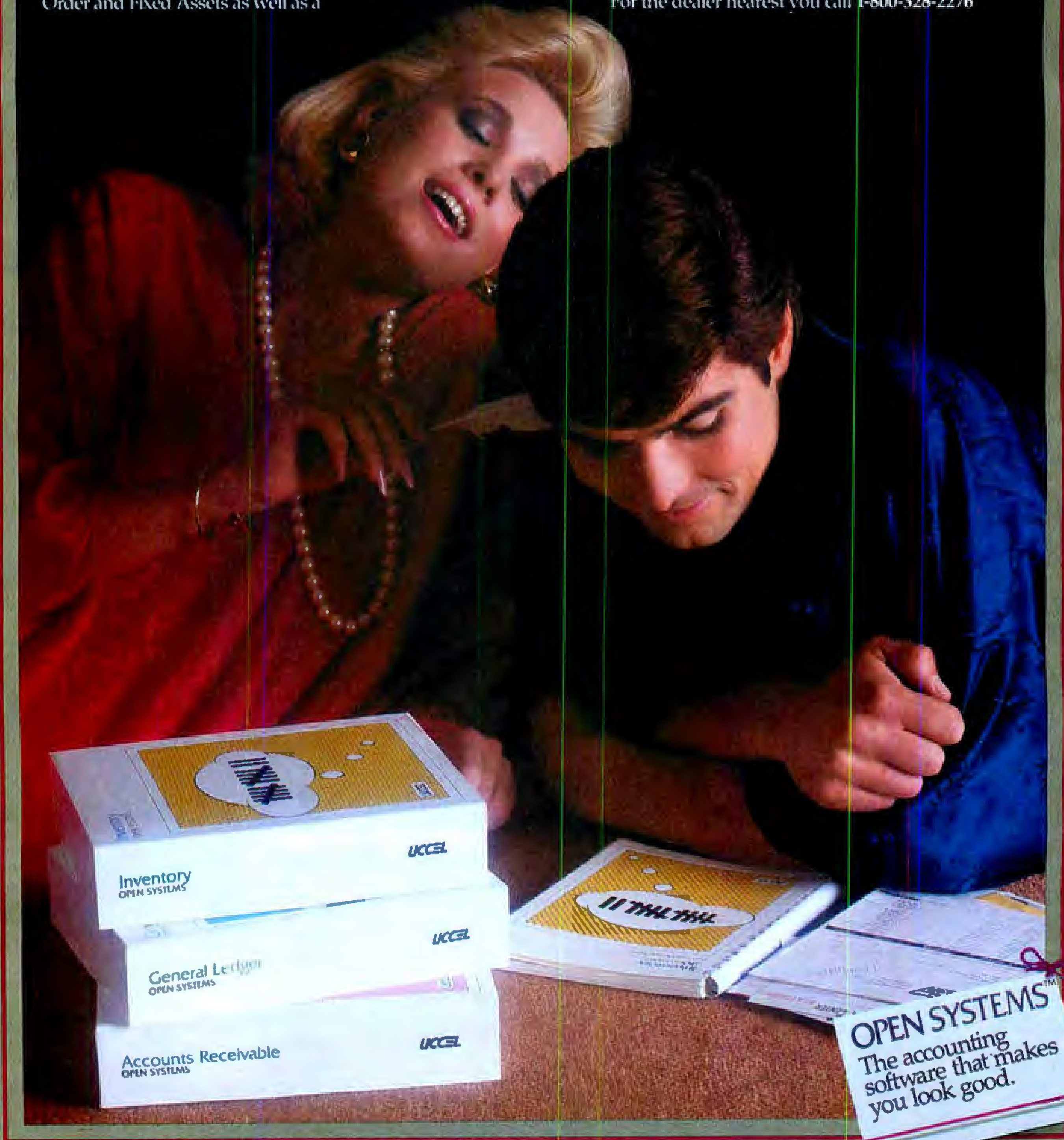

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```
      IF (token = MasterArray[ index ])
        THEN RETURN index;
      END;                                              (* end of IF *)
      index := index + 1;
      IF (index > MaxIndex)
        THEN
          Read(token);
            index := 1;
      END;                                              (* end of IF *)
    END;                                             (* end of WHILE *)
    RETURN 0;
  END SearchList;
```

Listing 4: *Examples of type and variable declarations and their uses. The three sections give several type definitions, variable declarations using the type definitions, and some program fragments that manipulate the variables.*

```
  MODULE sample2;                               (* sample module header *)
  TYPE
(*
Declare an enumeration type Color with 5 possible values.
*)
  Color = (yellow, red, green, blue, purple);
(*
Declare a subrange type Index that can take on values between 1 and 80, inclusively.
*)
  Index = [ 1 .. 80 ];
(*
Declare an array type CardImage to be an array of 80 characters, identified by indexes of 1 to 80.
*)
  CardImage = ARRAY Index OF CHAR;
(*
Declare a record type Name to be a last name, a first name, and a middle initial.
*)
  NameType = RECORD
    last: ARRAY [1 .. 20] OF CHAR;
    first: ARRAY [1 .. 10] OF CHAR;
    middle: CHAR;
  END;
(*
Declare a record type Person to be a collection of a name, city, state, zipcode, and age. Note that
you must store the zip code as characters, not as integers or cardinals, because a 16-bit computer
only allows integers up to 32767 and cardinals to 65535.
*)
  Person = RECORD
    name: NameType;
    city: ARRAY [1 .. 30] OF CHAR;
    state: ARRAY [1 .. 2] OF CHAR;
    zipcode: ARRAY [1 .. 5] OF CHAR;
    age: CARDINAL;
  END;
(*
Now, declare some variables using the above types
*)
  VAR
    yes, no: BOOLEAN;                              (* logical true/false *)
    foo, bar: INTEGER;                               (* signed integers *)
    temperature, height: REAL;                (* floating-point numbers *)
    ch, nextchar: CHAR;                            (* single characters *)
    distance, age: CARDINAL;                      (* unsigned integers *)
    myrose, herdaisy: Color;                   (* can be any of 5 colors *)
    i, j, k: Index;                        (* Indexes into a CardImage *)
    card1, card2: CardImage;                   (* arrays of 1 .. 80 chars *)
    me, you: NameType;                            (* records for names *)
    somebodyelse: Person;                  (* record for name and addr *)
(*
This declaration creates an array with room for 50 people
*)
```

(continued)

```
    friends: ARRAY [0 .. 49] OF Person;
  BEGIN                                    (* begin main program of module sample2 *)
    yes := TRUE;                                        (* set yes to logical TRUE *)
    no := (NOT yes);                              (* set no to the opposite of yes *)
    foo := -32768;                        (* signed integers have range -32768 *)
    bar := 32767;                              (*to 32767 on a 16-bit machine *)
    temperature := 96.8;                            (* floating point numbers have *)
    height := 6.125;                         (* several decimal places of precision *)
    Read(ch);                                           (* read a single character *)
    IF (ch = 'Y')                                               (* do a comparison *)
      THEN nextchar := 'N';                               (* and some assignments *)
      ELSE nextchar := 'Y';
    END;
    distance := 65535;                           (* unsigned integers have range 0 *)
    age := 0;                                   (*to 65535 on a 16-bit machine *)
    myrose := red;                              (* the color names are constants *)
    herdaisy := purple;
    IF (myrose = herdaisy)
      THEN WriteString('We Match!');
    END;
    FOR i := 1 TO 80 DO                                    (* can't exceed this range *)
      j := 81-i;
      card1[ i ] := card2[ j ];
    END;
    me.last := 'Paul';                              (* note that string assignments *)
    me.first := 'Robert';                            (* pad with nulls if necessary *)
    me.middle := 'J';
    somebodyelse.name := me;                        (* record assignments allowable *)
    somebodyelse.city := 'Watertown';
    somebodyelse.state := 'MA';
    somebodyelse.zipcode := '02172';
    somebodyelse.age := 23;
(*
Because Modula-2 allows record assignments, you can copy the entire structure above into another
structure using one statement. In this case, it would appear that I am my own best friend.
*)
    friends[ 0 ] := somebodyelse;
  END sample2.                            (* don't forget to end the module definition *)
```

of nonidentical data items, also follow the Pascal precedent (see listing 4).

Modula-2 inherits another data type, sets, from Pascal in a restricted form. The set type reflects the mathematical concept of a set: a collection of items that is not ordered—either an element is a set member or it's not. Pascal permits sets with many elements (the exact number depends on the implementation); Modula-2 restricts the set size to the number of bits in a word, the basic unit of storage. On most microcomputers and minicomputers, the word size is 16 bits, so sets can have only 16 elements on these systems. Listing 5 shows the declaration and use of a set type.

Modula-2 pointers provide a means of dynamically allocating storage. They are identical to the pointers available in Pascal. The compiler translates the standard Modula-2 procedures NEW and DISPOSE into calls to routines called ALLOCATE and DEALLOCATE—an interesting feature. You must either import these procedures from the standard library module *Storage* providing the standard functionality, or provide your own version. Thus, you can tailor storage allocation and deallocation routines to your particular application, if that is appropriate. Listing 6 illustrates the declaration and use of pointers in Modula-2.

One new data type added to Modula-2, the procedure type, is used to declare a formal parameter as a procedure. This allows you to pass the name of a function or procedure as a parameter to another procedure. (Note that you cannot declare the passed procedure local to any other procedures and that it cannot be a standard procedure.) Listing 7 illustrates the declaration and use of this facility.

Expressions

Expressions in Modula-2 are virtually identical to those in Pascal. Operands, the items you manipulate, can be sim-

(continued)

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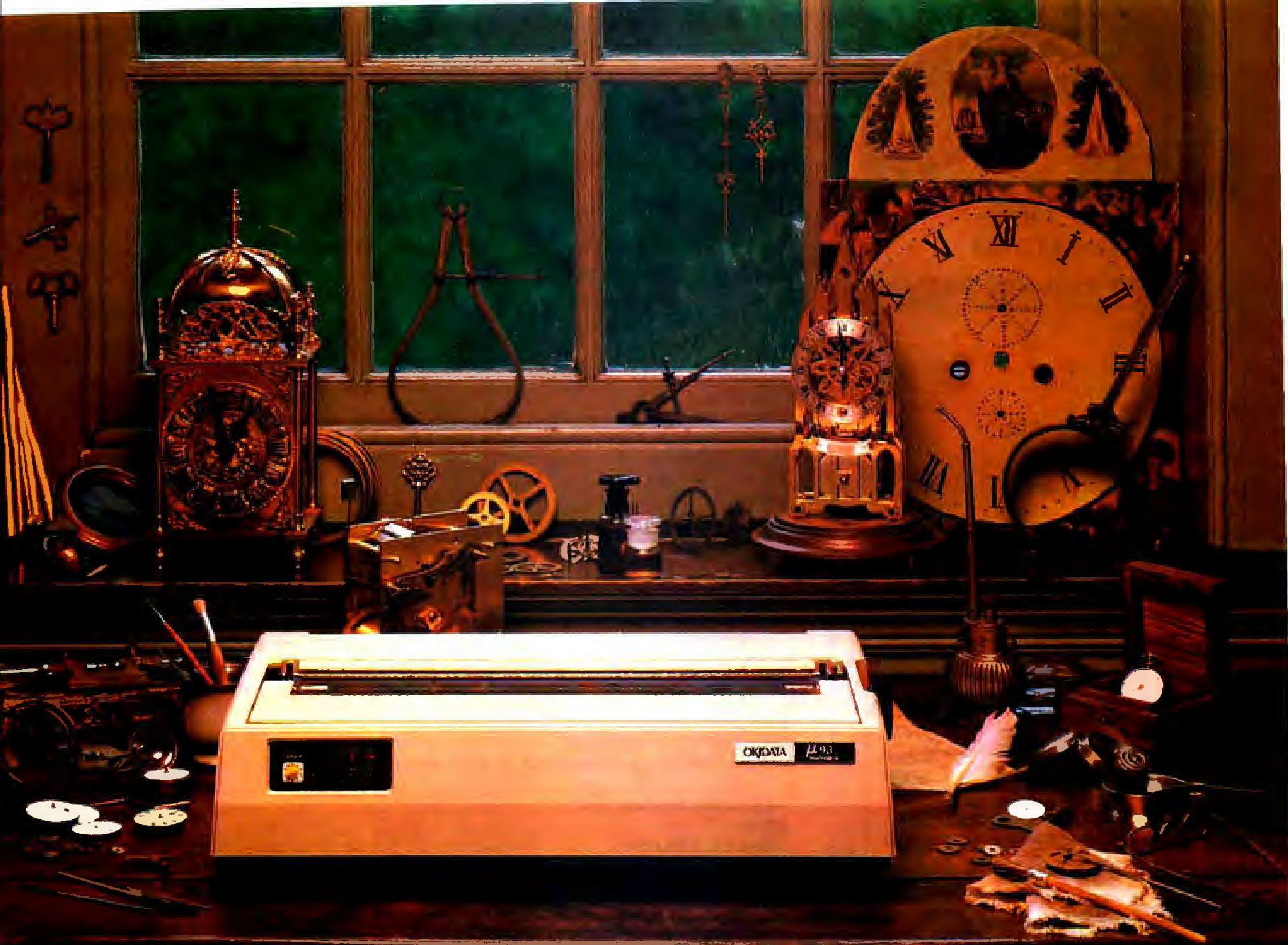
Listing 5: *This example of set type and variable declarations uses sets to represent a collection of spices in recipes. It's a reasonable use of sets, because you don't care about the order of the spices, and you wouldn't list the same spice twice for one recipe.*

```
  MODULE sample3;
  TYPE
(*
Declare an enumeration type that represents the spices that can go into a recipe
*)
    Spices = (basil, ginger, oregano, paprika, parsley, thyme);
(*
Declare a data type to indicate that none, some, or all of the individual spices have been selected
*)
    SetOfSpices = SET OF Spices;
  VAR                                              (* Declare an array of recipes *)
    recipes: ARRAY [1 . . 20] OF SetOfSpices;
  BEGIN                                                         (* main program *)
(*
Mark the first recipe as using oregano and thyme, but no other spices
*)
      recipes[1] := { oregano, thyme };
(*
Mark the second recipe as using no spices; the third recipe as using ginger, parsley, and thyme;
and the fourth recipe as using those spices used in recipes 1, 2, and 3 (that is, ginger, oregano,
parsley, and thyme). Note that you can't list thyme twice, as the set merely records whether the
item appears in the list or not.
*)
      recipes[2] := {};
      recipes[3] := { ginger, parsley, thyme };
      recipes[4] := recipes[1] + recipes[2] + recipes[3];
  END sample3.
```

Listing 6: *An example of pointer types and usage. Pointers are one of the most difficult features of Modula-2 (and Pascal, for that matter) to use properly. This example reads characters from the input file until a control character (value less than* ASCII *space) is found. If a space is read, the list assembled so far is printed; otherwise, the character is added to the list. The list is singly linked, with each entry pointing to the next one using the "next" field of the record. The list is stored in ascending alphabetical order, so you must search the list to look for an appropriate place to insert.*

```
  MODULE sample4;
(*
Note: the usage of the standard procedures NEW and DISPOSE requires, in turn, the definition
of procedures ALLOCATE and DEALLOCATE. Usually, these are the standard routines.
*)
  FROM Storage IMPORT ALLOCATE, DEALLOCATE;
  FROM TTIO IMPORT Read, Write, WriteLn;
  TYPE
    link = POINTER TO element;                     (* declaration of pointer type *)
    element = RECORD                               (* type that we're pointing to *)
      symbol: CHAR;                                            (* data in element *)
      next: link;                                      (* pointer to next element *)
      END;
  VAR
    list: link;                                      (* the list is merely a pointer *)
(*
  Procedure: Insert
  Parameters: sym, CHAR, element to insert
  Purpose: Inserts the element sym into the linked list
  Local variables:
      p = pointer to new element created for sym
      ptr = pointer into list, points to element just AFTER the element to be inserted
      last = pointer into list, points to element just BEFORE the element to be inserted
*)
```

(continued)



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```
PROCEDURE Insert(sym: CHAR);
VAR
  p, ptr, last: link;                                   (* local pointers *)
BEGIN
  NEW(p);                                               (* create a new element *)
  p^.symbol := sym;                                     (* and initialize it *)
  ptr := list;                                          (* make copy of pointer to list *)
  last := NIL;                                          (* pointer to element pointing to ptr *)
  WHILE (ptr # NIL) AND (ptr^.symbol < sym) DO
    last := ptr;                                        (* track parent of ptr *)
    ptr := ptr.^next;                                   (* and get next element *)
  END;                                                  (* end of WHILE *)
  IF (last = NIL)
    THEN                                                (* insert at top of list *)
      p^.next := ptr;                                   (* point to rest of list *)
      list := p;                                        (* make new first element *)
    ELSE                                                (* insert in middle of list *)
      last^.next := p;                                  (* point to p instead of ptr *)
      p^.next := ptr;                                   (* new element points to rest *)
    END;                                                (* end of IF *)
END Insert;
(*
Procedure: PrintList
Parameters: t, link, list to print
Purpose: write the characters in the list to the terminal
*)
PROCEDURE PrintList(t: link);
BEGIN
  WHILE (t # NIL) DO                                    (* for entire list *)
    Write(t^.sym);                                      (* print characters *)
    t := t^.next;                                       (* go to next entry *)
  END;                                                  (* end of WHILE *)
  WriteLn;                                              (* go to next line *)
END PrintList;
BEGIN                                                   (* main program *)
  list := NIL;                                          (* initialize to empty list *)
  LOOP
    Read(ch);                                           (* get character command *)
    IF (ch > ' ')
      THEN Insert(ch);                                  (* insert the character *)
    ELSIF (ch = ' ')
      THEN PrintList(list);                             (* print the list *)
    ELSE
      EXIT;                                             (* exit the program *)
    END;                                                (* end of IF *)
  END;                                                  (* end of LOOP *)
END sample4.
```

Listing 7: *Example of the* PROCEDURE *data type. This facility lets you construct general-purpose routines that require an (otherwise unspecified) auxiliary function to perform some calculation. For example, many* FORTRAN *libraries provide plotting, graphing, or statistical functions that require a user-specified function to work.*

```
MODULE sample5;
(*
This module sets up a statistical function, Average, which computes the average value of a function fx.
*)
TYPE
  fcn = PROCEDURE ( REAL ) : REAL;
VAR
  avg1, avg2: REAL;
PROCEDURE Average( fx: fcn; low, high, step: REAL) : REAL;
VAR
  sum: REAL;
BEGIN
  sum := 0;
```

(continued)

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```
    WHILE ( low < high ) DO                           (* until entire range done *)
      sum := sum + fx(low);                             (* find value and sum *)
      low := low + step;                                    (* bump index *)
    END;
    RETURN (sum / (high-low));                        (* return average value *)
  END Average;
(*                        Sample function : f(x) = x                       *)
  PROCEDURE Linear(x: REAL) : REAL;
  BEGIN
    RETURN x;
  END Linear;
(*                        Sample function : f(x) = x*x                     *)
  PROCEDURE Quadratic(x: REAL) : REAL;
  BEGIN
    RETURN x*x;
  END Quadratic;
(*                          Begin main procedure                           *)
  BEGIN
    avg1 := Average(Linear,    -1.0, 1.0, 0.01);
    avg2 := Average(Quadratic, -1.0, 1.0, 0.01);
  END sample5.
```

ple variables (foo, count), array references (recipe[4] refers to the fourth element of array recipe; priceindex [april, 1967] refers to the 1967th element of the aprilth array of priceindex), record field references (bob.name.middle refers to the middle field of record name, in the name field of record bob), and pointer dereferences (ptr^ refers to the item referenced by pointer ptr).

The standard operators from Pascal are also available in Modula-2. Arithmetic operators that work on both signed integers (INTEGER) and unsigned integers (CARDINAL) are addition (+), subtraction (−), multiplication (*), integer division (DIV), and modulus (MOD). Integer division (*x* DIV *y*) produces the integer part of the result of real division (*x* / *y*); the modulus function produces the remainder after an integer division. Real arithmetic includes addition (+), subtraction (−), multiplication (*), and real division (/).

Set operators include set union (+), yielding all elements that appear in either set; set difference (−), yielding all elements in the first set and not in the second set; set intersection (*), yielding those elements appearing in both sets; and symmetric set difference (/), yielding all elements in one set and not in the other (that is, a/b is equivalent to (a−b)+(b−a) if a and b are sets).

Relational operators produce Boolean (TRUE or FALSE) results, and you can use them to compare the basic types—INTEGER, CARDINAL, REAL, and CHAR—as well as enumeration and subrange types. These operators include equal to (=), not equal to (#), less than (<), less than or equal to (≤), greater than (>), and greater than or equal to (≥). You can use the relational operators set membership (IN) and improper set inclusion (≤ and ≥) to operate on sets. However, you can compare only pointer variables with the equality and inequality operators.

Conclusion

Modula-2 clearly surpasses Pascal in terms of its program-structuring facilities. It contains all the procedures and functions of Pascal and adds a standard way to separately compile portions of a program.

The control structures of the two languages are very close. Modula-2 has the edge over Pascal with the new LOOP statement and the consistent use of the END clause to terminate control statements.

Data typing in the two languages is also very close, but this time Pascal has a slight edge—Modula-2's restriction of sets to 16 elements (on a 16-bit computer) is unnecessary and too often inconvenient.

Both Modula-2 and Pascal provide powerful and flexible expressions, and neither language has an advantage over the other in this respect.

In many ways, Modula-2 is really a superset of Pascal. It takes the good points of the language and strengthens them with some logical and important extensions. When high-quality compilers become available on many machines, Modula-2 may replace Pascal as a language of choice. You can use Modula-2 everywhere you can use Pascal, and in many places where you can't. ■

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8096 XASM *new*	99.50	500.00	99.50	99.50	99.50
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PASCAL, ADA, AND MODULA-2

BY DAVID COAR

A system programmer's comparison

WHEN FACED WITH a reasonably large software project, many factors can influence the choice of an implementation language. Some are technical and some are not. In comparing Pascal, Ada, and Modula-2, I will deal with the major technical factors by using basic properties that these languages possess as measuring tools. In each case, I will describe the relevant programming issues briefly and then discuss the three languages within that context, pointing out differences, commenting on the relative merits of certain features, and offering opinions concerning possible improvements. Since I'm focusing on the capabilities provided by the language features rather than the specific syntax used to invoke them, this article complements detailed descriptions published elsewhere (see references).

Why did I choose these particular languages? Over the years, Pascal has achieved popularity as an implementation language. Nevertheless, its creator, Niklaus Wirth, apparently never thought of Pascal as a true systems-implementation language. Modula-2, on the other hand, represents a conscious effort on his part to define such a language. Modula-2 has facilities for hardware interfacing and allows many programmers to work together on the same project. Of course, these are the same goals that were established by the Department of Defense for the new programming language, Ada. Thus, Pascal and Modula-2 are different attempts by the same person to design a programming language, while Ada and Modula-2 have different origins but the same stated goals.

STRONG TYPING

In most modern programming languages you must declare each data element and routine before using it. First, you choose an alphanumeric identifier to serve as its name. Then, specify its type. You know certain primitive types, such as integer, real, Boolean, and character in advance (see table 1). You must declare the others explicitly before using them. You may create new types either by making certain minor modifications to previous types or by combining one or more previous types into composite structures such as arrays and records. In any case, the type of an element completely determines its storage requirements and the uses to which it may be put. This is what is meant by strong typing. Typing plays a major role in all three languages by restricting the way you can allocate and use data elements.

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STORAGE ALLOCATION

In order to generate code for your program, the compiler must know the size and location of each data element you declare. The data element's type completely determines its size. Its location normally is offset from the beginning of a multiple-element memory area. The compiler assigns an offset of zero to the first element in the area, the second gets offset more than the first, and so on. The details of this algorithm completely determine the resulting memory area's size. Each memory area location and the way it gets allocated depend on the kind of memory area it is. There are three possibilities: *stack*, *heap*, and *main*.

Stack areas are contained within a large memory area called an execution stack. A special *top-of-stack* pointer keeps track of the execution stack's current end. When you call a function or procedure, you change the top-of-stack pointer and the program uses the area between the old and new top-of-stack for your newly called routine's data elements. When the call completes, the program restores the top-of-stack pointer to its previous value and returns control to the calling procedure or function.

(continued)

Heap-memory areas contain a single data element, usually an array or a record. To use this data element, you must have a pointer to the heap-memory area containing it. A pointer is a special kind of data element that always contains the address of a data element in the heap. Your program must explicitly allocate each heap area that it needs, using special syntax provided for this purpose. The address of each new area is stored in a pointer. Pascal and Modula-2 also have syntax for explicit release of heap areas, but not Ada.

Main memory is allocated once when you load your program. A Pascal program has only one main-memory area, which contains all the data elements declared in the main part of your program and all the executable code. In Modula-2, each *library module* your program uses has a separate main-memory area that contains its data elements and the executable code for all its procedures and functions. Similarly, each *library unit* of an Ada program has its own main-memory area for data elements and executable code.

Ada is the only one of these three languages that gives you explicit control over the size and relative location of data elements. In Pascal and Modula-2, an element's size, as well as location within each enclosing memory area, is controlled completely by the compiler. For most applications this is not a problem. However, if you must generate or use data that has a predefined, external format, then you must have control over a data element's size and relative location within a record.

Both Ada and Modula-2 let you specify an absolute address for a data element or routine. This facility, which does not exist in Pascal, is essential for implementing interrupt handlers and memory-mapped I/O (input/output). It would be nice if there were a related facility in any of the three languages that would allow you to specify a data element or routine's symbolic address for linking it with an external system.

It's a little surprising that Modula-2 has no mechanism for creating variable-length arrays. Instead, when you declare an array you must specify its type fully, including the range of acceptable index values. Because the upper and lower bounds for such a range must be constant, the number of elements in the array will also be constant. Modula-2 inherited this unfortunate feature from Pascal with only one minor improvement. When you specify the type of an array parameter to a procedure or function in Modula-2, you need not include its size. This allows you to use a parameter to pass different size arrays to a procedure or function. However, Modula-2 doesn't let you create an array whose size is determined at run time, which makes the language unnecessarily restrictive. It should at least give you pointers to such arrays.

Table 1: *The data types available in each of the three languages are shown in the table. Enumerated types, records, and arrays are not primitive types; the others are. Strictly speaking, characters are a special enumerated type and strings are a particular class of character arrays.*

Language	Integer Types	Real Types	Structured Types	Special Types
Pascal	enumerated character integer	real	record array string	pointer Boolean set (bit mask)
Modula-2	enumerated character integer	real	record array	word address Boolean set (bit mask) procedure
Ada	enumerated character integer short long integer	real short real long real	record array string	pointer Boolean exception task

Type Conflicts

Each expression in your program belongs to two potentially different data types. One type comes from the way it's used, because that tells you the type of data value it must produce. The second comes from the expression's structure. Given inputs of a specific type, each operator in the expression produces outputs of a specific type. So the expression's data elements and the operators that are used to combine them tell you what type of data value it will produce.

If these two types are different, the compiler must decide how to resolve the conflict. In a strongly typed language, conflicts are generally treated as programming errors. This has one unfortunate consequence: an element's data type is not determined by its intrinsic properties but by your need to combine it with other data elements. In Modula-2, for instance, I learned to avoid cardinal (unsigned integer) data elements quickly because they could not be mixed with integers in expressions.

Pascal provides almost no relief from the regimen of strict typing. There are few implicit type conversions, and functions for explicit type conversion are limited to ORD, CHR, TRUNC, and ROUND. With the function ORD you can convert an enumerated value into an unsigned integer. With the function CHR you can convert an unsigned integer into a character. The functions TRUNC and ROUND convert values of type real into values of type integer. The program has to handle other type conversions by using case statements, explicitly initialized arrays, or untagged variant records. In particular, there is no safe and easy way to recover an enumerated value from an unsigned integer. All too often conversions that are perfectly natural from a conceptual standpoint, and which should be programmatically simple, lead to the use of untagged variant records—probably the least safe construct in the language.

Modula-2 provides a little more relief from strict typing. In certain situations, it provides implicit type conversion when a value is assigned to a different-

(continued)

Listing 1: *This listing shows how subtypes and derived types are declared in Ada. In Ada, everything between the "--" symbol and the end of line is ignored by the compiler. Text included in this manner may be used to explain the details of a program.*

```
Subtypes and Derived Types in Ada
TYPE day IS (mon, tue, wed, thu, fri, sat, sun); -- an enumerated type.
SUBTYPE weekday IS day RANGE mon..fri; -- a subtype of the type day.
-- Values of type day may be stored into data elements of type weekday
-- and conversely.
TYPE midweek IS NEW day RANGE tue..thu; -- a new type derived from the
-- type day. Values of type midweek may not be stored into data elements
-- of type day or weekday. Similarly, values of type day and weekday may
-- not be stored into data elements of type midweek.
SUBTYPE nibble IS integer RANGE 0..255; -- a subtype of the type integer.
-- Values of type nibble may be stored into data elements of type integer
-- and conversely.
TYPE byte IS NEW nibble; -- a new type derived from the type nibble.
-- Values of type byte may not be stored into data elements of type
-- nibble or integer. Similarly, values of type nibble and integer may
-- not be stored into data elements of type byte.
```

ly typed data element. For example, you may store a cardinal value in an integer data element and a positive integer in a cardinal element. However, neither an integer nor a cardinal may be stored in a real element. There is a slightly richer set of functions for making explicit type conversions. In particular, the function VAL allows you to recover enumerated values from unsigned integers. Additionally, certain types have a built-in function that shares the type name and converts input values of that type. The drawback of this feature is that it appears to be system dependent because no computation can be performed in making the conversion. Consequently, use it with care if you intend to move your software from one system to another.

Ada is similar to Modula-2 in its enforcement of strict typing. For certain well-defined types, there is a built-in function that shares the type name and converts input values into the particular values of that type. This means that many type conversions are reasonably easy. Moreover, the collection of type names that can be used for sharing and converting is well defined, and the results are independent of any implementation. All of this is a definite improvement over Modula-2.

Ada's implicit type conversion is based on the notion of a *subtype*. When a type is created by placing restrictions on another one, it is called a subtype (see listing 1). Its values may be mixed with expressions of the original type, and values of either type may be stored in data elements on the other, as long as the constraints of the subtype are not violated. While subtypes (called subranges) exist in both Pascal and Modula-2, Ada tries to make their meaning more precise.

Derived Types and Overloading

Ada further refines strong typing by introducing the notion of a *derived type*: an exact copy of another logically distinct type (see listing 1). Derived types allow you to have look-alike data types whose corresponding data elements cannot be confused with one another. In order to make the derived type an exact copy of the original, Ada gives it logically distinct copies of each original operation. While this feature seems reasonable at first, it has some undesirable side effects. To understand them, however, we must first discuss another distinctive Ada feature, overloading.

Two elements of your program are *overloaded* if both are visible and have the same name. In a strongly typed language, overloaded elements normally cannot be confused with one another as long as they have different types. In spite of this, both Pascal and Modula-2 prohibit overloading. Ada allows it, but only for procedures and functions. An Ada procedure or function call may refer to any one of several routines with the same name. The compiler then chooses the correct one according to the number of its parameters, the type of each parameter, and the type, if any, of its return value.

Overloading is closely associated with another distinctive Ada feature, the ability to redefine basic operators such as addition, subtraction, and multiplication. To do this, you simply declare a function that has the right number of parameters and use the appropriate symbol for its name. If you have defined a collection of operators, you can use them in an expression with values of the correct type exactly as you would use any ordinary operator. One desirable consequence of all this is that it lets you create versions of the basic operators that mix types in a more or less arbitrary way.

Another less desirable consequence of overloading comes from the rules governing types in general and derived types in particular. There is a set of operations for each type in your Ada program. Each set of operations is a procedure or function with at least one type-oriented parameter or return value. The operations belong to the type either because they were inherited by the type or because both the type and the operations set were declared in the visible part of the same package.

Now consider the following situation. Types *x*1 and *x*2 are declared in package *x* along with a procedure *q* whose parameters are of type *x*1 and *x*2. In package *y*, type *y*1 is derived from *x*1, and type *y*2 is derived from *x*2. As mentioned earlier, a derived type inherits a copy of each operation belonging to the original type. Inside *y* there are now two procedures named *q*: one with parameters of type *y*1 and *x*2 belonging to *y*1, and one with parameters of type *x*1 and *y*2 belonging to *y*2 (see figure 1). Of course, you probably wanted a procedure with parameters of type *y*1 and *y*2, but to get it you'd have to explicitly declare it. And that would not be the end of your problems. The literal values for types *x*1 and *y*1 are indistinguishable, as are those for *x*2 and *y*2. So a call on *q* that substitutes a literal value for one of its parameters will be ambiguous inside *y*, unless the literal value is appropriately qualified. What makes this ambiguity especially frustrating is that there is really only one procedure *q*. The copies are merely pseudonyms. Ambiguity regarding a literal value's type is probably unavoidable. Nevertheless, the automatic proliferation of overloaded procedures and functions that occurs in the Ada language seems unreasonable.

INITIALIZATION

The problem of initialization is related to strong typing and storage allocation. When you declare a data element, you often might want to give it an initial value. Occasionally, you might even want to specify an initial value for all data elements of a given type. This would let you document important properties of such data elements. For stack and heap elements, convenience, documentation, and control centralization are the major advantages provided by initial values. For main-memory data elements, however, the initial value's primary virtue is efficiency, since the loader generates them from a map at run time. If you don't generate them at that time, you wind up with two copies of each initial value in main memory. The list of hardware instructions that must be executed to initialize the data element will contain one copy, while the data element itself will hold the other once the hardware instructions are executed. In addition, there will be hardware instructions to write the value into the correct memory location. For a large table of error messages, this could lead to a significant increase in memory requirements.

Beyond some reasonably simple syntax extensions for declarations, a strongly typed language must have facilities for creating structured constants if you want to implement initial values. Otherwise you can't describe the initial values for compound data structures such as records and arrays. Ada is the only one of the three languages that supports either declarations or structured constants. The decision not to include these features in Pascal and Modula-2 presumably was motivated by a desire to keep the language as simple as possible. Most Pascal implementations have extensions in this area, but they differ substantially and will cause problems if you want software that is easy to move from one system to another.

STRUCTURED CONTROL

The data elements in your program control its behavior. Depending on their contents, you may decide to examine an input value, compute a new value for one of them, or produce an output value. Statement lists in the body of the program specify these actions in detail. Program execution is basically sequential in nature. At any given instant, only one statement controls your program. Certain kinds of statements let you transfer control to either a different statement list or to another statement within the same list. In the absence of such explicit transfers, however, the program executes the statement list in order, starting with the first one. All three languages provide essentially the same facilities for dealing with this type of deliberate, sequential control. Ada provides two additional control mechanisms, the rendezvous and the exception, but both have serious flaws, and the rendezvous is not an appropriate construct for a low-level systems implementation language.

SEQUENTIAL CONTROL

All languages let you explicitly transfer control from one part of your program to another. The GOTO statement is the most primitive example of such a feature. It lets you jump to a more or less arbitrary location within the same list of statements. Often, a particular relationship between two or more data elements, such as $x + y = z$, is consciously preserved for a number of consecutive statements. Because you run the risk of destroying such relations whenever you jump into the middle of a list of statements, you should use GOTO statements sparingly. Good programming languages discourage explicit transfers by providing more structured methods for altering the flow of control, e.g., procedures, functions, conditional statements, and looping constructs. Ada and Modula-2 transfer control similarly and both are a substantial improvement over Pascal.

In both Ada and Modula-2, a procedure's or function's return statement lets you cut off its execution and transfer control to the place where it was called. However, when you invoke the return statement to get you out of a function, you must always supply an appropriate return value. Unlike Pascal, neither Ada nor Modula-2 have a special data element that contains the

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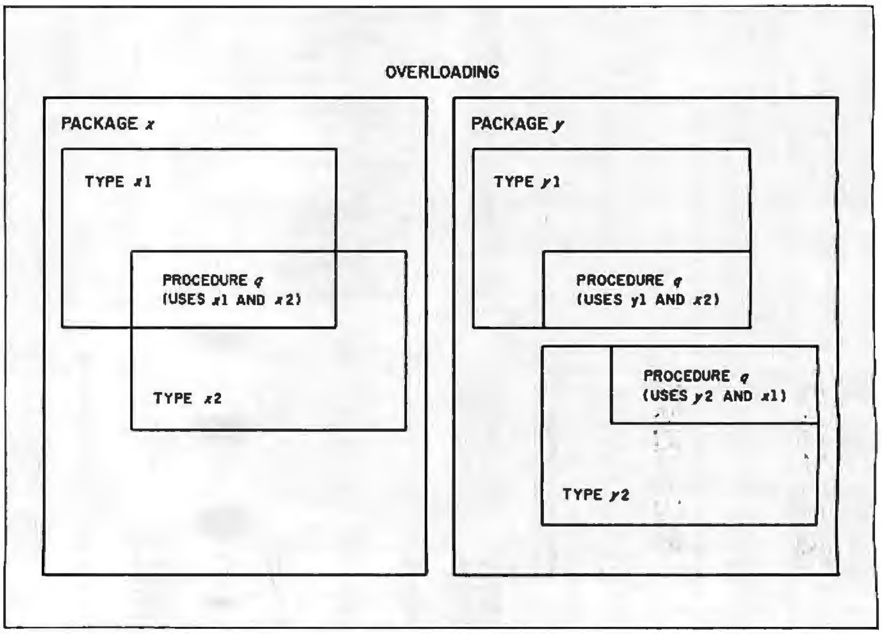

Figure 1: *Procedure* q *in package* x *has parameters of type* x1 *and* x2. *Type* y1 *in package* y *is derived from type* x1. *Type* y2 *is derived from type* x2. *As a result, package* y *contains two procedures named* q. *One has parameters of type* y1 *and* x2. *The other has parameters of type* y2 *and* x1. *If you want a procedure that does the same thing for* y1 *and* y2 *that the original* q *does for* x1 *and* x2, *you will have to declare it yourself. If you call it* q, *it will be overloaded with these two other procedures named* q *that you got for free.*

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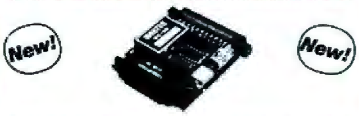

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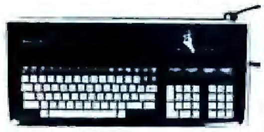

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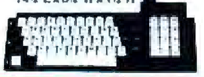

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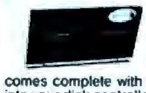

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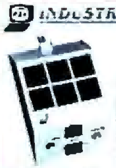

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result of the function. Consequently, the function cannot return an uninitialized data value. If you reach the end of a function before executing a return statement, the program generates a run-time error. This makes it much easier to guarantee that the generated value is appropriate.

In both Ada and Modula-2, an exit statement within a program loop allows you to cut off its execution and transfer control to the next statement beyond it. In Ada you can label a loop, and you can exit from any one of several nested loops by supplying the correct label. In Modula-2, however, you cannot label loops, and there is no easy way to curtail an outer loop. The exit statement always terminates the innermost loop, as it does in Ada when the program doesn't supply a label.

Of the three languages, only Modula-2 has no GOTO statement. The availability of exit and return statements makes them unnecessary. However, Ada has retained them. The Modula-2 exit statement, on the other hand, is too restrictive, and the Ada construct seems more appropriate. In fact, it might be better if an exit statement always required a label. This would prevent problems from arising when one loop is inserted within another after it's written.

A final difference between the three languages has to do with the handling of statement lists. When you write a loop in Ada or Modula-2, the body of the loop is assumed to contain a list of statements. The same is true for each branch of a conditional or case statement. In Pascal, on the other hand, most of these constructs require a single statement, which can, if necessary, be a list of statements enclosed within a begin-end pair. The absence of explicit begin-end bracketing in Ada and Modula-2 creates the need for a way to terminate the corresponding statement list. Ada has introduced three new tokens, end if, end case, and end loop, while Modula-2 has simply reused the reserved word end for all three. The Ada solution is often helpful in pinpointing the cause of syntax errors.

Exception Handling

Exceptions are conditions you wish to exclude from normal processing considerations. They are normally the result

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of an unlikely set of circumstances that may or may not represent an error. Many times a particular exception can arise at almost any point during the execution of your program, and you would like to be able to deal with it without continually testing for it. A hardware interrupt, especially one caused by an arithmetic error such as dividing by zero, is a perfect example of this type of exception. Since the hardware must check for it, additional software tests may be wasteful. A mechanism for handling exceptions should probably be rated by its ability to deal with this kind of hardware interrupt.

Of the three languages, only Ada has attempted to solve the problem of exception handling. At the end of each function or procedure, and at certain other points in your program, you can define an exception handler. It is essentially a case statement containing one branch for each exception you are willing to handle. Exceptions must be declared and you may activate one at any point in your program by executing a raise statement that references it. When an exception is raised during the execution of a procedure or function, by the routine itself, by another routine that it called, or by the hardware, the appropriate branch of its exception handler is invoked.

Once a routine has dealt with an exception, it must return control to the list of statements that called it. You can prevent the exception from propagating, but you can't fix things up and return to the place where the exception occurred. For this reason, Ada exceptions have only marginal value. They will be adequate for many situations, but they aren't useful enough to justify an expensive implementation.

Task Management

As mentioned earlier, most program execution is sequential. If you wish to simultaneously execute more than one statement sequence you need to create a separate task or process. You also need to control it once you create it. At any given moment, there is a potentially different statement in control of each task in your program. If your program contains more than one active task, a collection of statements (rather than just one) determine its behavior. A task may or may not be active, and an active task may or may not be executing on a processor. Active tasks must share the available processors. If there are several processors, then several tasks may be executing at once. Otherwise there will be only one.

Pascal has no task-management facilities. Modula-2 allows you to create them by calling the procedure NEWPROCESS and to control them by calling the procedure TRANSFER, which suspends the execution of one task and resumes the execution of another at the point where you last left it. Both of

(continued)

these routines, as well as the type PROCESS, are contained in the special module called SYSTEM, and little is said about their implementation. Ada, on the other hand, has defined an elaborate set of tasking facilities.

An Ada task is activated along with the part of your program that contains its declaration, and it must be terminated before that part of your program can be deactivated. If it's declared within a procedure or function, a copy of the task will be activated each time the routine is called, and this copy must terminate before the call can complete. If you don't want the task to run to completion, you can terminate it explicitly with an ABORT statement.

To communicate with an Ada task you must declare one or more *entries* for it. When you declare an entry you specify only its name and parameter structure. An accept statement within the body of your task associates a list of statements with the entry and thus defines its meaning. If there is an outstanding call on the entry, it will be executed and the caller will be activated. Otherwise the task suspends execution until the entry is called. If an entry is called before the accept statement is executed, the call is queued along with any others that are pending for that entry and the caller is suspended. The pairing of a call and an accept statement is called a **rendezvous**. Special syntax allows you to accept one of several possible entries and to make conditional calls on an entry.

The Ada tasking model is complex and cumbersome. It has lots of features and not much flexibility. As a result, it will be costly to implement and not very useful. And to top it off, the problems associated with updating shared data elements are dealt with only as an afterthought. The moral of this story is that elaborate tasking models have no place in a systems-implementation language. A few simple mechanisms are needed, not a complicated structure.

MODULARITY

You can partition almost any large software system into reasonably small, self-contained units, or modules—each with a number of related data elements and the procedures and functions needed to manipulate them. If you have carefully defined and suitably restricted the module interfaces, you will be able to code and debug them independently. As a general rule, focusing on individual modules reduces the number of variables you have to contend with at any given moment and makes the system as a whole easier to design, debug, and maintain. Moreover, to the extent that you can overlap work on several parts of the system, less time will be required to implement it.

Pascal discourages modular design by preventing you from breaking up your implementation. In the first place, you must group your declarations as follows: label declarations, followed by type

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declarations, then variable declarations, and finally, procedure and function declarations. This makes it virtually impossible to group functionally related elements. In the second place, there are no mechanisms for splitting your program into smaller pieces for separate encoding. Everything you do is part of a single program, and data files are the only mechanism for communicating between separate programs.

As its name implies, modularity is a strong point of Modula-2. A Modula-2 module contains data elements, procedures, and functions, all of which are declared within its scope. You must explicitly export any elements you need somewhere else, and you must explicitly import any external elements you need inside. A module that is not contained within another is called a library module. You may declare a library module all at once, in which case it is called a program module. Alternatively, you may declare it in two stages. The first stage is called a definition module. In it you declare only those portions of the module that are visible from the outside. Procedures and functions may be introduced but not fully declared. The second stage is called an implementation module. You use it to complete your declaration of the elements you introduced in the corresponding definition module. Additionally, you declare any other elements that may be required. A definition module and its implementation module need not import the same external elements (see listing 2). This lets library modules serve each other without creating circular de-

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Listing 2: *This listing shows a pair of library modules that depend on each other. The implementation of module* a *makes use of procedure* q *in module* b, *while the implementation of module* b *makes use of procedure* p *in module* a. *In Pascal and Modula-2 everything between the symbols "(*" and "*)" is ignored by the compiler.*

```
DEFINITION MODULE a;
  EXPORT QUALIFIED p;
  PROCEDURE p(x: INTEGER);
END a.
DEFINITION MODULE b;
  EXPORT QUALIFIED q;
  PROCEDURE q(x,y: INTEGER);
END b.
IMPLEMENTATION MODULE a;
  FROM b IMPORT q;
  PROCEDURE p(x: INTEGER);
  BEGIN
    (* statements defining the behavior of p *)
  END p;
  PROCEDURE r(x: INTEGER);
  BEGIN
    (* statements defining the behavior of r *)
    q(x,4); (* a call on the procefure q from module b *)
    (* more statements defining the rest of r *)
  END r;
BEGIN
  (* statements for initializing a *)
END a.
IMPLEMENTATION MODULE b;
  FROM a IMPORT p;
  PROCEDURE q(x,y: INTEGER);
  BEGIN
  (* statements defining the behavior of p *)
  END q;
  PROCEDURE r(x: INTEGER);
  BEGIN
    (* statements defining the behavior of r *)
    p(2); (* a call on the procedure p from module a *)
    (* more statements defining the rest of r *)
  END r;
BEGIN
  (* statements for initializing a *)
END b.
```

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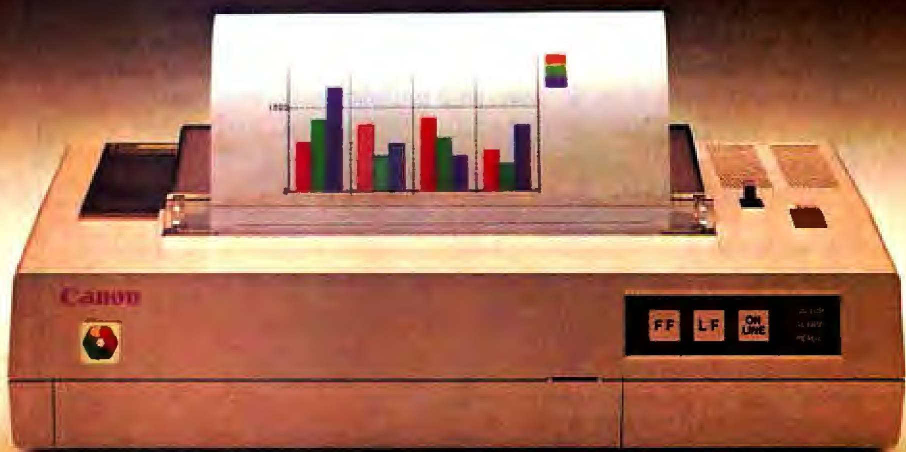

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pendencies in their definition modules.

All of the Modula-2 compilers I know implement the following mechanism to allow one library module to use the exported element of another. When a definition module is compiled, a file is created that contains a summary of its declarations and a timestamp that was generated by the compiler. This summary file is used to establish correct typing information for any elements that are imported by other library modules (see listing 3). It is also used when the implementation module is compiled. In both cases, the timestamp contained in it is copied to the resulting code file, and run-time checks guarantee that all code referring to the definition module was compiled using the same summary file. Since the functionality provided by this mechanism is a requirement of the language, Modula-2 is excellent for modular decomposition of large systems.

An Ada package equates to a Modula-2 module, except for the way you make elements visible externally. All elements declared in a package specification (the Ada equivalent of a definition module) are assumed to be visible outside the package unless they are declared in its private part. In Ada you must explicitly hide an element, while in Modula-2 you must explicitly make it public.

In Modula-2 a compilation unit must be a library module. In Ada it may be a procedure, a function, or a package, and it may or may not be declared within another compilation unit. Ada's generality adds little to the overall capabilities of the language but does increase the compiler's cost by making it more difficult to implement. The facilities provided by Modula-2 seem adequate for most applications, and anything less would certainly be unacceptable.

One final point on modularity. In Ada you may demand in-line expansion for selected procedures and functions. You can thus implement new arithmetic operators and have the compiler generate the code for them in line, exactly as it would for normal arithmetic operators. Since this code can make use of any resource within the package that declared the operator, it can create external dependencies on routines and data elements of the package that are supposed to be hidden. If you change the implementation of such a package in any way, you must recompile every compilation unit that uses one of its inline routines. It would be better if Ada required you to supply a complete definition for any such routine in the public part of its package. However, this is not only not required, it's not allowed.

Listing 3: *When a definition module is compiled, a summary file is produced that contains a timestamp. When a module imports anything from another module, the compiler uses information from the appropriate summary file to insure correct usage. When an implemenation module is compiled, the timestamp from its definition module is included in the resulting code file, along with timestamps for any imported modules. At load time, all copies of the timestamp for a particular module must agree.*

```
DEFINITION MODULE a;
  EXPORT QUALIFIED p;
  PROCEDURE p(x,y: INTEGER);
END a.
```

The summary file resulting from this definition module contains a timestamp whose value, for instance, is v1.

```
MODULE b;
  FROM a IMPORT p;
  (* declarations for b *)
BEGIN
  (* statements initializing b *)
  p(32,2); (* calls the procedure p from module a *)
  (* other statements defining the behavior of b *)
END b.
```

The code file for module b contains a copy of the timestamp value v1. The compiler obtained this value from the summary file for module a because of the import statement at the beginning of b.

```
IMPLEMENTATION MODULE a;
  PROCEDURE p(x,y: INTEGER);
  BEGIN
    (* statements defining the behavior of p *)
  END p;
BEGIN
  (* statements initializing the module a *)
END a.
```

The code file for this implementation module contains the timestamp value v1. The compiler obtained this value from the summary file for module a. The implementation module may be changed and recompiled. As long as it agrees with the description contained in the summary file, there will be no need to recompile module b.

```
DEFINITION MODULE a;
  EXPORT QUALIFIED p;
  PROCEDURE p(x: INTEGER);
END a.
```

The summary file resulting from this definition module contains a timestamp whose value v2 is not equal to v1.

```
IMPLEMENTATION MODULE a;
  PROCEDURE p(x: INTEGER);
  BEGIN
    (* statements defining the behavior of p *)
  END p;
BEGIN
  (* statements initializing the module a *)
END a.
```

The code file for this implementation module contains the timestamp value v2. The compiler obtained this value from the summary file for the second definition module. The module b must now be changed and recompiled before it can be used with this new version of module a.

Abstract Typing

When combined with modules or packages, strong typing provides a fine tool for creating data structures that have specific, well-defined properties. However, strong typing is representation-oriented by its very nature. It is inevitably tied to the production of types and data structures rather than to their consumption. Another form of typing, which I shall call abstract typing, has to do with consumption rather than production. It comes into play when you wish to write a program dealing with data structures having certain properties but whose exact representation is

(continued)

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unimportant to the algorithm.

The traditional way of doing this is to require that each external data structure be represented internally by a tag or address, and that all necessary operations on them be passed as explicit parameters to the algorithm. You can do this in Pascal and Modula-2 but not in Ada. The first two languages allow you to pass procedures and functions as parameters, while the latter does not. In Pascal, you would probably use integers for the data structure tags. In Modula-2, you could use pointers passed in as parameters of type "word." Of course, this solution forces you to bypass all type checking by the compiler. It would be nice if you could declare a routine with some parameters that are pointers to a data structure of type *x* and others that are routines to manipulate such pointers where *x* is left unspecified. Then the compiler could verify that all appropriate types matched.

At first glance, this is what an Ada generic declaration appears to do. You specify a collection of parameters, some of which may be types, and then you declare a routine or package using these parameters wherever necessary. However, what you get is not a simple routine or package. Instead, you get a routine or package that will generate a second one when supplied with the correct parameters. You may use it to declare any number of nongeneric instances, and each time you execute a part of your program that contains such a nongeneric routine, a new version of the underlying routine or package will be generated. By using generics you end up with more routines and packages, not fewer. While the algorithm is shared, the code and data are not, and each copy of the generic routine or package will require its own memory. However, since Ada doesn't allow you to pass procedures and functions as parameters, generics are all you've got.

With procedure types, Modula-2 has provided a consistent way of dealing with functions and procedures as data values in an arbitrary data structure, and not just as parameters to a routine. With this feature, which has no counterpart in either Pascal or Ada, you can declare a type that defines the parameter structure for a procedure or function. A data element of that type behaves like a procedure or function, but it may be located anywhere in memory, including the heap (see listing 4). Any routine that belongs to a library module and has the right parameter structure may be assigned to it. Procedure types may be used in high-level structures, such as files, that include both data and control, and in low-level structures such as interrupt handlers. They allow you to simplify the structure of your application without obscuring its intent.

Listing 4: *Modula-2 procedure variables can be used to provide handlers for a data structure within the data structure itself.*

```
DEFINITION MODULE structure;
  EXPORT QUALIFIED reference, node, handler, create;
  TYPE reference = POINTER TO node;
  TYPE handler = PROCEDURE(REAL,INTEGER,reference);
  TYPE node =
    RECORD
      link: reference;
      x,y: INTEGER;
      h: handler;
    END;
  PROCEDURE create(h: handler): reference;
END structure.
IMPLEMENTATION MODULE structure;
  FROM Storage IMPORT ALLOCATE;
  PROCEDURE create(h: handler): reference;
    VAR r: reference;
  BEGIN
    NEW(r); (* calls ALLOCATE *)
    r↑.h := h;
    RETURN(r);
  END create;
BEGIN
  (* statements initializing the module structure *)
END structure.
MODULE manager;
  FROM structure IMPORT reference, node, handler, create;
  PROCEDURE transition(x: REAL; y: INTEGER; r: reference);
  BEGIN
    (* statements defining the behavior of transition *)
  END transition;
  VAR ref: reference;
BEGIN
  ref := create(transition);
END manager.
```

CONCLUSIONS

As a systems-implementation language, Modula-2 is a major improvement over Pascal. In fact, it is substantially better than most currently available languages. From what I have said so far, you might be tempted to call it the "poor man's Ada," but this is certainly wrong. While there are many extra features in Ada, most of them are marginal improvements. The only one that seems really necessary is the feature that allows you to control the size and relative location of data elements within a data structure.

With all its shortcomings, Modula-2 is a good implementation language and a technical success. It has no surprises and no overlapping functionality. Ada, on the other hand, is a questionable experiment at best. It contains several costly features that are of little value, and the implications of certain other features, such as derived types, seem to lack forethought. Of course it's easier to criticize than to create, but it seems that without the support of the Department of Defense the many "gotchas" and funny features of Ada would have caused its demise. ■

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Wirth, N. *Programming in Modula-2*. New York, Heidelberg, Berlin: Springer-Verlag, 1982.

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Memory	128K	128K OPTION	256K	256K OPTION
Graphics Display (640 x 200 resolution)	YES	OPTIONAL	YES	OPTIONAL
Printer Port	YES	OPTIONAL	YES	OPTIONAL
Communications Port	YES	OPTIONAL	YES	YES
MS™-DOS/BASIC®	YES	OPTIONAL	YES	OPTIONAL
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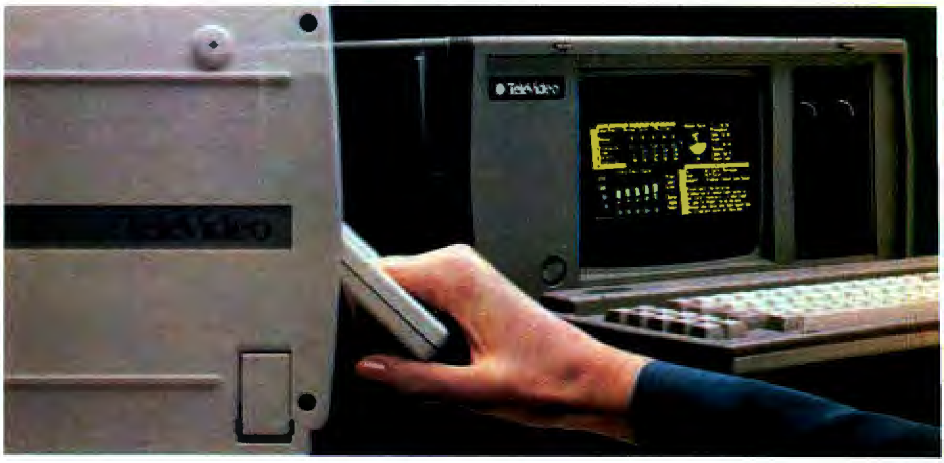

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Quiet Operation	YES (NO FAN)	NO
Display	YELLOW	AMBER
Memory	256K	256K
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Communications Port	YES	OPTIONAL
Printer Port	YES	OPTIONAL
MS™-DOS 2.11	YES	OPTIONAL

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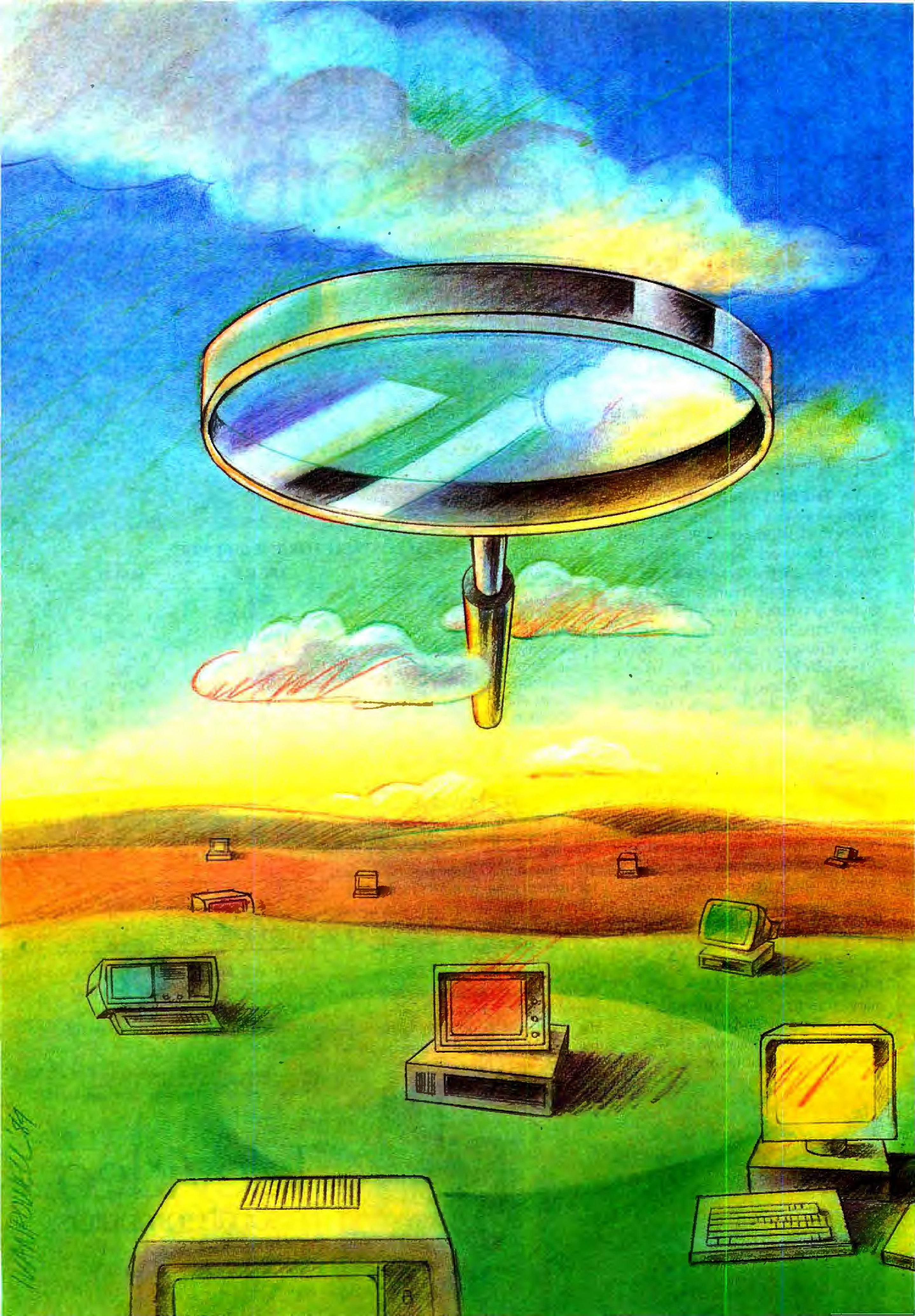


Reviews

REVIEWER'S NOTEBOOK

WordStar—the old, reliable word-processing program from MicroPro—is being besieged on all sides. First there were the competing word processors. Then came NewWord, a low-cost WordStar work-alike program written by some of the same people who wrote the original. And now there's a WordStar work-alike written in BASIC.

At the BYTE/*Popular Computing* show in Chicago, Bruce Tonkin approached me, claiming that he had a compiled-BASIC program called My Word!. He said that it runs faster than WordStar, that it runs on everything except Apple computers, and that it costs only $25.

Fortunately, he had a version for the IBM Personal Computer (PC) with him and there was a new Zenith Z-150 just across from the BYTE booth. (I'll talk more about the Zenith later.) Anyway, this $25 program actually worked. Of course, it doesn't do everything that WordStar does (such as on-screen justification), but it does almost everything. And it does some things that WordStar can't do. For example, you can set up a long table and then sort the table according to information in any of its columns.

Bruce Tonkin's company is called TNT Software (34069 Hainesville Rd., Round Lake, IL 60073).

About six months ago we did a review of the Zenith Z-100, the Heath company's first MS-DOS machine. The Z-100 has the best version of MS-DOS I've seen on any machine. The only problem with the Z-100 is that it cannot take advantage of the large variety of IBM PC software that is available.

Now we're trying to get the Z-150, Heath's true IBM PC-compatible machine. If they applied the same care and intelligence that they did on the Z-100, then the new Z-150 must be some machine. I must admit, however, that the portable version—the Z-160—looks a bit strange.

A few months ago, I mentioned the Leading Edge Word Processor, a slick package with unique, rather unwieldy file-handling procedures. Now, because of competition from IBM's own word-processing programs called DisplayWrite, the basic price of the LEWP has been reduced to about $200. Also, the Leading Edge PC has finally arrived here. The Leading Edge PC is one of the newest IBM PC clones. An identical twin of the Sperry PC, it is produced by Mitsubishi in Japan, and its most distinguishing characteristic is its dual-speed processor.

The 8088 microprocessor in the LEPC can run at either 4.77 MHz (just like the IBM PC) or 7.6 MHz (a significant improvement). Running your favorite programs at this higher clock speed is a bit of a thrill.

The Leading Edge PC—like every PC clone I've seen—is not 100 percent compatible. In fact, I give it a "98." All of the major non-graphics programs run on it (we haven't received the graphics board yet).

Heading our reviews this month is a look at the MacIntosh, the machine that has probably received more attention than any other. Contributing Editor Bruce F. Webster examines whether the "Mac" can do serious work.

Next, our veteran analyst Rowland Archer Jr. examines the IBM PCjr, another machine that has been in the news a lot. Rowland carefully examines what this machine can and cannot do.

Then we shift to a popular MS-DOS-based system—the Sanyo MBC-550. Bill Sudbrink determines whether this low-cost machine—which looks like part of your stereo system—is a real alternative to the high-priced office systems.

For programmers, we have a review of four Logos for the IBM PC that offer turtle graphics of varying quality.

And finally, we have a review of a new low-cost daisy-wheel printer—the Juki 6100—written by our features editor, Mike Vose.

—Rich Malloy, Product-Review Editor

The Macintosh

The many facets of a slightly flawed gem

BY BRUCE F. WEBSTER

Few computers—indeed, few consumer items of any kind—have generated such a wide range of opinions as the Macintosh. Criticized as an expensive gimmick and hailed as the liberator of the masses, the Mac is a potentially great system. Whether it lives up to that potential remains to be seen.

Personally, I think the Macintosh is a wonderful machine. I use one daily at work, and then at night I play with the one I have at home. Or, at least, I try to play with it. You see, my wife—who for years resisted all my attempts to introduce her to computers—has fallen in love with the Mac (her words, not mine). She uses it to type up medical reports, notes on her clients, and personal letters. In fact, she's suggested that we get a second Macintosh so that we won't have to fight over the one we have.

The Macintosh is not without its problems. Resources are tight—it needs more memory and disk space—and software has been slow in coming to market. Many have criticized its price ($2495). In fact, there are indications that Apple considered a lower price ($1995) and then rejected it. It doesn't seem to have hurt the Mac's market—people are still buying them faster than Apple can make them—but there's the potential for backlash if the machine doesn't deliver on all its promises.

Whatever its problems and limitations, the Mac represents a breakthrough in adapting computers to work with people instead of vice versa. Time and again, I've seen individuals with little or no computer experience sit down in front of a Mac and accomplish useful tasks with it in a matter of minutes. Invariably, they use the same words to describe it: "amazing" and "fun." The question is whether "powerful" can be added to that list.

In an industry rapidly filling up with IBM PC clones, the Macintosh represents a radical departure from the norm. It is a small, lightweight computer with a high-resolution screen, a detached keyboard, and a mouse (see photo 1). It comes with 128K bytes of RAM (random-access read/write memory), 64K bytes of ROM (read-only memory), and a 400K-byte 3½-inch disk drive. If you throw in an Imagewriter printer (see photo 2 and figure 1) the system costs $2990. The processor is a Motorola 68000, running a nameless operating system (see the text box, "A Second Opinion" on page 248 for a full description). It has absolutely no IBM PC/MS-DOS compatibility, and it would appear Apple plans none.

The Display

The display is small (9-inch diagonal), but it has very high resolution (512 by 342 pixels). Every pixel is crisp. Several things make the display unusual. First, the Macintosh has no "text mode." Instead, the display is always bit-mapped graphics. Second, the display is black-on-white rather than amber-, green-, or color-on-black, giving it an ink-on-paper effect. Third, the pixels are equally dense both horizontally and vertically, eliminating the "aspect-ratio" problem that plagues other graphics systems. (In other words, a box 20 pixels wide and 20 pixels high will be a square.)

The effect is excellent. The display is clear, crisp, easy to read, and easy on the eyes. Because all text is graphically generated, true "what you see is what you get" word processing is available (with multiple fonts, sizes, and styles). Embedded drawings and proportional spacing are also possible. Some criticism has been made about the lack of a color-graphics capability. Frankly, I am unconvinced of its necessity. Most applications I have seen use color graphics as a substitute for detail, and the Mac can give you lots of detail. (An interesting footnote: the QuickDraw graphics routines in the Mac's ROM *do* provide for color, although Apple has not announced any intentions for supporting such.)

The Mac's display does create a problem. Computer graphics are memory-intensive: once you start drawing pictures, you start using up lots of memory. The video display itself consumes about 22K bytes (or about one-sixth) of the total RAM. Any off-screen manipulation (windows) or information (text fonts) chews up additional memory quickly.

The Keyboard

Like the rest of the machine, the keyboard is significantly different from those found on other systems (see photo 3). It's smaller than most and has only 58 keys. It is detached but the 3-foot coiled cord has lots of give to it so you don't have to wrestle the computer for the keyboard. The full printable ASCII (American National Standard Code for Information Interchange) set is available, and the layout of alphanumeric and punctuation keys is pretty standard. There are no function keys, no cursor keys, and no control key. Instead, you will find two Option keys and a Command key. The Option keys, located directly under either Shift key, are used to generate special text characters (Greek letters, math symbols, and the like). The Command key, whose symbol looks like a freeway cloverleaf, is an alternative to the mouse. For example, if I'm typing along and wish to underline some text, I can type Command-U instead of stopping and using the mouse to select Underline in the Style pull-down menu.

All in all, I like the keyboard. I'm a fast touch-typist and occasionally I overrun the two-key "rollover" (the number of keys you can press down simultaneously), but I never lose characters because of buffer overflow. The keyboard's layout is compact, so I can easily reach any key—well, almost any key. The Command key, located between the left Option key and the space bar, is in an awkward position. I often hit the Shift key or Option key instead.

I don't like function or cursor keys and the mouse renders them fairly useless, so their absence doesn't bother me at all. A separate numeric keypad is available for $99 (it plugs in between the keyboard and the Mac). This keypad has cursor keys on it, but I wonder how many applications will recognize them.

The Mouse

The Macintosh has a standard, one-button, mechanical-tracking, optical-shaft-encoding mouse (again a departure from industry norms). The mouse has a 3½-foot cord, its own port in the back, and full support from the ROM routines and the operating system. In other words, almost every application on the Macintosh will use the mouse. (I say "almost" because someone is bound to come out with a program that ignores it altogether.)

Before buying my Macintosh, I used a mouse on an IBM PC and was not impressed. The Macintosh mouse impresses me. In some applications, such as MacPaint, I seldom touch the keyboard, except to hold the Shift, Option,

(continued)

Bruce F. Webster (7909 Ostrow St., Suite F, San Diego, CA 92111) is vice-president of FTL Games and Oasis Systems. He received his B.S. in computer science from Brigham Young University and did graduate work at the University of Houston. His hobbies include reading and war-gaming, especially science-fiction and fantasy war games.

Photo 1: *The Apple Macintosh computer.*

Photo 2: *The Macintosh dot-matrix printer.*

This is 9-point text, Geneva.
This is 12-point text.
This is 14-point text.
This is 18-point text.
This is 9-point text, Geneva, bold.
This is 12-point text, bold.
This is 14-point text, bold.
This is 18-point text, bold.
This is 9-point text, New York, and this is bold.
This is 12-point text, New York, **bold.**
This is 14-point text, New York, **bold.**
This is 18-point text, **bold.**

Figure 1: *A sample printout from the Macintosh using its printer and the MacWrite word-processing program. The printout was obtained using MacWrite's high-quality output mode, as opposed to the draft and ordinary quality modes. The output here is shown at 100 percent of actual size.*

or Command key down with my left hand while moving the mouse with my right. I find using the mouse faster, easier, and less disruptive than using function and cursor keys. Function and cursor keys do not fall within the standard touch-typing layout because they vary in size, number, position, and function. To use them, I have to stop and think about what key I need, look down at the keyboard, find it, hit it, and look up again. Often this process has to be repeated several times. With the mouse, I never take my eyes off the screen. I just reach to my right, grab the mouse, and do what I need to do.

Of course, the mouse isn't always a perfect solution. Some commands can be tedious to perform via the mouse and pull-down menu. For example, deleting text to the right of the cursor in MacWrite can only be done with the mouse. This is a nuisance if you have only one or two characters to delete. I'd also like the mouse's cord to be a little longer and sometimes I have trouble finding enough surface area to work the mouse, but these are minor complaints. The mouse is an excellent feature of the Macintosh.

User Interface

Macintosh's user interface is far different from those of other personal computers. Strictly speaking, it is not all that new. The original concepts were pioneered at Xerox's Palo Alto Research Center (PARC) several years ago. Apple used them heavily in the original Lisa machine, released a year before the Mac. However, that Lisa sold for $10,000, and the Xerox machines for much more. The people who most needed the interface were those who could least afford it: small businesspeople, students, etc. The Macintosh is still a bit expensive, but it's within the reach of far more people than any of its predecessors.

In creating the Macintosh's unique user interface, Apple has attempted to make the abstract seem concrete. Few things are as abstract as the data and programs stored and used on a computer. The Mac takes that abstraction and presents it as something familiar: a desktop cluttered with pencils, papers, manila folders, and even a wastebasket. Do you want to put a document in a folder? Pick it up with the mouse and put it in the folder. Do you want to throw something away? Pick it up and put it in the wastebasket. Abstractions take on real forms that we can understand and use without obscure commands or bizarre syntax.

Another important aspect of this user interface is the way in which the Macintosh makes commands available to the user. As I write this review with MacWrite, the top of my screen has an Apple symbol and six words (File, Edit, Search, Format, Font, and Style) written across the top. If I point at any of the items with the mouse and press the button, a menu of options appears on the screen. When I release the button, the menu disappears. All available commands appear in the menus. I haven't had to memorize or learn much; in fact, I opened my MacWrite manual only

(continued)

AT A GLANCE

Name
Macintosh

Manufacturer
Apple Computer Inc.
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010

Components
Size: 13.5 by 9.7 by 10.9 inches (main unit)
2.6 by 13.2 by 5.8 inches (keyboard)
Weight: 19.5 pounds
Processor: Motorola 68000 (7.8336 MHz)
Memory: 128K bytes of RAM; 64K bytes of ROM
Display: 9-inch built-in monitor; high-resolution bit-mapped display (512 by 342 pixels); adjustable
Keyboard: 58 keys, detached, standard layout, no function keys, software-mapped
Mouse: single button, mechanical tracking, optical shaft encoding
Mass storage: built-in single-sided 3½-inch Sony drive (400K bytes)
Sound generator: four-voice sound
Interfaces: two RS-422A serial ports (230.4K bps transfer rate); external-disk interface for second (optional) disk drive; mouse interface; synchronous serial keyboard bus

Operating System
Proprietary unnamed

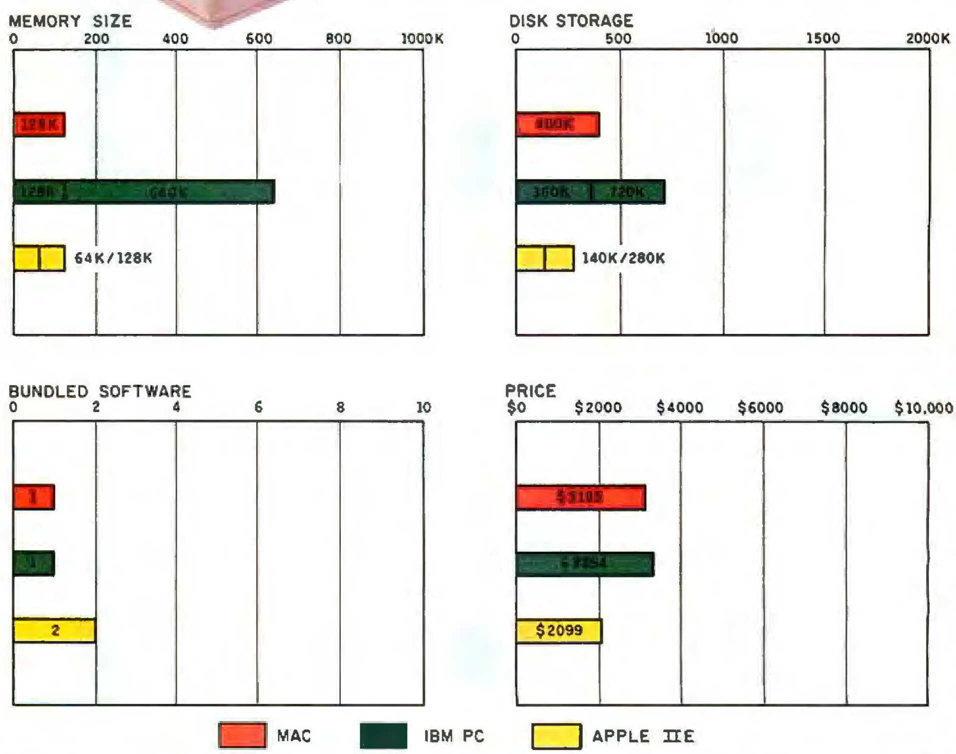
Optional Hardware

Imagewriter dot-matrix printer:	$595
Numeric keypad:	$99
Carrying case:	$99
Modem (300 bps):	$225
(300/1200 bps):	$495
Security Accessory Kit:	$49
Second floppy-disk drive:	$495

Optional Software
See text box

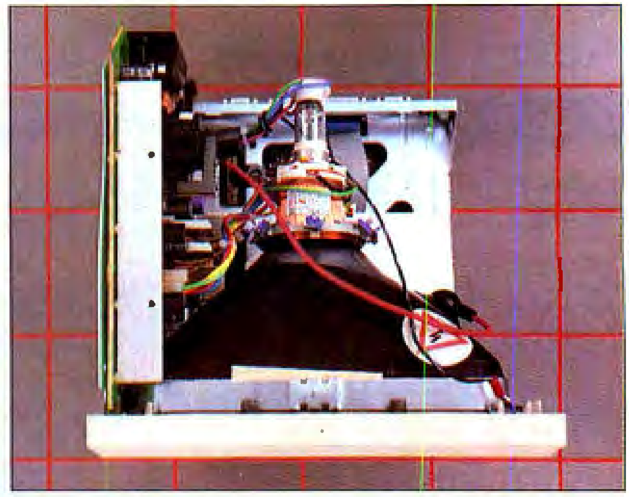
Documentation
160-page user's manual

Price
$2495 ($2990 with Imagewriter)

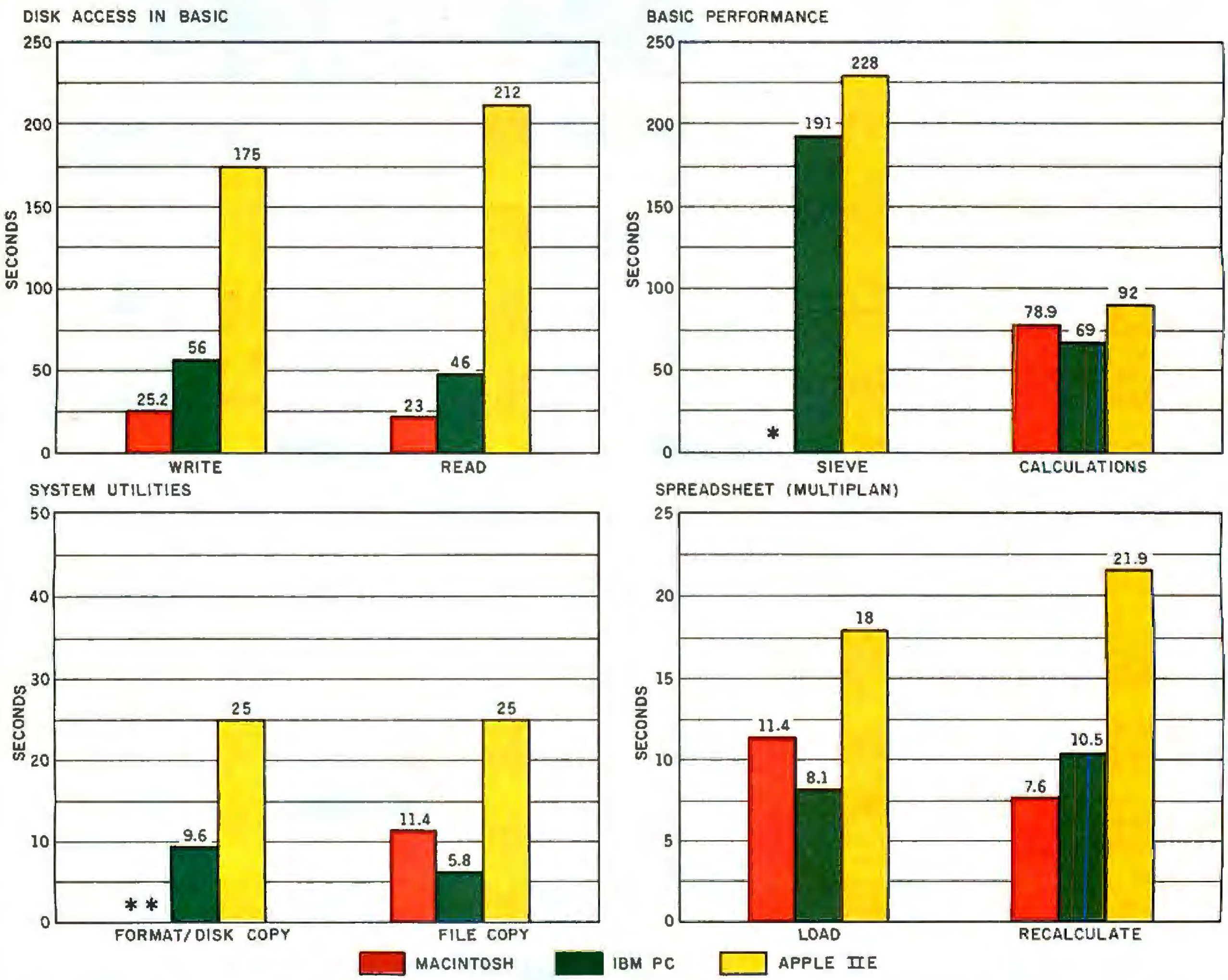


The Memory Size graph shows the standard and optional memory available for the computers under comparison. The Disk Storage graph shows the highest capacity of a single floppy-disk drive for each system. The Bundled Software graph shows the number of software packages included with each system. The Price graph shows the list price of a system with two high-capacity floppy-disk drives, a monochrome monitor, graphics and color-display capability, a printer port and a serial port, 256K bytes of memory (64K bytes for 8-bit systems), the standard operating system for each system, and the standard BASIC interpreter for each system. The Mac's price includes 128K bytes of memory only.

The rear of the Mac. Note the icon labels. The bottom row of connectors is for (from left) the mouse, second floppy disk, printer, modem, and speaker.



The top of the Mac with the cover removed. The disk drive and digital circuitry are below the cathode-ray tube; the analog circuitry is to its left.



The graph for Disk Access in BASIC shows how long it takes to write a 64K-byte sequential text file to a blank floppy disk and how long it takes to read this file. (For the program listings, see "The Chameleon Plus," by Rich Krajewski, June 1984, page 327.) The BASIC Performance graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. In the same graph, the Calculations results show how long it takes to do 10,000 multiplication and division operations using single-precision numbers. The System Utilities graph shows how long it takes 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 spreadsheet where each cell equals 1.001 times the cell to its left. The spreadsheet program used was Microsoft Multiplan. The time for the format/disk copy test on the Macintosh reflects using the disk-copy utility on a single-drive system. Four disk-swaps are required for the complete disk copy, the time for which is included in the benchmark.
*The Sieve benchmark couldn't be run on the Mac (see text for details).
**The new Disk Copy program was not available at press time.

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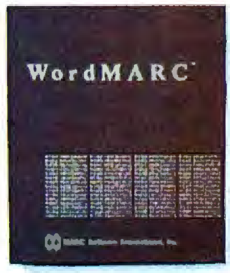

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once or twice, briefly. The same is true at the "desktop" level. Any actions can be performed via the pull-down menus or by direct "physical" manipulation of the objects shown. The best feature of the Mac documentation is that I almost never have to refer to it.

My one complaint about the user interface is that it's slow. Sometimes running a program or opening a file seems to take longer than it should. File copying on a one-drive system is also tedious.

A special disk-copy utility is now available that lets you copy an entire disk in just four swaps—not too shabby when you realize that this utility uses nearly 80 percent of the total RAM just to hold the data. Unfortunately, this utility won't solve the problem of copying several files onto a disk that's already formatted and in use. There is a simple solution: more RAM.

MEMORY LIMITATIONS

The 68000 is a powerful microprocessor but it has a limited environment in the Macintosh. The Mac comes with 128K bytes of RAM: less than 1/100th of the 16-megabyte RAM the 68000 could use, and there's no way to expand it. True, Apple is planning to upgrade the Mac to 512K bytes sometime in the future, but that still leaves 97 percent of the potential memory space unused and unusable. The Mac has no provisions for expanding memory beyond replacing the 64K-bit chips it currently uses with 256K-bit chips as they become available. It has no expansion slots and no external bus. And remember, this is a graphics-intensive environment where memory often gets eaten up rather quickly.

Apple is planning to upgrade the Mac to 512K bytes sometime in the future, but that still leaves 97 percent of the potential memory space unused and unusable.

So the question arises: why did the Macintosh design team so limit their machine? The most common reason I've come across is that the Macintosh team wanted to provide a standard environment for software developers and users (although the latter is less often cited). In other words, software developers know that a Mac will always have 128K bytes of RAM and users will never have to worry about software requiring more RAM than they have. The idea is sound, but it causes two problems. First, 128K bytes is *not* enough RAM for a standard, especially in the Macintosh environment, where graphics chew away at your free space. Second, there will be no standard for software developers when the 512K-byte upgrade becomes available. Many software developers are ignoring (or unable to use) the 128K-byte machine and will release their packages for 512K-byte machines only. Unless Apple plans a free update to all Mac owners, the standard environment will no longer be standard.

Another argument I've heard to support the concept of such limited memory is that the expansion slots were dropped to avoid power and cooling problems and to keep the user out of the machine. Again, this is a good idea if you provide sufficient resources in the unexpandable model. I have no complaints with Apple's choice of two RS-422A ports, an external disk port, the mouse port, and audio output. External video would be nice, but it isn't critical. But there's just not enough memory.

Others argue that 128K bytes of RAM is enough because so much of the work is done for you in the 64K-byte ROM. The ROM toolbox (the optimized 68000 machine-language routines that handle all aspects of the user interface) is truly a marvelous thing, but it doesn't change the fact that large, complex programs need lots of memory, *especially* if the displays are all graphical. A supporting argument points to MacPaint and MacWrite, saying, "See, these work fine!" Yes, they do, but both have easily reached limits. Furthermore, these programs were developed over a long period of time, concurrently with the Macintosh. The authors of these programs knew a lot about optimizing code for the Mac. Software developers with less time and more ambitious designs will find the lack of RAM a serious roadblock.

I also have heard that the upgrade to 512K bytes will eliminate all such problems because there will be more than enough RAM for any application. Again, I disagree. You can never have enough RAM. I think it no accident that the

(continued)

Photo 3: *The Macintosh keyboard. Note the absence of a control key, but the presence instead of a "cloverleaf" key just to the left of the space bar. This key performs several of the functions usually performed by a control key.*

Thinking of buying a modem? You owe it

Inside Outside

to yourself to check out the Qubie' 212A modems.

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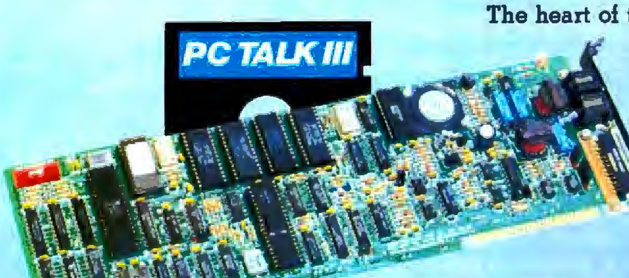

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Apple says the 68000 is much better than the 8086/8088 chips used in the IBM PC and its compatibles, yet they can use more RAM than the Mac.

Commodore 64, with 64K bytes, has dominated the low-end market over machines that have (or had) 8K, 16K, or 24K bytes. Apple gave the IIc, which uses an 8-bit 6502 chip, 128K bytes of RAM. Why the company limited the 68000, a 32-bit chip, to the same initial amount of memory is beyond me. Even the fourfold upgrade is too limiting. Apple delights in stating how much better the 68000 is than the 8086/8088 chips used in the IBM PC and compatibles, yet most of those systems can use more RAM than the Mac. Where's the advantage?

Obviously, I think that 128K bytes is not enough RAM to make the Macintosh a truly powerful machine. My attempt to run the Sieve of Eratosthenes benchmark on the Mac provides one indication of its RAM limitations. Once BASIC was loaded into the Mac, there was too little space left in memory for the Sieve program. To fit the program into memory, I had to declare all variables integer. This will, of course, speed the execution time considerably. Thus, the speed of the Mac Sieve is not commensurable to the other two systems. (If you are curious, the modified benchmark took 96.4 seconds on the Mac.) The upgrade to 512K bytes will help considerably, but it's still an inexcusable limit. I am convinced that this limited RAM has held up the release of Mac software. As I write this, it has been three months since the Macintosh was released, and all the Apple dealers in town have only three software packages for the Mac besides MacPaint and MacWrite, which are still bundled. Mac should have had at least double the initial and upgrade RAM, i.e., 256K bytes and 1 megabyte, respectively. It may be that Apple will release yet another upgrade when 1-megabit chips become available in mass quantities, or they may just release a new machine.

Although the RAM is a limitation on the Macintosh, the ROM is a tremendous strength. In what is undoubtedly one of the marvels of modern programming, the Macintosh design team crammed an unbelievable amount of power into the 64K bytes of ROM in the form of tightly written, highly optimized machine code. In doing so, the team provided standard user interfaces so that most application programs on the Mac will be used in similar forms. I tried

(continued)

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A Second Opinion

BY J. EDWARD CHOR

The Macintosh is advertised as a 128K-byte machine. In reality, the Finder (Macintosh's operating system) and other systems software take about 40K bytes. Subtract from this another 40K to 70K bytes for any applications programs that may be in memory and the 128K-byte Macintosh becomes an 18K- to 38K-byte machine. For example, when Mac's Microsoft BASIC package is loaded on top of the resident software, there is only 13K bytes of space for programs and data left. Similarly, MacWrite, Macintosh's word-processing program, only allows documents with a maximum size of about 24K bytes. This problem seems to be an inherent limitation in the current design of the Macintosh because there is no way to expand the memory capacity of the machine. When 256K-bit memory chips become available the Macintosh will be upgraded to a 512K-byte machine, enough space for the most ambitious application programs. However, at the time of this writing these chips are only in the development stage. This means that they will not be commercially available before 1985.

DISK SWAPPING

Closely related to the memory limitations is the problem of "disk swapping." Because the basic Macintosh system has only one disk drive, transferring data from one disk to another requires that the Macintosh read from the input disk, eject the input disk, and prompt the user to insert the output disk. After sending the data to that disk, it is ejected and the user is told to reinsert the input disk. This cycle is repeated until the data transfer is complete. Initially, this shuffling of disks seemed to be tolerable. At least I thought it was until I attempted to back up a disk with 270K bytes of data on it. It took more than 50 disk swaps and 20 minutes to perform this simple operation. This works out to an effective transfer rate of about 5K bytes per swap. The process becomes even more hectic when the Mac has to consult systems software during the transfer. The user must then swap three disks in and out of the internal drive. Unfortunately, this is precisely the kind of design flaw that will prevent the Macintosh from gaining widespread acceptance in a business environment. Disk backups are absolutely essential to business applications. Therefore, the need for a second drive is a hidden and unadvertised cost of owning the machine.

All things considered, the Desk Accessories (accessory programs that can be run at the same time as another program) are an excellent complement to the Finder. These accessories are available to the user at all times, regardless of the application program that may be resident in memory. This means, of course, that users will be able to cut and paste between diverse application programs. Although not as sophisticated as Lisa's information-passing capability, the Macintosh currently is the only machine in its price range that provides this feature as a system-resident function. However, sometimes the Finder does its job too well. If there are two or three disk icons present on the desktop, each with a copy of the System Folder, calling up a Desk Accessory such as the Alarm Clock will cause the Finder to request that the disk under which the system was initialized be inserted. The Finder then gets the data pertaining to the Desk Accessory from that disk's System Folder instead of using the System Folder of the disk that was in the internal drive. After the Finder gets that information, the user must then reinsert the disk he or she was originally working with to display the accessory. Although not a major inconvenience, this procedure does become somewhat aggravating when one wants to do a simple thing like set the Alarm Clock.

PROGRAMMER'S PERSPECTIVE

Nothing much has been said about Macintosh from the programmer's point of view. Unfortunately, the reason for this is that there is very little to say. The Macintosh is the only machine in recent history to be offered without a programming language. However, Apple has promised assembly language, BASIC, and Pascal for the Mac. As of April 1984 none of these packages was being marketed. The only language currently available, Microsoft BASIC, is extremely disappointing. Programs written with it will essentially look like MBASIC programs written for the IBM PC. Even when Apple's language packages for the Macintosh are released, users should not expect to be able to produce application programs that utilize Macintosh features like the menu bar, dialogue boxes, and windows. Because any language that is run on a Macintosh will be treated like an application program, these routines will be inaccessible to programs created at a lower level than the application program that uses those features. The Macintosh applications that use those features are being done currently in one of two ways. They are either created on a Lisa and downloaded to the Mac, or two Macs are used in tandem (one for writing the program and the other for running it). Developing software in this fashion can be an expensive proposition.

Although Apple has indicated that programmers will be given assistance in developing application programs for Macintosh, in fact this assistance will be available only to a certain chosen few, i.e., established software houses or individuals who have a proven track record of commercial success. Of course, one can always purchase the technical manual for Macintosh, which presumably contains all of the information regarding the highly touted Macintosh toolbox, and attempt to develop Mac applications from scratch. It can be obtained from Apple for $150. Regrettably, it is unlikely that a "cottage industry" will grow up around the Mac in the same way that one grew around the Apple II. But in spite of its shortcomings, the Macintosh is a significant advance in user-friendly computing.

J. Edward Chor (1307 West Addison St., Chicago, IL 60613) is an attorney. He received his B.A. in psychology from Eastern Illinois University and his J.D. from Southern Illinois University. His hobbies include reading, sports, and fiddling with machines.

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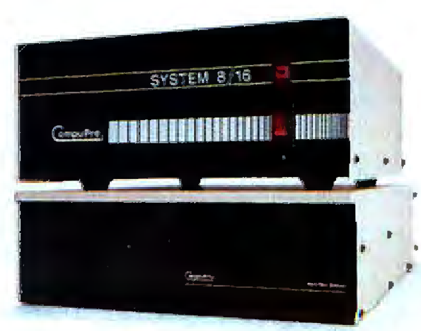

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Software for the Mac

When I bought my Macintosh in mid-February, three software packages were available for it: MacWrite/MacPaint, which Apple developed and gave away with the system, and Microsoft Multiplan and Microsoft BASIC (Microsoft has been working with the Mac for two years.) By the end of April, the number of available packages had climbed to four: MacFORTH, from Creative Solutions Inc. (CSI) had hit the shelves. (CSI already had a commercially available 68000-based FORTH.)

By the time you read this, the trickle of Mac software should have grown modestly. The torrent probably won't hit until early 1985 when the 512K-byte, two-disk Macintosh emerges as the new standard and software firms have a year of development under their belts. The 512K-byte Mac will increase the flow of software in another way. With the extra RAM, individuals will be able to develop Mac software without having to buy a Lisa. Programs will be able to do fancier things because graphics capability increases as memory does. And the programs themselves will not have to be as tightly coded to fit into available memory; therefore, they will be developed more quickly. I think the result will be a flood of programs, both public-domain and entrepreneurial.

MacWrite and MacPaint

Both MacWrite and MacPaint are great. Get them, use them, and have fun with them.

MacWrite gives you nine different fonts, six different point sizes, five different *styles (mix and match)*, and superscripting and subscripting. The program has three types of spacing, four types of justification, adjustable margins, and two kinds of tabs. It also has headers, footers, rulers, and page breaks. And it has a screen that shows you what you're going to get and a printer that gives you what you saw. The result: the fanciest letter and report writer you ever saw. I don't think I'd use it to write a book, though. The amount of text you can edit is too limited and some things (such as pulling in or appending files) are awkward or impossible. Still, it's great fun.

An example of MacPaint on the Macintosh.

MacPaint is also destined to be a classic. Admit it: you've always wanted to draw nice pictures but you haven't had the time to learn the necessary skills. Enter MacPaint (see the photo on this page). In seconds, you can create images that would take you hours by hand (if you could do them at all). Children and adults can learn to use it in an amazingly short time (a tribute to Bill Atkinson). My boss and I laid out a 16-page manual for a new software product in two days, complete with borders, boxes for illustrations, and varying type sizes (MacPaint will generate text). We also designed the disk labels and drew up specs for some booth props we had built. However, you can only draw in a 3- by 5-inch window, which in turn moves around on an 8- by 10-inch area. The small drawing window makes large pictures tedious, especially if you're trying to put in text that is wider than the window. But this is a minor problem. MacPaint is a perfect example of what's amazing and fun about the Macintosh.

MacWrite/MacPaint is available from Apple Computer Inc. (20525 Mariani Ave. Cupertino, CA 95014) for $195.

Multiplan

Microsoft Multiplan is a Macintosh version of a standard spreadsheet. Not so standard are the crisp display, pull-down menus, and ease of cell manipulation via the mouse. The worksheet is limited to 63 columns and 255 rows, but these figures should increase once the 512K-byte machine becomes widely available.

I found Multiplan easy to use—easier, in fact, than any other spreadsheet I've used. But I do have a few complaints. The documentation assumes a fair amount of knowledge on the part of the user, a poor assumption considering the Macintosh's market. For example, this is the documentation for conditional expressions:

IF(*logical-expression,value-if-true,value-if-false*)

The IF function evaluates the logical expression, then returns the value-if-true if the expression is TRUE; or it returns the value-if-false if the expression is FALSE.

There are no examples and no explana-

some prerelease programs with no documentation and I was able to use them almost immediately. Try that under CP/M or MS-DOS. The ROM toolbox is a vital facet of the overall amazing nature of the Macintosh.

The Macintosh also lacks adequate mass storage. At first, it doesn't look bad: it consists of one single-sided 3½-inch built-in disk drive (made by Sony) holding 400K bytes. Having only one disk drive can be a nuisance, but it's acceptable if the drive holds enough data and if you can copy it easily. However, the system files on a Macintosh disk take up over 200K bytes, or half the disk. Even with trimming, you only have about 220K bytes of usable space on a bootable disk. If any other company marketed a CP/M or MS-DOS system with a single disk drive with only 220K bytes of free space, no one would buy it. It takes a lot of time and disk swapping to copy files or to back up a disk. The Mac's only saving grace on this point is that it automatically ejects the disk and prompts you for a new one.

The 128K-byte Macintosh with one single-sided drive is not a powerful machine. You can do useful work with it, and the user interface beats all others cold. But for the same price or less, I could go out and buy, for example, a Compaq with 256K bytes of RAM and two 360K-byte disk drives. And I could get *lots* of software for it—programs that can handle larger, more difficult tasks than the Mac currently can.

The upshot is this: a $3000 Macintosh,

tion of what a "logical expression" is or how it resolves to true or false. The index refers us to the definitions of NOT or OR; the latter gives us a little more information and one complex example (demonstrating IF, OR, AND, and NOT). This will be confusing to novice users.

But consider getting Multiplan anyway. Not only does it work well, it can share its information with other Microsoft programs, such as BASIC, Word, Chart, and File. The program is available from Microsoft Corporation (10700 Northup Way, Bellevue, WA 98004) for $195.

MICROSOFT BASIC

Microsoft BASIC is fairly standard. It does have lots of Mac-specific graphics calls. However, most of the them are poorly documented: instead, the documentation refers you to the *QuickDraw Programmer's Guide*, which doesn't come with the system.

The BASIC itself runs in an environment with three windows: Command, Output, and List. All commands, typing, and editing take place in the Command window; program output and echoed commands show up in the Output window; and program text is seen in the List window. It all works nicely, although I find a few things annoying. The Command/Output window dichotomy can cause problems, especially when the Output window insists on writing text behind the Command window (and nowhere else). Also, the List window has a tendency to propagate itself, so that you end up with several List windows stacked behind each other.

Even with its shortcomings, Microsoft BASIC is useful. Several public-domain programs for it have already shown up on computer bulletin boards, including a terminal-emulation program and a 68000 disassembler. The program is available for $195 from Microsoft Corporation (10700 Northup Way, Bellevue, WA 98004).

MACFORTH

MacFORTH (Level 1) lets you do amazing things on the Macintosh. You can create windows complete with close and size boxes and "attach" programs that will execute automatically when a given window is activated. You can build your own pull-down menus with check marks, inactive items, and command-key options. In fact, you could code your own application and have it "take over" the Mac, putting up its own menu bar and controlling all the windows.

The only catch to all of this is that you have to learn FORTH, a programming language unlike any other. FORTH isn't difficult to learn, but it can be a bit confusing to use because of its stack orientation and "reverse Polish notation" syntax. CSI's Going FORTH module helps a bit. Going FORTH is a clever program that sets up two side-by-side windows. One window steps you through an introduction to FORTH. The other is an active FORTH window, where you can try out the things you're learning. Also, each chapter in the printed documentation is a tutorial on a given subject (menus, windows, etc.) with lots of examples to key in and try out.

I think CSI has developed a solid FORTH implementation. (I programmed in FORTH professionally for a year, but I am by no means an expert.) The window, menu, and graphics functions are well done and easy to use. For example, if you create a window called Easel, and a program to run within Easel called Sketch, the FORTH command EASEL ON.ACTIVATE SKETCH links Sketch to Easel. If you select the Easel window with the mouse, the Sketch program will automatically start executing.

All in all, CSI has done an excellent job. It has made FORTH relatively easy to learn. The documentation is easy to read and use, although the glossary can be cryptic to a FORTH neophyte. Best of all, CSI has unlocked a lot of the Mac's power. FORTH produces very compact code, which means that the Mac's limited RAM isn't so limited anymore.

CSI has three levels of MacFORTH. I reviewed Level 1 ($149), which is designed as an introductory package. It does all the things I mentioned, but it doesn't support real (floating-point) numbers or all of the ROM toolbox routines. Level II ($249), aimed at in-house developers, has real numbers and advanced graphics as well as provisions for inserting 68000 assembly routines. Level III ($2500) is for software developers interested in marketing programs developed in MacFORTH. It includes technical support, a run-time package, and licenses for 250 copies. Additional licenses cost $5 per copy.

If you want to make your Mac do things, get a copy of MacFORTH and have fun. MacFORTH is available from Creative Solutions Inc. (4801 Randolph Road, Rockville, MD 20852).

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with 128K bytes of RAM, a 400K-byte disk drive, and an Imagewriter printer, is an amazing machine but not really a powerful one. A 512K-byte Mac with two 400K-byte disk drives is both amazing and powerful, but it is also expensive ($3500, including printer and not counting any cost for the RAM upgrade). In the two-and-a-half months that I've owned my Mac, I've often wondered if I should have bought one so quickly. However, the arrival of MacFORTH (see the text box "Software for the Mac" on this page) has done much to quell my reservations. I can now create my own windows, graphics, and pull-down menus, and the "fun quotient" of my Mac has made a quantum leap. Besides, I suspect that by the time this sees print, prices will have dropped and the software base will have expanded considerably.

CONCLUSION

You won't find another machine that's as easy to use or as much fun as the Macintosh. In the right configuration, it can do as much as any microcomputer on the market. However, you should go for a 512K-byte system with two disk drives and a printer. Anything less and you'll find yourself frustrated by the machine's limits.

I have no doubt that I would have bought a Macintosh sooner or later, and I have no intention of getting rid of the one I own. The Mac's a gem—rough, slightly flawed, but a gem nonetheless. ■

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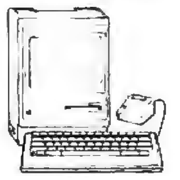

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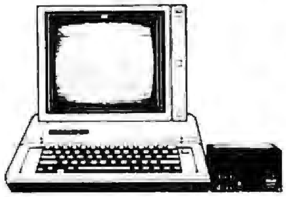

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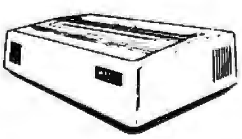

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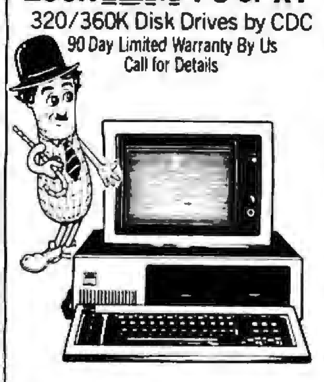

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The IBM PCjr

Impressive but disappointing

BY ROWLAND ARCHER JR.

The IBM PCjr makes a good first impression. It is slickly packaged, easy to set up and use, and gives an overall impression of quality. It is lightweight compared to the IBM PC, primarily because of its plastic case (the PC's case is metal.) Clearly, IBM took some time in deciding how to pack the system and guide the first-time user. For example, the design of the connectors makes it virtually impossible to plug the wrong peripheral device into a jack. This is a good thing because the jacks, located on the back panel, are labeled sparsely. (See the photo in the "At a Glance" spread on page 258.)

The IBM PCjr's options are also easy to install, requiring at most a flat-blade screwdriver. As with the back-panel connectors, you cannot plug an option into the wrong motherboard connector. I never had to set a DIP (dual-inline package) switch or change a jumper while installing options, a welcome relief from the PC. PCjr's software notices newly installed options and adjusts automatically.

On the minus side, the PCjr's plug-in cards are wobbly, with no card guides or tie-downs. I haven't seen any adverse effects from this, but it is unsettling.

Specifications Overview

The PCjr is highly compatible with the IBM PC. It uses the same Intel 8088 microprocessor, runs the same PC-DOS version 2.1 disk operating system, and can use many of the same application programs. It comes in two basic models and many extra-cost options are available. The least expensive model retails for $599; it includes 64K bytes of RAM (random-access read/write memory), a color-video controller for use with your TV set, an RGB (red-green-blue) or composite monitor, a three-voice sound generator, a cordless keyboard, and two slots for plug-in ROM (read-only memory) program cartridges (see photo 1).

No display device is included in the base price. You must either use your TV set, in which case you will need the TV adapter; an RGB monitor, which requires the RGB monitor adapter; or a composite monitor, which requires a cable with an RCA phono plug at one end and the appropriate connector for your monitor at the other.

The enhanced version of the PCjr costs $999 and includes all the features of the base model plus 64K bytes more RAM (for a total of 128K bytes), 80-column video display capability, and a built-in half-height 5¼-inch floppy-disk drive that holds 360K bytes. Each of these is also available as a separate option to the base-model PCjr. Additional options include Cartridge BASIC (a ROM cartridge incorporating an enhanced BASIC that is compatible with the PC's BASICA), a TV connector (radio frequency, or RF, modulator), cassette recorder cable (IBM does not sell a cassette recorder), an internal modem, a thermal printer, one or two joysticks, a parallel-printer adapter, and a keyboard cord that replaces the infrared link.

IBM also announced several new software packages concurrently with the PCjr. These packages demonstrate IBM's intention to sell the PCjr to families and schools; they include easy-to-use home applications, arcade-style games, and some game-based math programs.

Keyboard

Most reviewers have roundly jeered the PCjr's keyboard. I wish I could report that it seems better after a couple of months of use, but it doesn't. As photo 2 shows, the keyboard has widely separated keys with no legends on them. The definition of each key is printed on the grid between the keys. This lets software vendors provide keyboard templates that give a label for many keys, as Sierra On-Line does for the HomeWord word processor, which I'll discuss later.

Unfortunately, it also means that you have to lean over the keyboard or tilt it toward you to read the legends. The keys themselves have a mushy feel, most unpleasant for touch-typing. I get the impression that IBM designed this keyboard for children, and perhaps that's why I don't like it.

The keyboard's cordless feature is of questionable value. Besides being one more thing to buy batteries for, it is direction sensitive. If you put the keyboard in your lap, its signal will not reach the system unit (IBM's lingo for the main computer box) unless it is pointing right at it. If you place the keyboard in your lap and sit within the 20-foot acceptable distance from the system unit, it is easy to tilt the keyboard out of contact with the receiver. Contact is also lost if someone or something passes between the keyboard and the system unit. And if the keyboard sits on a table in front of the system unit, being cordless doesn't add much.

The PCjr's keyboard has only 62 keys (the IBM PC has 83). However, it can produce all the PC's key codes through multiple keystrokes (see table 1). For example, on the PC, function code 1 is generated by hitting F1; on the PCjr you must first hit the key labeled Fn, then the 1 key, which is also labeled F1. The PCjr *Technical Reference* manual refers to "the 62-key keyboard and the 83-key keyboard," so perhaps relief is around the corner in the form of an unannounced, full-size keyboard.

The keyboard is the PCjr's major weakness. Alternative keyboards are available already, but if you add the price of a keyboard from an outside vendor, the PCjr's costs creeps closer to that of the IBM PC.

VIDEO

The PCjr's video circuitry is an extension of the IBM PC color-graphics adapter. Its video controller is built into the system motherboard, rather than on a plug-in card like the PC's. Table 2 summarizes the modes available for text and graphics display. In addition to having all the PC color card's modes, the PCjr has some extended modes: 16 colors in 320- by 200-pixel format, and 4 colors in 640- by 200-pixel format. These give the PCjr an edge over the PC in color displays. Note that you need the 128K-byte memory option with the video-display adapter to enjoy 80-column text and the enhanced graphics modes.

As mentioned before, the PCjr comes with outputs for a composite monochrome or color monitor (RCA jack), an RGB color monitor such as the IBM color display, and a connector for an RF modulator to drive a color TV set. There is no support for the IBM PC monochrome display.

Most programs that run on the IBM PC color-video card will run on the PCjr video controller. However, the two differ in memory usage; the PCjr's video memory comes out of main-system memory rather than separate memory like that of the PC's display-adapter cards. Up to 16K bytes is used in the IBM PC's graphics modes, so some PC graphics programs that run in 128K bytes will not run on a 128K-byte PCjr because it has insufficient memory.

For speed, some programs store text directly into video memory, the area used by the video-controller circuitry to refresh the screen. The PCjr's video memory is located at the top of user memory, while the PC's color-card video memory is at location B8000 hexadecimal. IBM uses a hardware trick to allow programs that access this memory directly on the PC to function on the PCjr. References to B8000 hexadecimal are automatically redirected by the hardware to the PCjr's video-

(continued)

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Photo 1: *The IBM PCjr is slickly packaged, easy to set up, and gives an initial impression of quality, although it may disappoint more demanding users.*

memory location. No such compatibility with the IBM PC monochrome-display adapter is provided, so programs that access the monochrome display's refresh memory directly, with no support for the PC's color-display card, will not work on PCjr.

There are a few other minor differences between the PC's color video controller and the PCjr's. The PC turns color on by default; the PCjr turns color off. The PCjr includes a keyboard function that shifts the visible part of the display left or right to center it on the screen (this is especially useful on TV sets, which frequently have displays that are off center).

Disk Drive

The PCjr uses a half-height 5¼-inch floppy-disk drive that is compatible with the IBM PC's. You can freely interchange disks between the two machines. The drive in my PCjr was manufactured by Qume. It is double-sided double-density with 360K bytes per disk.

If you start with the base-model PCjr, you can add the disk drive later. Installation of the drive is easy: remove the face plate covering the disk-drive hole in the front panel, plug in the controller board, hook up the power and controller cables, and snap the drive into place.

Half-height drives have different timing parameters than full-size drives, and some software (a very few programs) will not function properly on them. In particular, copy-protection schemes that directly program the disk controller may cause a program to fail on the PCjr.

A more bothersome difference between the PC and the PCjr is the lack of DMA (direct memory access) on the PCjr's disk controller. The PC has DMA, which means that the disk controller can transfer a block of data from the disk to memory without intervention from the PC's central processor while each byte of data is transferred. The PCjr's designers saved money by keeping the circuitry simple and letting the main microprocessor handle the data. The net result is that, while the disks are active, other processing stops. The most annoying consequence of this is that keyboard type-ahead is ignored while the disks are active. This probably would not bother me if I were not used to the fact that I can type ahead on the PC. However, there are times when this is annoying. For example, if you use the Fn key plus Pause to control the display of a disk file, the PCjr frequently beeps when you press the key while the disk is active.

The restriction this places on simultaneous communications and disk-drive activity is perhaps more severe. You cannot download data from a communications line (modem or RS-232C port) directly to a disk file, unless your communications program can notify the remote machine to stop sending data temporarily while it saves its full buffer to disk.

The PCjr manual warns about a design limitation that I never witnessed. Ac-

(continued)

Table 1: IBM *creates all* 83 IBM PC *keyboard codes with the PCjr's* 62 *keys. Some commonly used single-key sequences on the PC, such as* Page Up *and* Page Down (PgUp, PgDn), *require two keystrokes on the PCjr.*

IBM PC Key Code	PCjr Equivalent
F1 — F10	Fn then F1 — F10
Shift F1 — F10	Shift Fn then F1 — F10
Ctrl F1 — F10	Ctrl Fn then F1 — F10
Alt F1 — F10	Alt Fn then F1 — F10
Ctrl Break	Fn Break
Ctrl End	Ctrl Fn then End
Ctrl PrtSc	Fn then Echo
Ctrl Home	Ctrl Fn then Home
Ctrl Num Lock	Fn then Pause
Ctrl PgDn	Ctrl Fn then Pg Dn
Ctrl PgUp	Ctrl Fn then Pg Up
Shirt PrtSc	Fn then Prt Sc
Scroll Lock	Fn then Sc Lock
Num Lock	Alt Fn then N
PgUp	Fn then Pg Up
Pg Dn	Fn then Pg Dn
Home	Fn then Home
End	Fn then End
\	Alt /
`	Alt '
|	Alt |
~	Alt |
Numeric keypad numbers	Alt Fn then number
Numeric keypad –	Fn then –
Numeric keypad =	Fn then =
Numeric keypad .	Shift Del
PrtSc *	Alt .

Photo 2: *The infamous PCjr keyboard features widely spaced keys and legends that are hard to read from a normal typing angle.*

AT A GLANCE

Name
IBM PCjr

Manufacturer
IBM Corporation
POB 1328
Boca Raton, FL 33432

Dimensions
System unit: 13.9 by 11.4 by 3.8 inches high
Weight: 5 pounds 8 ounces; 8 pounds 4 ounces with disk drive
Keyboard: 13.5 by 6.6 by 1 inches high
Weight: 1 pound, 6 ounces with batteries

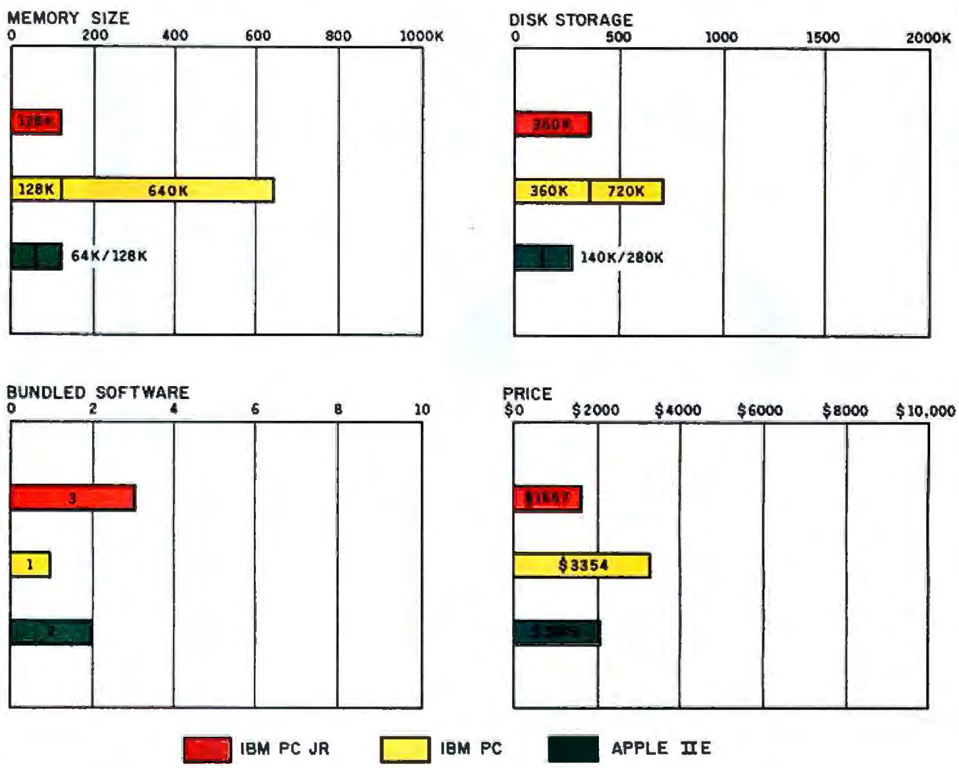
Features
Intel 8088 16-/8-bit microprocessor operating at 4.77 MHz, 64K bytes of RAM, 64K bytes of ROM, slots to plug in up to 128K bytes more ROM, one RS-232C serial port, 40-column video output for RGB (red-green-blue) or composite color monitor, or television with optional RF (radio frequency) modulator, single-voice beeper, three-voice sound generator with external audio output, cassette port (recorder not supplied), two joystick inputs, and cordless 62-key keyboard.

Software
Cassette BASIC, tutorial disk, and sample disk

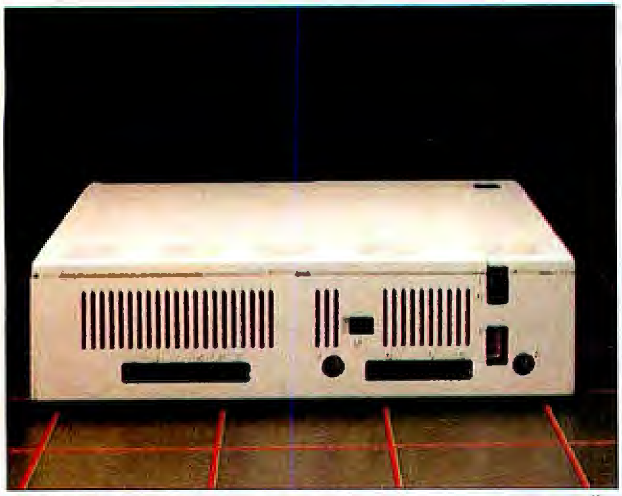
Hardware Options
RF modulator for TV connection: $30
360K-byte disk drive: $480
64K bytes RAM/80-column video: $140
Parallel-printer adapter: $99
Internal 300-bps direct-connect modem: $199

Software Options
PC-DOS 2.10: $65
Cartridge BASIC: $75

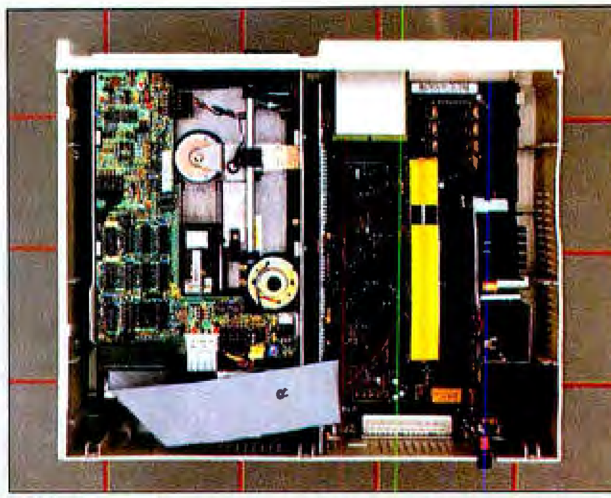
Documentation
Guide to Operations and *Hands-On BASIC*



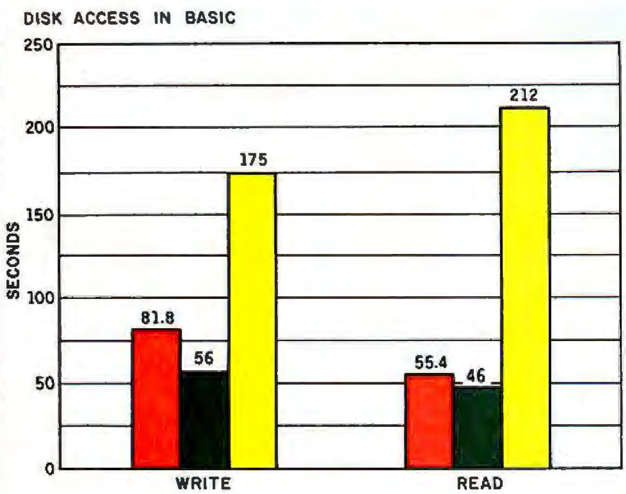
The Memory Size graph shows the standard and optional memory available for the computers under comparison. The Disk Storage graph shows the highest capacity of a single floppy-disk drive for each system. The Bundled Software graph shows the number of software packages included with each system. The Price graph shows the list price of a system with two high-capacity floppy-disk drives, a monochrome monitor, graphics and color-display capability, a proprietary serial printer port, 256K bytes of memory (64K bytes for 8-bit systems), the standard operating system for each system, and the standard BASIC interpreter for each system. Note that the IBM PCjr standard system includes the maximum of one floppy-disk drive, an IBM color monitor, and 128K bytes of memory.

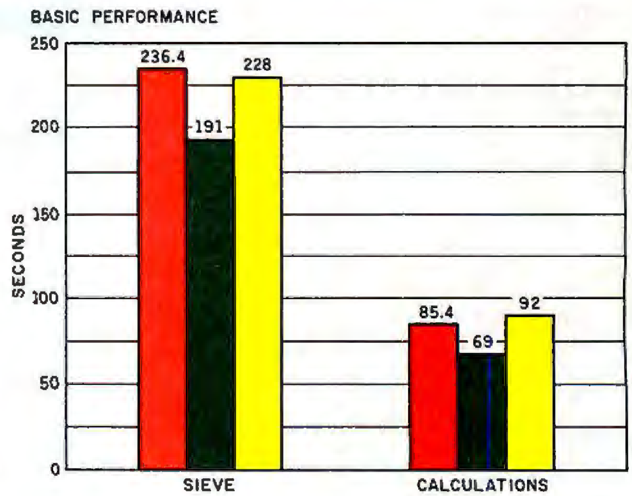


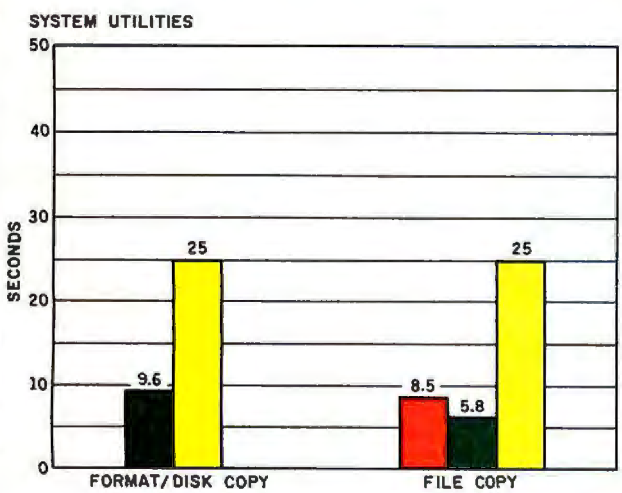
Connectors for a wide variety of input/output devices are minimally labeled on the back of the PCjr.

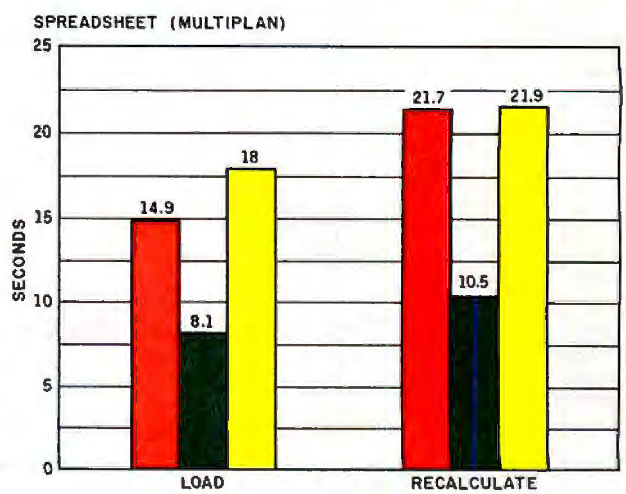


Taking the top off the enhanced IBM PCjr reveals the disk drive and controller card, 64K-byte memory add-on card, and power supply.









IBM PC JR IBM PC APPLE IIE

The graphs for Disk Access in BASIC show how long it takes to write a 64K-byte sequential text file to a blank floppy disk and how long it takes to read this file. (For the program listings, see "The Chameleon Plus," by Rich Krajewski, June, page 327.) The BASIC Performance graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark and also how long it takes to do 10,000 multiplication and division operations using single-precision numbers (see the Calculations results). The System Utilities graphs show low long it took to format and copy a disk (adjusted time for 40K bytes of disk data) and to transfer a 40K-byte file using the system utilities. The Spreadsheet graph shows how long the computers took to load and recalculate a 25- by 25-cell spreadsheet where each cell equals 1.001 times the cell to its left. The spreadsheet program used was Microsoft Multiplan. Note that because the PCjr has only one disk drive, the Format/Disk Copy graph is not applicable and File Copy was done to another part of the same disk.

cording to the documentation, disk errors can occur if you place your monitor or TV set within 6 inches of the disk drive. This includes the obvious position for a monitor—on top of the PCjr. Maybe I was lucky, but I never had a problem when I left mine on top of the system unit. If you heed IBM's admonition, you will find that the PCjr has a large "footprint"; i.e., it takes up a lot of room on your desk.

Cassette Tape and ROM Cartridges

The base-model PCjr supports two modes of program loading: cassette tape and ROM cartridge. Cassette-tape format is compatible with the PC. BASIC has commands to save and load programs and data files on tape.

The ROM cartridge is unique to the PCjr, and it seems to be IBM's preferred method of software distribution for non-disk software. Each ROM cartridge can hold up to 64K bytes of memory. There are two cartridge slots. The ROM in the cartridges can be programmed to replace the ROMs in the system unit. This means that you can replace the PCjr's "personality" with a completely different ROM-based package.

The *Technical Reference* manual gives instructions for programming a ROM cartridge to contain new DOS (disk operating system) commands, which will be added to the DOS's vocabulary when the ROM is plugged in. Cartridge BASIC uses this technique. When it is installed, the terms "BASIC" and "BASICA" invoke Cartridge BASIC, rather than causing DOS to look for a file on disk to run.

When ROMs are inserted or removed, the PCjr performs a warm restart sequence. This can be annoying. For example, if you boot a disk that requires Cartridge BASIC, you must insert the BASIC cartridge, causing the boot sequence to start all over again. On the other hand, if you leave the BASIC cartridge in one slot, it will remain available to the system, and you can use the second slot for other ROM cartridges.

Sound

The IBM PCjr's built-in sound capabilities are superior to the PC's.

The PCjr's sound capabilities are superior to the PC's, though the built-in speaker does not handle low notes as well.

There are two ways to produce sound on the PCjr. One is like the PC's, which uses a timer chip and a small speaker. The PCjr's speaker is a tiny piezoelectric one; it does not handle the low notes as well as the PC's speaker (which is not exactly a woofer itself).

The PCjr's second sound-generation method uses a TI (Texas Instruments) 76496 complex-sound generator chip, capable of producing three voices simultaneously. There is also a white-noise generator for sound effects. All channels can be controlled independently, mixed together, and fed to your television speaker, or through an RCA jack to any external amplifier (such as a spare input on your stereo system). Even though there are four sound sources in the TI chip, there is only one channel of sound output from PCjr, so stereo sound is not available.

Cartridge BASIC supports both the internal, single-voice speaker and the external, three-voice-plus-noise-channel sound output. BASIC's SOUND and PLAY statements can control each of the three voices individually, so successive SOUND statements to different voices result in chords. The volume of each voice can be controlled over a range of 15 increments. The BASIC NOISE statement controls the sound chip's white-noise generator. A creative programmer can have lots of fun creating some great sound effects and music on PCjr.

BASIC

The PCjr comes with a version of BASIC in ROM just like the BASIC in the PC's ROM. This is referred to as Cassette BASIC because it uses a cassette tape recorder (not supplied) for program and data storage. Cassette BASIC has no commands to support the disk drive.

Because the PCjr has limited memory,

(continued)

Table 2: *Summary of video-display modes available on the PCjr. The first group contains the IBM PC-compatible modes. The second group contains the PCjr's extended modes.*

PC Color-Card Compatible Modes:

Text Modes	Graphics Modes
40 by 25 — B&W	320 by 200 — 4 colors
40 by 25 — Color	320 by 200 — B&W
80 by 25 — B&W (1)	640 by 200 — B&W
80 by 25 — Color (1)	

PCjr Enhanced Color-Video Modes:

Graphics Modes
320 by 200 — 16 colors (1)
640 by 200 — 4 colors (1)
160 by 200 — 16 colors

(1) These modes require a 128K-byte PCjr

Table 3: A *comparison of memory (bits) available for* BASIC *programs and data in the* PC *and* PCjr, *given* 64K *bytes and* 128K *bytes of* RAM. *The* PCjr's *Cartridge* BASIC *is comparable in function to the* PC's BASICA.

	IBM PC		IBM PCjr	
	64K byte	128K byte	64K byte	128K byte
Cassette BASIC	61404	62940	45020	62940
Disk BASIC	23563	60891	n/a	n/a
BASICA	13335	60455	n/a	n/a
Cartridge BASIC	n/a	n/a	41744	59694

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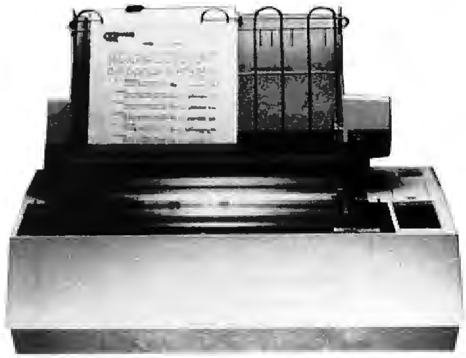

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IBM decided to provide the functions of the PC's advanced BASIC (BASICA) in the optional Cartridge BASIC, thus saving more RAM for user programs and data. Table 3 shows the free memory available under the various forms of BASIC on the PC and PCjr, given 64K or 128K bytes of RAM in each machine.

The PCjr's Cartridge BASIC, like BASICA, provides support for disk I/O (input/output), graphics, and communications. Cartridge BASIC also includes some things that are not found in the PC's BASICA, such as support for the PCjr's built-in sound generator, and the enhanced graphics modes.

Cartridge BASIC includes one command that is really a BASIC program. Typing TERM loads the program from the cartridge and lets you use your PCjr as a simple terminal via the built-in serial port or optional modem. Nothing fancy here—you can set the data rate, data bits, parity, duplex, and screen width, and issue commands to the internal modem. This simple program does not save incoming data to disk or send disk files down the communications line; it doesn't even have a mode for logging received data to the printer. If you get serious about using the PCjr for telecommunications, you will want a package with more features than this.

Table 4: *The commands supported by the IBM PCjr's optional internal modem. Each command can be typed in full or abbreviated to its first letter.*

ANSWER	Modem goes into auto-answer mode
BREAK n	Send a break character for n x 100 ms
COUNT n	Answer after n rings; hang up when dialing after n+3 rings
DIAL m...m	Dial a number; may include subcommands to pause for dial tone, wait 5 seconds, and switch between pulse and tone dialing
FORMAT n	Set parity, data bits, stop bits
HANGUP	Hang up the phone
INITIALIZE	Return to power-up state
LONG RESPONSE	Set message length short or long
MODEM	Modem carrier generated on line
NEW p	Set command character to p
ORIGINATE	Set modem to originate mode
PICKUP	Pick up the phone, voice mode
QUERY	Get modem status
RETRY	Redial if busy
SPEED o	Set bps rate to 110 or 300
TRANSPARENT	Modem commands are ignored and sent through
VOICE	Put modem into voice state
WAIT	Modem idle until next command
XMIT m...m	Send tone pairs m, m, etc.
ZTEST o	Modem test modes

Note: All commands may be abbreviated to their first letter

Table 5: *HomeWord word-processor commands.*

Print Functions	Edit Functions	File Management
See final document	Copy text	Get document
Print document	Erase text	Save document
Set first page number	Move text	Erase document
	Find text	Merge document
	Find and replace	Convert to/from ASCII file

Layout Functions	Preset Values
Align text right	Make automatic backup documents
Align text left	Change top, bottom margins
Justify text	Change left, right margins
Center text	Change line spacing
Start new page	Change tabs
Set top, bottom margins	Save preset values
Set left, right margins	Select 40- or 80-column screen
Set line spacing	Select printer type
Normal, bold, underlined text	
Headers and footers	

DOS 2.10

The disk-drive model of the PCjr runs PC-DOS 2.10. This version of PC-DOS also runs on the PC and PC XT. Prior to the time the PCjr was announced, PC-DOS version 2.00 was the latest revision available. The differences between DOS 2.00 and DOS 2.10 are bug fixes (unspecified by IBM) and support for the PCjr's half-height disk drives. According to IBM, the head-settling time parameter for DOS 2.00 is too fast for some of the half-height drives being installed in PCjrs, leading to disk I/O errors. I tried running several programs under DOS 2.00 and never noticed a problem. Even so, given IBM's warning, I wouldn't use DOS 2.00 on a PCjr for any important data.

Joysticks

IBM sells an optional joystick for the PCjr that works with most of the game programs mentioned on the "At a Glance" page. It appears identical to the joystick made by Kraft Systems. Programmers can also use it from BASIC with the STICK and STRIG functions, which return the joystick coordinates and the status of the joystick pushbuttons.

You can connect one or two joysticks to PCjr. They are smooth-acting and comfortable to use. You can set the X and Y joystick axes to spring return to center or to free float. There is also a bias dial for each axis, which can be used to adjust the cursor's response to movement of the joystick.

Internal Modem

Novation makes the IBM PCjr's internal modem, shown in photo 3. This direct-connect, 300-bps, auto-answer, auto-dial modem is easily installed. It can dial with tones or pulses, and it includes a cable to connect the modem to a modular telephone jack. If you want to have a telephone connected to the same jack, you must purchase a Y modular adapter.

When installed, the modem is automatically designated the COM1 device to BASIC and DOS; the built-in serial port is COM2. If there is no modem in

(continued)

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Records	dBASE II	KnowledgeMan
1,000	6.15	5.38
2,000	14.93	11.13
5,000	64.16	33.73
10,000	205.50	69.53

*K-MAN V1.05, dBASE II V2.3D, IBM XT, 256K RAM, heavily populated directory.

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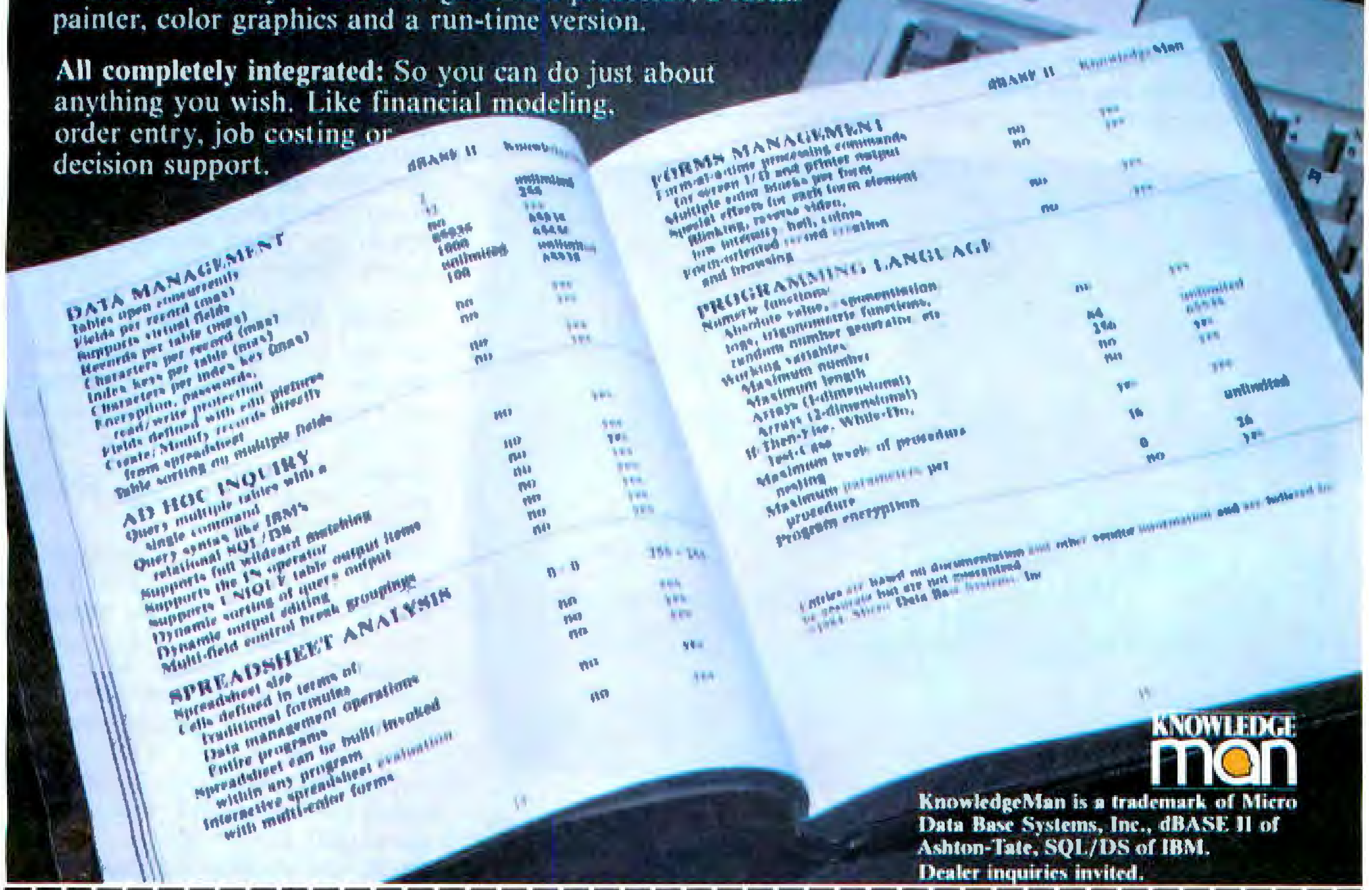

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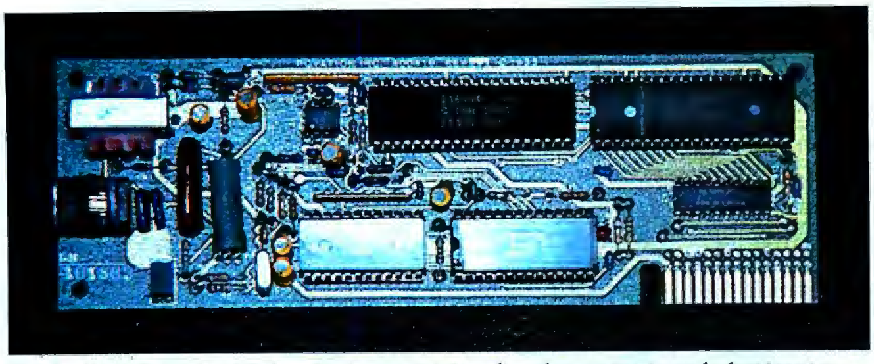

Photo 3: *The PCjr's 300-bps direct-connect internal modem option is made by* Novation *and features auto-dial and auto-answer.*

Photo 4: HomeWord, *an easy-to-use word processor for the* IBM PCjr, *features a text-edit area; icons for selecting print, edit, file, and layout functions; and a box containing a graphic representation of the current page's format.*

your PCjr, the serial port is COM1. Upon installation of the modem, this change in designation of the serial port forces you to reconfigure programs that access the serial port.

Table 4 summarizes the commands available with the IBM PCjr's internal modem. The PCjr's modem commands are not Hayes compatible, which is unfortunate given the amount of available telecommunications software using the Hayes command format. However, the commands are simple to use; you can enter any command from the keyboard by typing Control-N and then the command mnemonic.

HomeWord

Among the software released by IBM for the PCjr is Sierra On-Line's unique word processor, HomeWord (see photo 4). HomeWord is easy to use but adequate for most home word-processing needs.

The program includes an overlay template for the PCjr keyboard. If you have some experience with word processors, you can probably figure out how to use HomeWord from the template alone. Unfortunately, the template is made of heavy paper stock and comes folded in half. The crease in the middle keeps it from lying flat, and it looks like it could easily be torn in half from folding and unfolding.

HomeWord has several interesting features. A menu of icons or symbols appears at the bottom of the screen. You select word-processing functions by moving through this picture menu. For speed, you also can select most functions directly through special key sequences.

On most TV sets, you can only display 40 characters per line and still have readable text. A box in the lower right-hand corner of the HomeWord screen is a shrunken representation of the current page, using single pixels for each letter. This box lets you view the shape of text on your document's pages in the final format. Table 5 summarizes HomeWord's commands.

Other Applications

IBM has released four arcade games (Mouser, Crossfire, Scuba Venture, and Mine Shaft) in cartridge form for the IBM PCjr. Disk-based games include a couple of adventure games, educational games, and an introducation to Logo called "Turtle Power."

I received several other software packages to try out on the PCjr. They are IBM PC versions, with no apparent modifications for the PCjr. Information Unlimited Software's EasyWriter 1.15 has more features than HomeWord, but it seems dry after HomeWord's dazzling icons and use of color. Software Publishing's PFS:File and PFS:Report are a pair of file-management programs that allow you to store, modify, retrieve, and report on a database. I also ran MicroPro's WordStar version 3.30 on PCjr with no problems. This WordStar accesses the PC's video memory directly, apparently using the hardware trick mentioned earlier.

Accessories

If pointing the PCjr's keyboard at the infrared receiver is not your cup of tea, you can buy a cord to hook the keyboard to your system unit. The cord is a flat cable about 6 feet long. It is not coiled, and tends to get in the way on the desk. (With cables like this one, maybe cordless keyboards are not such a bad idea after all.)

Another option is a Centronics parallel-printer port, compatible with the PC's. Photo 5 shows the way this option attaches to the side of the PCjr. The panel on the right-hand side of the system unit snaps off to reveal a 60-pin connector that brings the bus out. The parallel-printer adapter snaps onto the side, connecting to the 60-pin bus.

When the installation is complete, the 60-pin bus is available for the next option. The PCjr *Technical Reference* manual states that up to five option adapters can be supported. However, power usage will be restricted on a machine that has all the internal options connected; only 400 milliamps of +5 V DC (volts, direct current) are available on the external bus, and the +12 V DC and −6 V DC sources are completely used up.

The way the parallel-printer adapter connects to the PCjr foreshadows other, more interesting options to come. The 60-pin bus includes 20 address lines, a bidirectional 8-bit data bus, three interrupt levels (requests 1, 2, and 7), memory and I/O read and write signals, and miscellaneous clock and timing signals. DMA devices (such as disk controllers that don't interfere with type-ahead and RS-232C data input) can be connected. This bus is the key to add-on third-party hardware, and several vendors have already announced PCjr hardware expansions that connect to it.

INSIDE THE PCjr

The PCjr's lid is easy to snap off (see photo on the "At a Glance" page), but there is no power interlock to prevent dangerous AC (alternating current) line voltages from being present when the PCjr's insides are exposed. The switching power supply is on the far left. The power supply is the trickiest card to install in PCjr—it requires mating two easily bent pins on the motherboard with a connector on the card, as well as inserting the card's edge into a connector.

To right of the power supply is the memory/80-column video-expansion card, which is individually shielded. Next is the Novation 300-bps modem. And finally, the disk drive controller is next to the disk drive.

Photo 6 shows the PCjr with all its cards out and the floppy disk removed. The eight chips in the lower left-hand corner contain 64K bytes of RAM. There is no parity checking bit, unlike the PC which includes a 9th-bit parity check for every 8 bits of memory. In the upper left-hand corner you will see the cassette relay, which is a yellow component. To the left of the relay is the tiny piezoelectric speaker used for internal sound. The large 40-pin chip just below the relay is the INS8250 UART (universal asynchronous receiver/transmitter) chip that controls the serial port. Below the 8250 is another 40-pin chip, the Motorola 6845 video controller. The 40-pin chip below that is a proprietary gate array used in the video section.

On the lower right are the covers for the two ROM program cartridges. Directly above the left-hand slot are the two system ROMs. To the right is the 60-pin system-bus extender (at the edge of the PC board). The large chip just to its left is the 8088 microprocessor, the PCjr's brain.

MANUALS

The documentation set is impressive. IBM made a real effort to make the computer understandable to novices. Chapters such as the one titled "Taking Control" in the *Hands-On BASIC* manual (jointly published by IBM and McGraw-Hill) deal with computer-fear by stressing that the computer is only a tool, not a diabolical machine with a mind of its own.

Hands-On BASIC uses cartoons and full-color diagrams liberally to make the pages visually interesting. IBM chose a little boy named "PC" for the theme

(continued)

Photo 5: *Some options, such as the parallel-printer adapter shown here, attach to the bus connector on the right-hand side of the PCjr.*

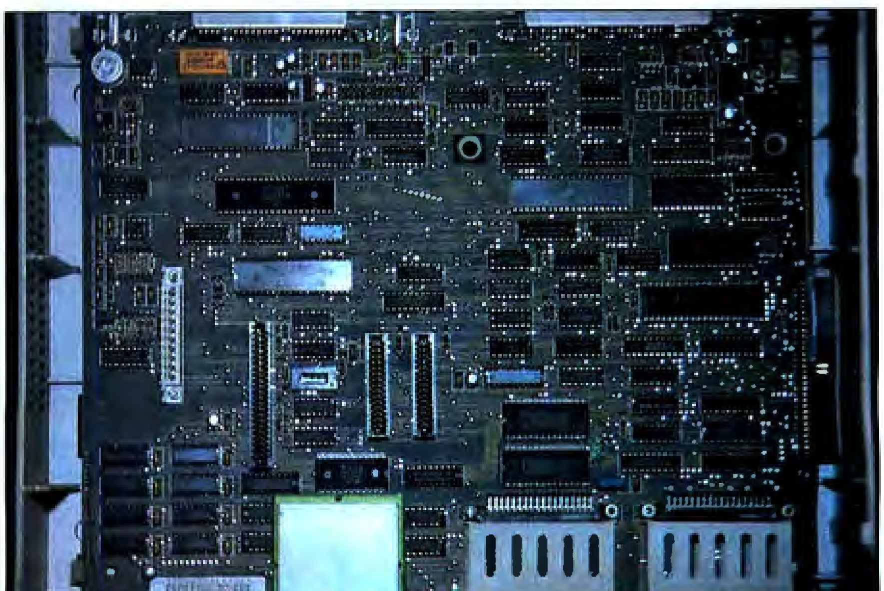

Photo 6: *The IBM PCjr's motherboard with all internal add-on adapters, disk drive and power supply removed. (See text for a guided tour.)*

character for the PCjr. He appears in some, but not all, of the end-user-oriented manuals.

The *Guide to Operations* tells you how to set up your machine, use the keyboard, install options, and run diagnostics. The writing style is simple and clear. The operations manual includes a keyboard tutorial linked to a program in the PCjr's ROM called Keyboard Adventure (and this keyboard *is* an adventure). This tutorial guides you through the PCjr keyboard with animated color graphics and a three-voice rendition of the opening to Beethoven's Fifth Symphony.

An interactive tutorial program called Exploring the IBM PCjr is included with disk-drive versions of the PCjr.

Another introductory program called the Sampler provides some sample application programs for the PCjr. It comes on a single floppy disk and includes some simple BASIC programs, seen in menu form in photo 7.

The *Microsoft BASIC* manual comes with Cartridge BASIC. It is almost identical to the manual shipped with the PC. Modifications include new PCjr commands, and references to the PC's disk-based BASIC and BASICA are changed to references to Cartridge BASIC. This is primarily a programmer's reference, but new programmers should start with *Hands-On BASIC*, which comes with every machine.

If you buy PC-DOS, you get two manuals: one is simply titled *Disk Operating System*, and the other is a small, staple-bound book called *Disk Operating System User's Guide*. The first is the reference manual for DOS users; the second is a get-acquainted guide for first-time users, complete with cartoon characters meant to ease computer anxiety. An extra-cost option is the DOS *Technical Reference* manual, intended for DOS programmers. One advantage of splitting the DOS manual into two parts is that each part fits into its binder, in contrast to DOS 2.0 documentation, which doesn't. The disadvantage is the extra cost for the now-optional technical manual. This new manual set is used for the PC and PC XT as well.

The *Technical Reference* manual follows the same style as the PC's manual. It gives a detailed look at the PCjr's design, including schematics and listings of the ROM BIOS code. IBM obviously knows that much of the PC's phenomenal success is due to third-party software and hardware vendors that need this detailed information to make additional programs and options available for the machine.

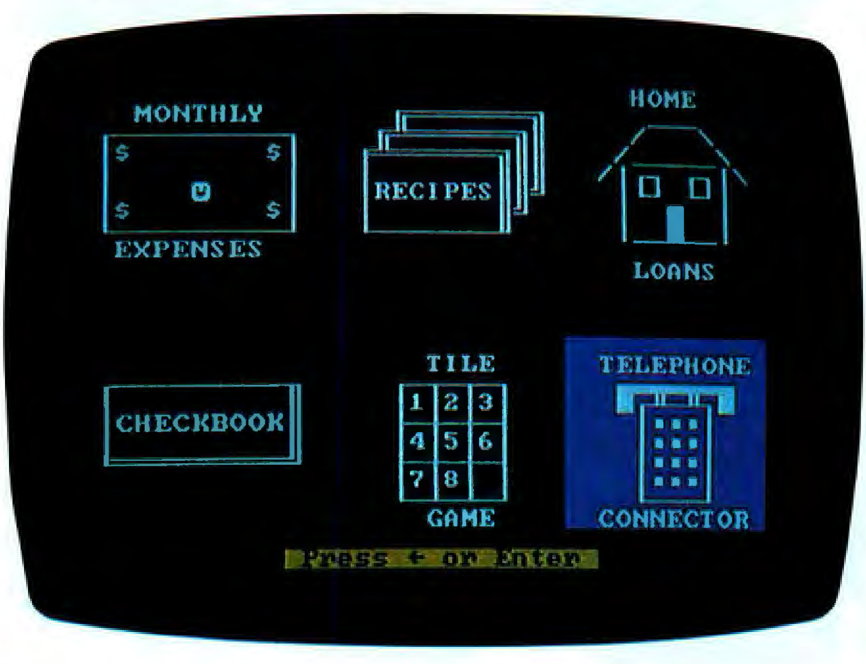

Photo 7: *The IBM PCjr Sampler Disk includes a number of BASIC programs demonstrating the kinds of applications that are available. Shown here are the selection icons for a budget program, recipe file, loan-payment computer, checkbook manager, number game, and simple communications program.*

The PCjr's modem commands are not Hayes compatible, which is unfortunate given the amount of available telecommunications software using the Hayes format.

CONCLUSIONS

The PCjr is impressive in many ways. It is also disappointing in some critical areas.

The PCjr's major advantages include: IBM PC compatibility; a large software base (at least for the disk version of PCjr); good graphics, text, and sound capabilities; and an excellent documentation set. The PCjr allows children and adults alike to acquire some computer literacy while learning to operate the machine—and of course, the IBM name ensures continued support and service.

Minuses include the keyboard, a real loser; limited expandability from IBM at this time (no external disk drive or add-on memory beyond 128K bytes total); and the price—it's rather expensive for a home computer, but with its current keyboard, it's not meant for business use.

As this article goes to press, new keyboard and memory options are rumored to be pending from IBM. For now, I must admit that the PCjr is not my choice for a personal computer. It may appeal to children and educational institutions or to hunt-and-peck typists. But if you are in the market for a computer and decide to buy an IBM machine, think carefully about buying a PC, or at least look at the price of a fully expanded PCjr versus a comparably configured PC. ■

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compatible. $995.

I had been regularly reading the classifieds for three years and knew this price was a typo. The correct price must be $1995 or $2995. I decided to call anyway, hoping that $1995 was right. The salesman told me that $995 *was* the correct price. "What's wrong with it?" went through my mind.

"What's wrong with it?" seems to be the reaction of all my friends and classmates upon first hearing the price and the features of the Sanyo MBC-550 series. Because attending college means paying to work instead of working for pay (leaving little money for buying a computer), I went to have a look at the MBC-550 and the two-disk MBC-555. What I found made me an owner the next day.

[**Editor's Note**: We've included two text boxes that provide additional insight into the Sanyo MBC-550 and 555. James G. Droppo Jr.'s "The Double-Drive MBC-555" is on page 278. John Unger and Jeffrey Phillips discuss "Sanyo MBC-555/IBM PC Compatibility" on page 276.]

The cabinet measures 15 inches wide, 4⅗ inches high, and 14⅕ inches deep. At first glance the cabinet looks a lot like a videodisc player. It has a smooth silver surface with air vents running across each side and a single power switch on the front. The keyboard case has the same finish as the cabinet, and the keys are two shades of grey with white lettering. A black coiled cable connects the keyboard to the cabinet. The cabinet contains a fan, which I didn't discover until several days after purchasing the system; the fan is virtually silent. The floppy-disk drives are also very quiet, with only the occasional click as the read/write head changes tracks.

The cabinet has positions for two floppy-disk drives. In the basic MBC-550 setup (one drive), the second drive position is occupied by a handy disk-storage box, which can hold 12 disks. On the rear of the cabinet is a grounded outlet that is on the same switch as the main unit. This outlet lets you turn on your system and display with one switch.

MONOCHROME AND/OR COLOR DISPLAY

The MBC-550 comes out of the box capable of driving both monochrome and RGB (red-green-blue) displays. As a matter of fact, it can drive one of each at the same time. The formats of the two displays are the same. The basic video signals are generated for the RGB display and auxiliary circuitry converts the color signals to monochrome signals. Table 1 shows the eight pixel values and their color and monochrome attributes. Figure 1 shows the pin-outs of the RGB socket.

The character-display format is 25 lines by 80 columns; for pixels, it's 640 horizontal by 200 vertical. Both graphics and text may be displayed at the same time. Each character is an array of 8 horizontal by 8 vertical pixels. In ROM (read-only memory), 256 characters are stored, and the lower 127 are standard ASCII (American National Standard Code for Information Interchange). The ASCII character set is pleasing to the eye, with lowercase descenders. I can distinguish no difference between the Sanyo ASCII characters and IBM's. The COLOR command in BASIC lets you display text in any character/background color combination.

Other BASIC graphics commands include LINE (draws a line between any two points on the screen), CIRCLE (draws circles, ellipses, and arcs anywhere on the screen), SYMBOL (puts the standard characters on the screen in any magnification and four orientations), PAINT (fills an enclosed area with a specified color), PSET and PRESET (colors and uncolors specific pixels), and GET and PUT (stores an area of the display into a numeric array and places a numeric array in a specified area of the display).

Display memory is set at cold boot to the highest 16K bytes available. Altering a value at I/O (input/output) address hexadecimal 10 changes the display memory block.

KEYBOARD

The MBC-550 keyboard (see photo 2) is arranged in the regular QWERTY format with one slightly annoying exception. The Shift keys at lower left and right are moved farther away from the bottom row by the addition of an < > (angle bracket) key to the left and an * (asterisk) key to the right; a jab for the shift key that falls short results in a < or *. Two Shift-Lock keys are situated on either side of the space bar. The Caps lock is on the left and the Graph lock is on the right. Each lock key has an embedded red LED (light-emitting diode) to indicate activity.

The keyboard has a very nice feel for touch-typing, with the home keys (F and J) more deeply dished to mark the position of the home row. The keyboard also has two adjustable legs to let you tilt the keyboard to your own tastes.

In addition to the QWERTY keypad, there are five function keys arranged vertically along the left side of the keyboard and a combination numeric/cursor-control keypad on the right. The function keys are programmed from BASIC with the KEY command.

The numeric/cursor-control keypad is a standard numeric keypad with =, *, −, +, ., and Return keys. Eight of the ten numeric keys can also serve as cursor-control keys. (Numeric key functions are shown in table 2.) A BASIC Break key (Control-C) is in the upper right corner of the numeric pad, out of the way but not inaccessible. A hardware processor reset switch is recessed on the left side of the keyboard.

The keyboard communicates with the computer in ASCII at 1200 bps (bits per second) with even parity, 8 data bits, and 2 stop bits. When a character is pressed while the control key is down, the character is transmitted in parity error. The keyboard has automatic repeat on all keys after approximately one-half second.

PROCESSOR

The MBC-550 uses the 16-/8-bit Intel 8088 microprocessor and an 8288 bus controller. The MBC-550 also has a socket for the 8087 mathematics coprocessor and is configured to take advantage of it.

The 8088 in the MBC-550 runs at 3.6 MHz, more than 1 MHz slower than the IBM Personal Computer (PC), which runs at 4.77 MHz. This speed difference shows in the processing benchmarks on page 274.

There is no question that Sanyo sacrificed speed in order to cut production costs. In my experience with computers, however, processing speed is really of importance only when dealing with real-time applications such as graphics animation. In these applications, a slow system usually results in poor graphics animation. The simple BASIC test program in listing 1 shows that the MBC-550 is capable of quick, smooth animation.

MEMORY

The Sanyo comes with 128K bytes of 4164 dynamic RAM (random-access read/write memory) soldered to the main board, which has sockets for another 128K bytes to bring the system total to 256K bytes. The last addressable 16K bytes of memory, FC000 to FFFFF (hexadecimal), contain the system

(continued)

Photo 1: *The Sanyo* MBC-550.

Bill Sudbrink (5100 Barto Ave., Camp Springs, MD 20746) is majoring in computer science at the University of Maryland, College Park.

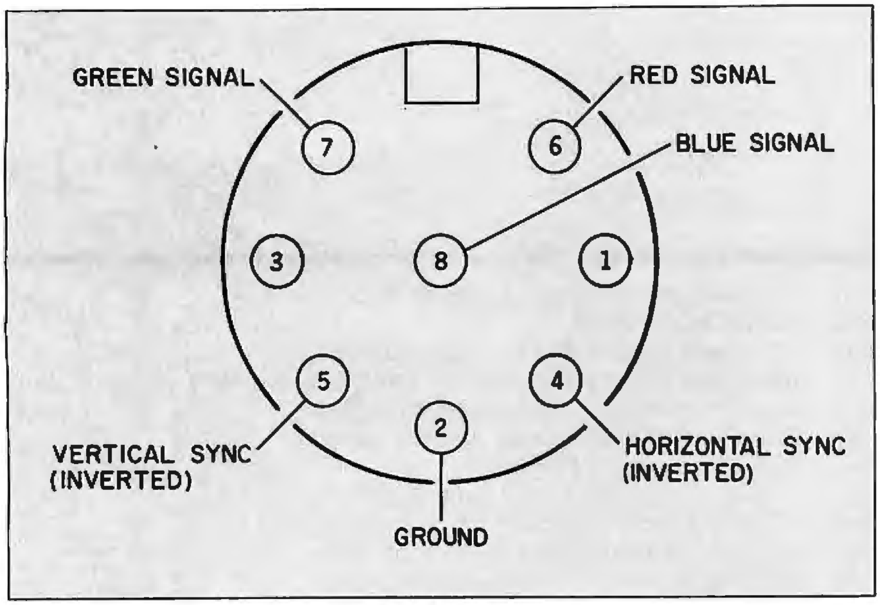


Figure 1: *The pin-out of the* MBC-550 *rear-panel* RGB *receptacle.*

Table 1: *The eight pixel values for color and monochrome displays.*

Pixel Value	Color Display	Monochrome Display
0	black	off (black)
1	blue	low intensity
2	green	medium intensity
3	light blue	high intensity
4	red	off (black)
5	purple	low intensity
6	yellow	blink off medium
7	white	blink low/high

Table 2: *Normal (unshifted) and shifted functions of the numeric keypad.*

Cursor Control (unshifted)	Keypad (shifted)
linefeed	1
not used	2
page down	3
right	4
down	5
left	6
home	7
up	8
page up	9
not used	0

ROM. The ROM contains, among other things, the floppy-disk bootstrap, the keyboard decoding, and the character images. The system uses no memory parity checking, so each 64K-byte upgrade requires only eight 4164 chips.

The documentation seems to indicate that memory expansion is limited to 256K bytes. Although there are no card slots in the MBC-550, the address and data buses and all of the memory and I/O signals are available through a 62-pin header on the processor board (see table 3). In the schematics, this header is noted only as an "external port." Interestingly, pin 30B, labeled CLK (clock), receives a signal referred to on the schematics as "OSC IBM BUSS." Maybe there is an IBM-compatible card cage in the future.

Disk Drives

Sanyo now supplies only 5¼-inch, single-sided, double-density disk drives with the MBC-550 series. In the February 1984 edition of *Sanyo Newsletter*, a short paragraph mentions that the EDH511 10-megabyte hard disk is available for the MBC-550, but at this writing my local dealers have not heard anything about the new disk. Double-sided disk drives are also said to be on the way.

The Sanyo-supplied drives use regular soft-sectored disks with a formatted storage area of 160K bytes under MS-DOS 1.25. Regular MS-DOS formatting is used, and the disks are transportable among various MS-DOS machines, including the IBM PC. The version of MS-DOS supplied with the MBC-550 supports from one to four drives. As I mentioned before, the drives are pleasingly quiet.

While Sanyo may be slow in producing hardware options for its computer, other firms are not. Two dealers in the Maryland suburbs of Washington, D.C., are offering double-sided, double-density disk drives and MS-DOS 2.0 for the MBC-550. Prices are less than $250 for the drive and DOS (disk operating system). The double-sided drives are also MS-DOS standard, and they double the formatted storage area to 360K bytes under MS-DOS 2.0. [Editor's Note: At press time, we learned that MS-DOS version 2.11 is now available for the MBC-550.]

(continued)

AT A GLANCE

Name
Sanyo MBC-550

Manufacturer
Sanyo Business Systems Corp.
Computer Division
51 Joseph St.
Moonachie, NJ 07074
(201) 440-9300

Size
15 by 14⅛ by 4⅜ inches; keyboard, 17⅞ by 6⅝ by 1⅜ inches

Processor
8088 16-/8-bit at 3.6 MHz with 8288 bus controller

Memory
128K of 4164 dynamic RAM; expandable to 256K

Mass Storage
One or two 160K 5¼-inch, single-sided, double-density floppy-disk drives

Display
25 rows by 80 columns; color (RGB) or monochrome

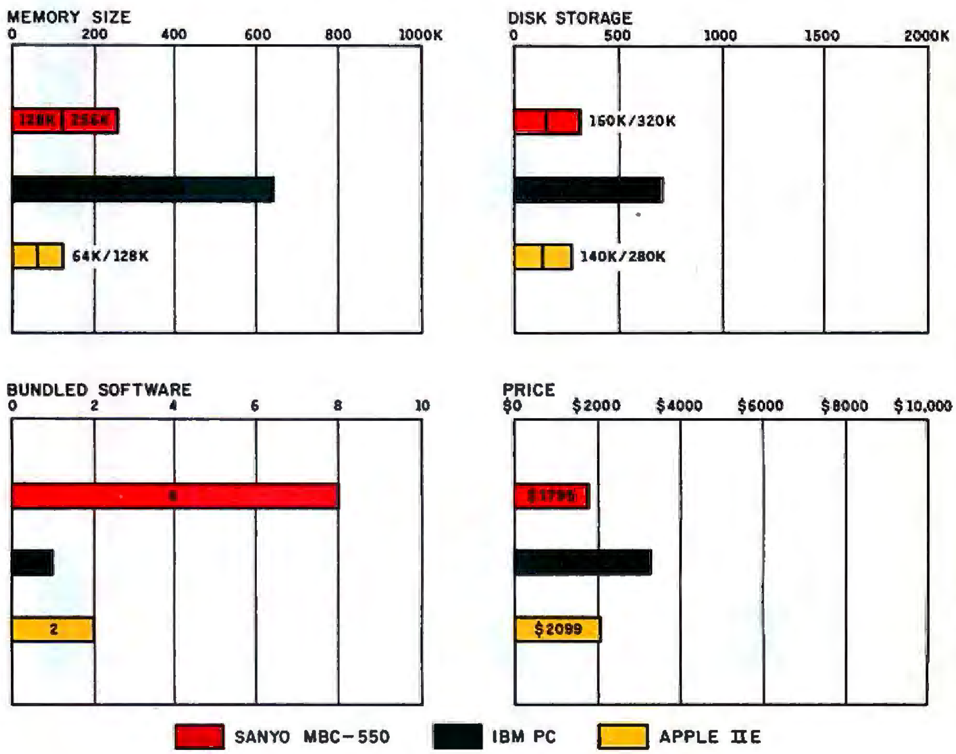
Keyboard
Detached QWERTY with five function keys and numeric pad

Software
MS-DOS 1.25, Sanyo BASIC, WordStar, CalcStar, EasyWriter

Options
RS-232C serial port ($100), Apple joystick, 8087 math coprocessor, 64K RAM expansion ($120), monochrome monitor ($199), color monitor ($749), double-sided disk drive ($499)

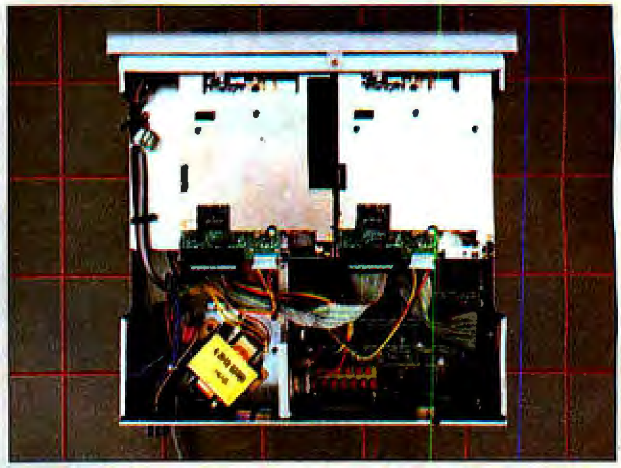
Documentation
Operator's guide, 287 pages; software guide, 492 pages

Price
MBC-550 (one drive), $995; MBC-555 (two drives, MailMerge, SpellStar, and InfoStar), $1495; with monitor and serial port, $1795

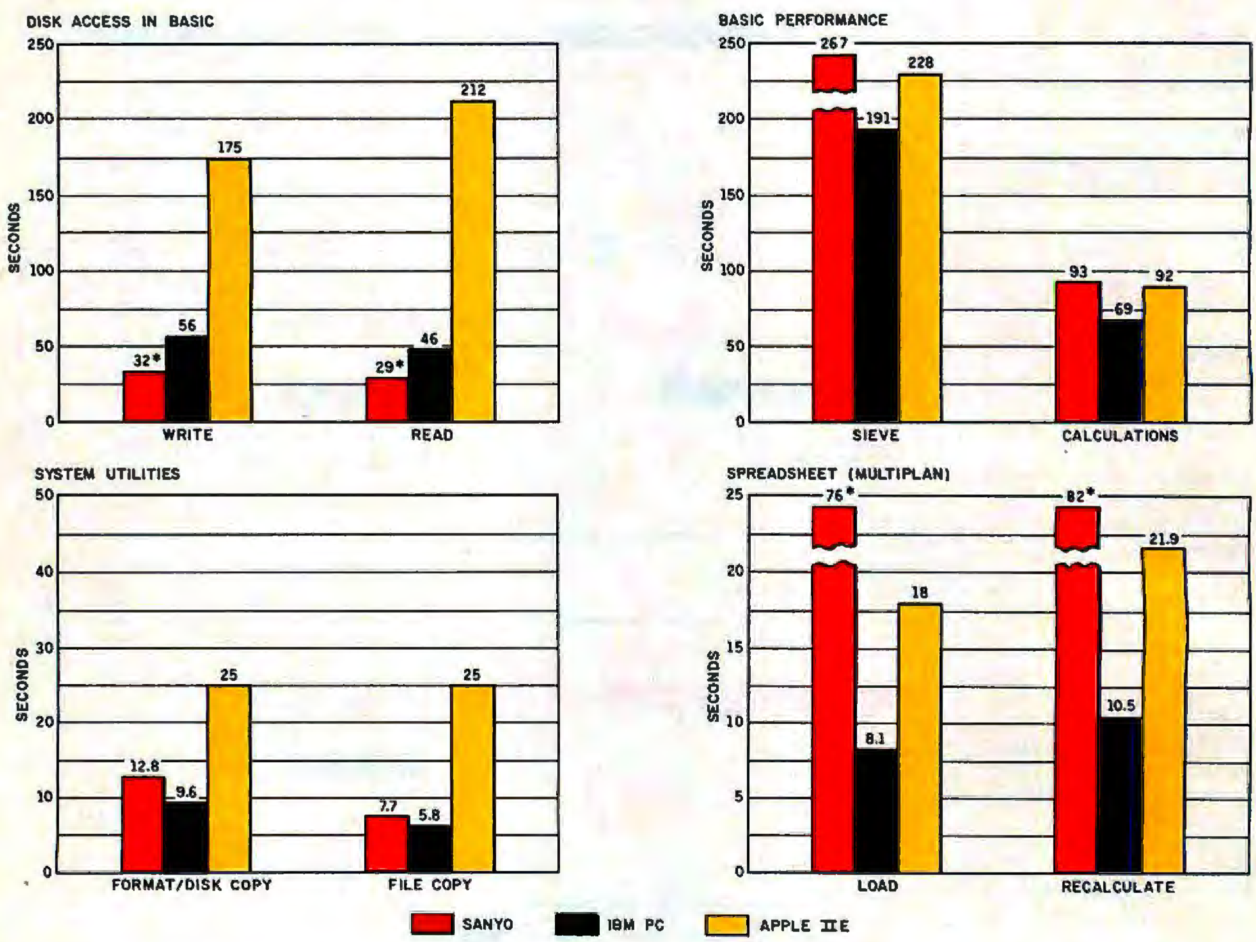


The Memory graph shows the standard and optional memory available for the computers under comparison. The Disk Storage graph shows the highest capacity of a single floppy-disk drive for each system. The Bundled Software graph shows the number of packages included with each system. The Price graph shows the list price of a system with two high-capacity floppy-disk drives, a monochrome monitor, graphics and color-display capability, a printer port and a serial port, 256K bytes of memory (64K bytes for 8-bit systems), the standard operating systems for each system, and the standard BASIC interpreter for each system.

The rear panel of the Sanyo MBC-550. Note the parallel printer connector.



The inside of the Sanyo MBC-555. Note the two floppy-disk drives at the top (front) and the lack of expansion slots.



The Disk Access in BASIC graph shows how long it takes to write a 64K-byte sequential text file to a blank floppy disk and how long it takes to read this file. (For the program listings, see "The Chameleon Plus," by Rich Krajewski, in the June BYTE, page 327.) The Sieve bar shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations bar shows how long it takes to do 10,000 multiplication and division operations using single-precision numbers. The System Utilities graph shows how long it takes to format and copy a disk (adjusted time for 40K bytes of disk data) and to transfer a 40K-byte file using the system utilities. The Spreadsheet graph shows how long the computers take to load and recalculate a 25- by 25-cell spreadsheet where each cell equals 1.001 times the cell to its left. The spreadsheet program used was Microsoft Multiplan.

Note that in the tests of BASIC disk access for the Sanyo, the test file was written to and read from the default (i.e., nonblank) disk. Sanyo BASIC apparently cannot access other disk drives. In the spreadsheet test on the Sanyo, CalcStar was used. The standard 25 by 25 spreadsheet could not fit into memory. A 25-column by 17-line spreadsheet was used and the times were extrapolated to 25 lines.

Sanyo MBC-555/IBM PC Compatibility

BY JOHN UNGER AND JEFFREY PHILLIPS

As scientists, both of us have done extensive programming in the work environment on mainframe computers and minicomputers using FORTRAN and PL/I. However, our home computing needs are different and include program development, word processing, and remote communications with minicomputers at the office. When we purchased identical Sanyo MBC-555 computer systems, we had no great illusions concerning IBM Personal Computer (PC) compatibility. Dealers had informed us that the Sanyo would not run IBM software requiring graphics and might not run other IBM software. Documentation was known to be poor. Nevertheless, the attractions of the low cost, bundled word processing, database, BASIC software, graphics, and IBM compatibility (in terms of disk format, microprocessors, and operating system) were too good to pass up. If public-domain software developed for the IBM PC could be adapted for use on the Sanyo, then so much the better.

We first ran the MicroPro (WordStar, etc.) and I.U.S. (EasyWriter) packages bundled with the MBC-555; we found them to be completely installed for the Sanyo system, and everything worked flawlessly right out of the package. Working with WordStar was somewhat disconcerting at first, though. Because of the way the Sanyo writes to the screen, using the scroll feature (Control-QZ) to review text is difficult to adjust to; the text does not scroll smoothly and appears to jump around the screen as the top line is erased and a new line is added at the bottom. This effect is especially bothersome with double-spaced text. Also, the Sanyo appears to write to the screen much more slowly than some 8-bit CP/M machines that we've used, but it's about the same speed as the IBM PC. Interestingly, this problem does not seem to be as apparent with the version of EasyWriter that comes with the Sanyo; perhaps I.U.S. uses more efficient code for screen-writing routines.

One of the first programs we attempted to convert was PC-Talk, a "freeware" communications program written in IBM BASIC. (A compiled version would not run on the Sanyo.) The initial problem we encountered was an "out of memory" message during the load. It seems that the Sanyo, supplied with 128K bytes of RAM (random-access read/write memory), can spare only about 40K bytes for BASIC program space. We corrected this problem by adding 64K bytes' worth of memory chips to the main board. All add-on memory is available to programs running under Sanyo BASIC. The remainder of the conversion attempt was an education in the differences between IBM BASIC and the simpler Sanyo BASIC, which is structured much like 8-bit Microsoft BASIC.

The problem that caused us to abandon the attempt was the failure of PC-Talk to recognize extended keyboard codes such as Home or Shift-Ctrl (which are supposed to translate to the IBM Alt extended code) when typed on the Sanyo. This problem made it impossible to get past the main menu of PC-Talk without destroying the integrity of the BASIC code. It is just as well we did not spend more effort on converting this program because no one in our user group had succeeded in setting the data-transmission rate on the Sanyo using the instructions in the owners manual. Also, the situation has now changed because Sanyo has come up with its own communications software.

A second exercise involved using POKE commands to enter assembly-language subroutines into BASIC programs, as outlined by Hugh Howson in two BYTE articles (references 2 and 3). Going through his examples gave us our first look at the BIOS (basic input/output system) of the Sanyo. We were very encouraged to discover that most of the BIOS and DOS (disk operating system) interrupts found on the IBM PC also are

SERIAL COMMUNICATIONS

The MBC-550 does not come with a built-in serial port. The optional serial board, which costs $100, can drive either a modem or a printer and is completely under software control. Transmission rates can be varied between 110 and 4800 bps but not by BASIC. Sanyo includes in the user's guide a BASIC routine to alter the data-transmission rate; however, due to rather temperamental timing, the BASIC routine does not work. The assembler routine in the guide works perfectly. The serial board communicates through a standard DB25 female connector. The connector pin-outs comply with standard printer and modem configurations.

The main component of the serial board is the Intel 8251A serial interface controller chip, which takes data on its parallel bus and converts it into serial order. It also receives data on its serial RxDATA pin and converts it for the parallel bus. The 8251A is completely software controlled. Parity, word size, and stop bits are variable. Parity can be even, odd, or none; word size can be 5, 6, 7, or 8 bits; and the number of stop bits can be 1, 1½, or 2. You select these characteristics by sending a control word to I/O address 2A (42 decimal). Table 4 shows the 8251A control word coding; listing 2 is an assembly-language program to alter the serial setting.

PARALLEL COMMUNICATION

The standard MBC-550 system includes a Centronics-type parallel interface. The interface can drive many kinds of printers and seems to cooperate with WordStar nicely. I have a C. Itoh dot-matrix printer that has operated perfectly with the MBC-550.

supported on the Sanyo. Specifically, interrupts 0, 1, 3, 10 through 1C, and 20 through 27 are supported. All others halt the processor. Interrupts 15, 18, 19, 1B, and 1C return to the calling program without taking any action. There also are some minor differences. For example, the keyboard interrupt (17) does not have the option of returning a status byte, the video interrupt (10) does not have graphics options, and the memory-size interrupt (12) always returns 16K bytes less memory than you thought you had, apparently to compensate for the 16K bytes of dedicated video RAM. A related conversion attempt involved a screen-dump program written in IBM BASIC with an assembly-language subroutine. This program used the graphics GET statement to access the screen, then used the VARPTR function to pass the address for the screen array through a CALL statement to the assembly-language subroutine. It soon became apparent that on the Sanyo the format of the array output by the GET statement differed radically from that produced on the IBM. In addition, the offset address returned by the VARPTR function was relative to an unknown segment address, making it next to useless. Furthermore, parameters passed through the CALL statement were not correctly utilized by the assembly-language subroutine. We were able to write a clumsy but functional version of the program only by eliminating passed parameters and taking advantage of "proprietary" information regarding the format of the GET array.

After reading articles on C compilers (references 1 and 4), we ordered a copy of the DeSmet C compiler for one of the new Sanyos. The decision to buy this compiler was not made without some anxiety; although the product is supposedly able to run on plain-vanilla MS-DOS, some of the more interesting features and utility functions have been designed around the IBM PC. However, we were pleased to discover that not only does the fast and handy editor, SEE, work flawlessly, but the entire library of functions for direct screen I/O (input/output) on the IBM PC are completely compatible with the Sanyo. This feature is a direct consequence of the fact that the BIOS interrupt 10 routines are identical between the IBM and Sanyo machines.

Our version of DeSmet C (2.2) is more recent than the one reviewed in BYTE for the IBM, and the benchmarks we've run on the Sanyo show that the Sanyo produces results comparable to those reported for the IBM in the BYTE article. We're pleased with the package and now have the freedom to create not only EXE files from powerful and versatile source code but also machine-language programs using the 8088 assembler that comes with the C compiler.

In brief, the biggest problem with the MBC-555 is the lack of in-depth technical documentation. This lack prevents use of the machine's excellent graphics. Now all we have to do is figure out how to access the fine high-resolution graphics of the Sanyo with C-language functions or, at least, through assembly-language programs.

We were frustrated again when we attempted to run compiled public-domain utility software. Two RAM-disk programs written for the IBM failed to work on the Sanyo, as did an IBM program to play "Mary Had a Little Lamb." (The Sanyo apparently does not support music.) The moral seems to be: If you expect to run IBM software, don't buy a Sanyo.

If you plan to write your own software using the full power of the 8088 and Sanyo graphics capability, expect to spend a lot of time with the debugger, searching through the DOS, BIOS, and BASIC assembly code in order to glean some insight into the interrupt and port structure. We think that Sanyo should correct the problems with the VARPTR and CALL statements or at least provide the information needed to use them in their present form.

Are we unhappy that we bought Sanyos? Not at all. The MBC-555 has proven to be a versatile computer with great potential at a great price. With a little help from Sanyo, especially in the form of good documentation on the BIOS and details for the rest of the operating system, that potential will begin to be realized.

John Unger (POB 95, Hamilton, VA 22068) and Jeffrey Phillips (1629 Apricot Court, Reston, VA 22090) are geophysicists for the United States government.

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1. Houston, Jerry, Jim Brodrick, and Les Kent. "Comparing C Compilers for CP/M-86." BYTE, August 1983, page 82.
2. Howson, Hugh R. "POKEing Around in the IBM PC." Part 1, BYTE, November 1983, page 121.
3. Howson, Hugh R. "POKEing Around in the IBM PC." Part 2, BYTE, December 1983, page 417.
4. Phraner, Ralph A. "Nine C Compilers for the IBM PC." BYTE, August 1983, page 134.

SOUND

The MBC-550 has no complex sound generators. Sanyo BASIC recognizes SOUND and PLAY as reserved words but apparently does nothing with them. When SOUND or PLAY is the first word on a line, the rest of the line is ignored. A simple test shows that

```
10 FOR T=0 TO 10000
20 NEXT T
```

takes 15.8 seconds to execute. When you insert 15 SOUND or 15 PLAY, the loop takes 22.0 seconds to execute. Dividing the difference, 6.2 seconds, by 10,000 demonstrates that not much is going on in these two statements.

The MBC-550 does have a bell. When accessed through the normal channels, BEEP or PRINT CHR$(7), the bell sounds rather like a frog being stepped on. When accessed in other ways, the bell makes other amusing sounds. The TxDATA pin of the 8251A that receives the keyboard data drives the bell. The I/O address of the 8251A is hexadecimal 38. Executing the statement OUT &H38,&HFF causes a short "pop" to come out of the speaker. The loop

```
10 FOR X=1 TO 50
20 OUT &H38,1
30 FOR T=1 TO 50:NEXT T
40 NEXT X
```

causes a sound like a machine-gun: "tock-tock-tock-tock." The following routine generates a "crash" or "you've-been-shot" sound.

```
10 FOR X=0 TO 255
20 OUT &H38,X
30 NEXT X
```

The parity, data bits, and stop bits of the keyboard 8251A chip can be controlled

(continued)

The Double-Drive MBC-555

BY JAMES G. DROPPO JR.

I have used the Sanyo MBC-555 as a word processor at home; I use an IBM Personal Computer (PC) in the office. A major advantage for me is the fact that the Sanyo comes with MicroPro software, eliminating any business/home software licensing questions.

My overall impression of the MBC-555 is good. MicroPro's IBM-compatible software works fine on the Sanyo. I am able to write reports, letters, data files, etc., interchangeably between the Sanyo and the IBM PC. As I'll describe, simple BASIC programs are easily transferred. The hardware and software works pretty much as advertised.

An obvious omission in the documentation, which is otherwise good, is the lack of a description of pin-outs for plugs on the back of the computer. With all the information on signal characteristics contained in the manual, pin-out information would be appropriate and quite useful. My color monitor could not be hooked up without a definition of pin-outs so I could make up an adapter cable.

I did not find all the software items I looked for, either. Sanyo BASIC documentation is quite good as far as it goes. The trouble is that not all commands are covered; you are referred to a book on Sanyo BASIC that the Sanyo dealer is supposed to have. I asked my dealer—he did not have such a book. I checked another Sanyo dealer—no book. I checked local bookstores—no book. So the following discussion of compatibility of Sanyo BASIC and IBM PC BASIC was produced without benefit of this additional documentation.

WordStar, SpellStar, MailMerge, InfoStar, and CalcStar are documented in the second volume. Because I already was quite familiar with the MicroPro software, I have not yet had to refer to the second volume. The detailed manual sections and training guides will be useful to new users. The menus in this software are of considerable help in the learning process. Also, the popularity of these packages has resulted in a number of good books, available in most bookstores, to supplement a beginning user; documentation of these programs is no problem.

THE GOOD, THE BAD

Sanyo makes it clear in its literature on this series that the BASIC supplied is Sanyo BASIC. What this translates to is a BASIC that is close to IBM PC BASIC, but not identical. Files may only be transferred in ASCII (American National Standard Code for Information Interchange) format. The internal coding of BASIC statements is not the same. The procedure for transferring files is to save a version with an "A" option; that is, in BASIC with the program loaded, you enter

```
SAVE "FILENAME.BAS",A
```

and then the program may be loaded with no special options on the other computer. This works when going from the IBM PC to the Sanyo MBC-550, and vice versa.

The BASIC editing mode on the Sanyo is different than on the IBM PC; it works only on numbered program lines and requires hitting the Break key to stop the editing mode. I find it relatively easy to use, but compared to the IBM PC BASIC screen editor, it's limited.

On the positive side of the Sanyo is its more standard keyboard. I find I can hit Delete or Return without a several-second search. The Sanyo also has a handy reset button on the side of the keyboard. Both computers have an extra key between the Shift and Z keys (< > on the Sanyo; \ on the IBM). Just recently I stopped making those annoying shift errors caused by this extra key.

On the Sanyo's negative side is the placement of the disk drives, which follows the Oriental practice of going from right to left. The A drive is on the right and the B drive is on the left. If you're going back and forth between machines, it gets quite frustrating. A lot of disks get put into the wrong drives. Although I felt I could not complain too much, I *could* do something about it.

I opened up the computer and reversed the disk-selection jumpers on the half-height disk drives. This gave me the same logical order as on the IBM PC. Near the back of the circuit board on the disk drive, drive A has the second and fourth pins jumpered and drive B has the third and fourth pins jumpered. My MBC-555 had two different models of disk drives—one with jumpers readily accessible when the case was opened, one with the circuit board underneath it. The latter required the complete removal of the drive to change the jumper. Changing the jumpers can mean a very simple operation or a relatively major one, depending on the type of drives.

If you have to remove the disk drives in order to change the jumpers, you might be tempted to merely reverse the complete drive mechanisms. This is not recommended because, generally, the final drive on the end of the disk-drive ribbon cable has a special set of termination resistors not used in intermediate drives. Anyway, the ribbon cable within the Sanyo is too short to let you physically switch the drive position.

The drives are single-sided, double-density units that have half the capacity of double-sided, double-density drives used in many IBM PCs. You must format disks on the IBM with the single-sided option for compatibility with the Sanyo. The instruction

```
A> FORMAT B:/1
```

loads the Format program from drive A and gets ready to format one side of the disk in drive B. No special commands are necessary when formatting disks on the Sanyo.

James G. Droppo Jr. (3521 Sylvester St., Pasco, WA 99301) *is a senior research scientist in the geosciences department at* Battelle, Pacific Northwest Laboratories. *He holds a doctorate in atmospheric sciences from the* State University of New York at Albany.

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in assembly language just like the serial port 8251A. The control address for the keyboard 8251A is hexadecimal 3A. Once you alter the attributes of the keyboard control address, however, data from the keyboard is no longer received properly. The correct value of the keyboard control address is hexadecimal FF. With some experimentation and im-

(continued)

Table 3: *The pin-out of the MBC-550 expansion header. In the schematic diagrams, pin 30 (CLK) has a notation that reads* "OSC IBM BUSS."

Pin	Signal	Pin	Signal
A01	NMI (inverted)	B01	ground
A02	D7 (data)	B02	reset
A03	D6	B03	+5V
A04	D5	B04	unused
A05	D4	B05	unused
A06	D3	B06	unused
A07	D2	B07	−12V
A08	D1	B08	RQ/GT (inverted)
A09	D0	B09	+12V
A10	RDY	B10	ground
A11	AEN	B11	MWR (inverted)
A12	A19 (address)	B12	MRD (inverted)
A13	A18	B13	IOW (inverted)
A14	A17	B14	IOR (inverted)
A15	A16	B15	unused
A16	A15	B16	unused
A17	A14	B17	unused
A18	A13	B18	unused
A19	A12	B19	unused
A20	A11	B20	CLK
A21	A10	B21	IR7
A22	A09	B22	unused
A23	A08	B23	unused
A24	A07	B24	unused
A25	A06	B25	unused
A26	A05	B26	unused
A27	A04	B27	unused
A28	A03	B28	ALE
A29	A02	B29	+5V
A30	A01	B30	CLK
A31	A00	B31	ground

Table 4: *Control-word codes for the 8251A serial interface controller chip. All aspects of the transceiver are subject to software control.*

Bit	Value	Function
7 and 6	00	invalid
	01	1 stop bit
	10	1½ stop bits
	11	2 stop bits
5	0	odd parity
	1	even parity
4	0	parity disable
	1	parity enable
3 and 2	00	5 data bits
	01	6 data bits
	10	7 data bits
	11	8 data bits
1 and 0	should always be 10 for the MBC-550	

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Listing 1: *An animation test program for the* MBC-550.

```
10 REM SIMPLE ANIMATION WITH PUT AND GET
20 REM USE ARROW KEYS TO MOVE BLOCK AND S TO STOP
30 REM THE BLOCK IS MOVING ONE PIXEL WITH EACH KEYSTROKE
40 REM DIM PATTERN%(25)
50 X=320:Y=100
55 REM INITIALIZE ARRAY
60 GET (1,1)-(16,8),PATTERN%
65 REM CLEAR ARRAY EXCEPT FOR ARRAY SIZE INTEGER
70 FOR A=2 TO 25:PATTERN%(A)=0:NEXT A
75 REM PUT BLOCK INTO ARRAY
80 FOR A=11 TO 16:PATTERN%(A)=&HFE7F:NEXT A
90 CLS
100 PUT (X,Y),PATTERN%
110 I$=INKEY$
120 IF I$="" THEN 110
130 IF I$="S" THEN 190
140 IF (X>1) AND (I$=CHR$(28)) THEN X=X-1
150 IF (Y>190) AND (I$=CHR$(31)) THEN Y=Y+1
160 IF (Y>1) AND (I$=CHR$(30)) THEN Y=Y-1
170 IF (X<630) AND (I$=CHR$(29)) THEN X=X+1
180 GOTO 100
190 END
```

Listing 2: *An assembly-language program to alter serial communications functions.*

```
SSEG     SEGMENT STACK
         DB 256 DUP (?)
SSEG     ENDS
;
DSEG     SEGMENT
DATA     DB ?
DSEG     ENDS
;
CSEG     SEGMENT
         ASSUME CS:CSEG,DS:DSEG,SS:SSEG
START    PROC FAR
         PUSH DS
         PUSH AX
         MOV BX,DSEG
         MOV DS,BX
         CALL MAIN
         RET
START    ENDP
;
MAIN     PROC NEAR
         MOV AL,0
         OUT 42,AL ; THE FIRST THREE OUT STATEMENTS ESTABLISH TIMING
         MUL AL ;ALL MUL STATEMENTS ARE FOR TIMING
         OUT 42,AL
         MUL AL
         OUT 42,AL
         MUL AL
         MUL AL
         MOV AL,64 ; 64 IS THE PREPARE TO RECEIVE COMMAND SIGNAL
         OUT 42,AL
         MUL AL
         MUL AL
         MOV AL,250 ;250 SETS THE 8251A FOR EVEN PARITY, 2 STOP
         OUT 42,AL ;BITS AND 7 DATA BITS. SEE TABLE 4.
         MUL AL
         MUL AL
         MOV AL,55 ; 55 IS THE LOCK COMMAND SIGNAL
         OUT 42,AL
         MUL AL
         MUL AL
         RET
MAIN     ENDP
CSEG     ENDS
         END START
```

agination, you can make the MBC-550 generate plenty of sound.

SOFTWARE

The MBC-550 comes with five software packages: MS-DOS 1.25, Sanyo BASIC 1.1, WordStar 2.4, CalcStar, and Easy-Writer 1.3. WordStar, CalcStar, and Easy-Writer are all standard releases and don't need to be reviewed here.

Sanyo BASIC is standard BASIC and is code-compatible with IBM BASIC except for some of the graphics commands that IBM's version lacks—WINDOW, VIEW, and SYMBOL. The VIEW and WINDOW commands enable you to set aside areas of the screen for special graphics tasks. The SYMBOL command takes any string of the 255 displayable characters and magnifies or rotates them and places them anywhere on the screen.

Sanyo BASIC has a nice screen editor that you engage by listing the line or lines that you want to edit and then pressing the up-arrow on the numeric pad. The cursor-control and the Delete and Insert keys then enable you to make whatever changes you like, including changing line numbers and creating new lines. When you're through, press the Break key and the editor stores all changes and returns you to BASIC.

In its February 1984 newsletter, Sanyo printed a list of 48 IBM software packages that run on the MBC-550 without modification. The list included seven languages, eight adventure games, ten word processors, and six database-management systems. The MBC-550 can run a lot of software.

CONCLUSION

Having now owned a Sanyo MBC-550 for four months, I am very pleased with this machine. The MBC-550 is more computing machine for the dollar than any other personal computer on the market. Because it offers compatibility with the IBM PC and other 8088-based systems, the MBC-550 will *never run* short of software. With a large organization like Sanyo behind it and a price one-third that of comparable machines, the Sanyo MBC-550 is a good buy. ■

ACKNOWLEDGMENT

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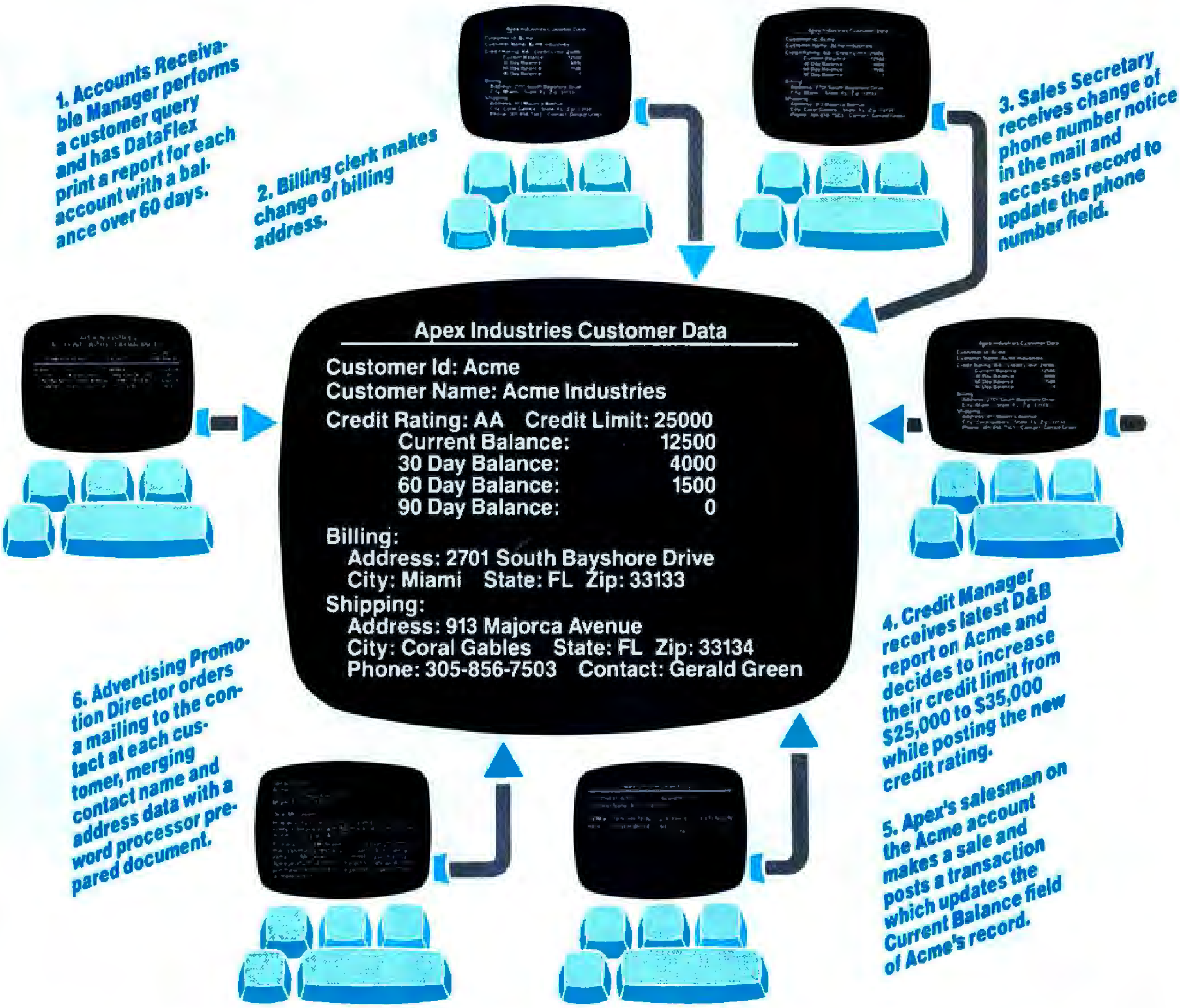

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Four Logos for the IBM PC

Several new Logos offer turtle graphics of varying quality on the IBM PC

BY MARK BRIDGER

This is not, of course, the famous Big Blue IBM logo; this is the Logo programming language, specifically the four versions currently available for the IBM Personal Computer (PC) and/or PCjr. Until recently, the only Logos available ran either on mainframes with lots of memory or on 8-bit machines, such as the Apple and the Commodore, with barely enough memory—at most 64K bytes. The widespread availability of 16-bit machines like the IBM PC with adequate memory (128K bytes or more) and color graphics enables you to enjoy the power and fascination of a full Logo implementation.

AN OVERVIEW

In terms of structure and ancestry, Logo is a cousin to LISP—the language generally used by artificial intelligence researchers. LISP, which was invented in the early 1960s by J. McCarthy, is a language whose basic data structure is a list. A list is an ordered collection of objects, which may be names, numbers, or other lists. Both Logo and LISP (short for list processing) can manipulate lists in many different ways. The full implementation of LISP contains many features not found in Logo (see references 2 and 6).

The most dramatic difference between Logo and other programming languages—including LISP—is its *turtle graphics*. Originally, the turtle was a motorized metal and Plexiglas creature, controlled by the programmer, which could lower its pen to draw a trace of its path on the floor. Instructions for the turtle were coded in Logo, and you could draw quite complicated pictures with relatively few commands. When CRTs (cathode-ray tubes) became widely used on computers, the turtle appeared on them as a small triangle, and its path as a line of pixels (dots) on the screen. Logo and turtle graphics have been considered virtually synonymous for quite some time, and it is fair to say that most people who use Logo do so to use the turtle. Schools use Logo and turtle graphics extensively as a means of teaching programming and geometry and fostering creativity (see references 3 and 5).

Like BASIC and LISP, Logo is an interpreted language. This means that when you run a Logo program, an interpreter translates each line into the strings of zeroes and ones that are machine language. Even if you repeat a line or the program goes to an instruction it has already translated, the interpreter must translate it into machine code all over again. This means that an interpreted language produces relatively slow-running programs, but it has advantages over compiled languages. A compiler translates a complete program, line for line, into machine code and then saves it as an autonomous stand-alone program, needing no interpreter. Pascal, FORTRAN, and C are compiled languages. While compiled programs execute very quickly, they have a disadvantage: to change a compiled program, you must change the source code using a text editor and then recompile it. Only then can you see if the changed program works the way you want it to. With an interpreted language you just change the text and run.

One last point: Logo is a structured language, like Pascal and C. There are no line numbers in Logo—commands execute sequentially and special commands control repetition. You can organize instruction sequences that are used several times in your program into procedures, give them names, and invoke them by these names. Thus, Logo doesn't need line numbers because the interpreter tells the machine what to do and when to do it based solely on the logical structure of the written program.

THE LOGOS AVAILABLE

I will discuss four Logo packages in this review, Dr. Logo, IBM Logo, PC Logo, and Waterloo Logo. I will look at various features of the language, give some examples, and try to com-

(continued)

Mark Bridger (Math Department, Northeastern University, Boston, MA 02115) *is an associate professor of mathematics at* Northeastern University. *He has a* B.A. *from* Columbia University *and a* Ph.D. *in mathematics from* Brandeis University. *When he isn't playing with his computer, Mark enjoys carpentry, gardening, and playing bluegrass music, particularly on the mandolin.*

pare how each of these products implements those features.

GRAPHICS

The turtle, represented on the screen by a small triangle, responds to the basic commands: FORWARD (distance), BACK (distance), RIGHT or LEFT (angle), and PENUP or PENDOWN, with distance and angle as specified numbers. You can also set the BACKGROUND color, the PALETTE, and the PENCOLOR. In addition, the various Logos provide other graphic enhancements as follows.

WRAP/FENCE/WINDOW: With the WRAP option, if the turtle leaves the screen on the right, it reappears on the left at the same height; similarly, if it leaves on the left, top, or bottom, it reappears on the opposite side. FENCE prevents the turtle from leaving the screen at all, while WINDOW allows the turtle to leave and keep going even though you can no longer see it. All the Logos except Waterloo provide these three options. Waterloo allows the turtle to operate in FENCE mode only.

PAINT or FILL: This is similar to IBM BASICA's PAINT command. It fills in the closed area that contains the turtle with a specified color. Only Waterloo and IBM Logos provide this feature. Waterloo Microsystems claims that a new version of its Logo will be able to paint in user-selected textures.

HIGH RESOLUTION: The standard graphics mode for Logo is 320 by 200 pixels in four colors; however, PC Logo lets you choose 640 by 200 pixels with one color on a black background. This results in crisper, more detailed pictures, but only in one color. (This color comes from directly programming the IBM Color Graphics Adapter and does not apply to the PCjr.)

PICTURE SAVING: All four Logos offer procedures for saving a picture on either disk or the printer. The only printer supported is the Epson/IBM. The screen dump occurs via the DOS 2.0 GRAPHICS command in PC and IBM Logos (but only under 2.0).

ARCS/CIRCLES: Procedures for drawing arcs and circles are built into Waterloo Logo and are among the listed utility programs for IBM Logo. However, if you have Dr. Logo or PC Logo, you must write your own.

MUSIC: All four Logos provide some sort of tone and duration primitive commands, along with complete instructions for their use in producing music of a sort from the IBM PC's rather meager audio system. Waterloo and PC Logos provide sample programs that play tunes ranging from "The Star-Spangled Banner" to a Bach Partita (one of my favorites, but it sounds like an anemic Moog synthesizer on the PC).

SPEED: I performed some benchmark tests on the Logos, using the Hilbert (HIL, or actually Peano) Curves program (see listing 1 and reference 1). Since graphics is a primary use for Logo, and since drawing repeated and recursive designs is very popular, this program is a pretty fair representation of a Logo application. The first time I drew a level-6 curve, I left my 8087 chip turned on and produced the rather lopsided results found in table 1.

The reason for PC Logo's speed is easy to figure out. Logo, like BASIC, assumes—unless told otherwise—that its variables are real. In particular, the turtle moves through real coordinates processed by floating-point calculations. A machine with an 8087 Numerical Data Processing chip (the one that sits next to the central processor 8088 chip) handles real variables like lightning. If you have an 8087, you can expect PC Logo, the only Logo to provide support for it, to be much, much faster in graphics and all real-number manipulations. If you're a speed demon, PC Logo is probably the way to go.

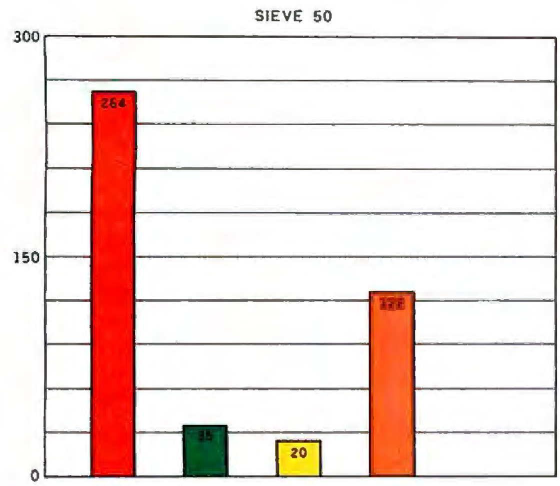
On the other hand, there is something to be said for watching the way the turtle actually draws your picture. You can learn and savor the act of creation—sometimes speed may not be a major concern if you have children using Logo. If you turn off the 8087 chip, IBM wins (see table 1). You have to admit that 12 or 15 minutes is a long time to watch a picture being drawn.

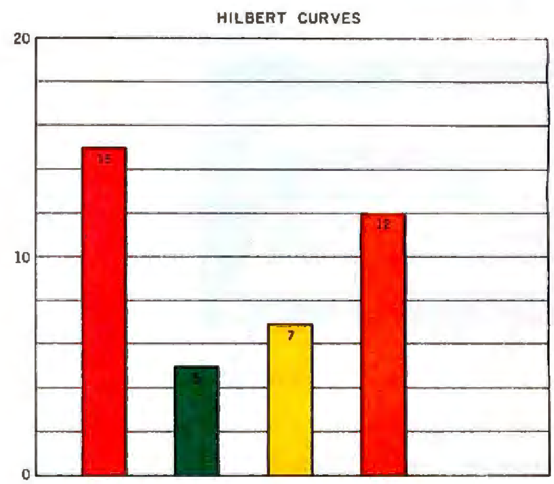
(continued)

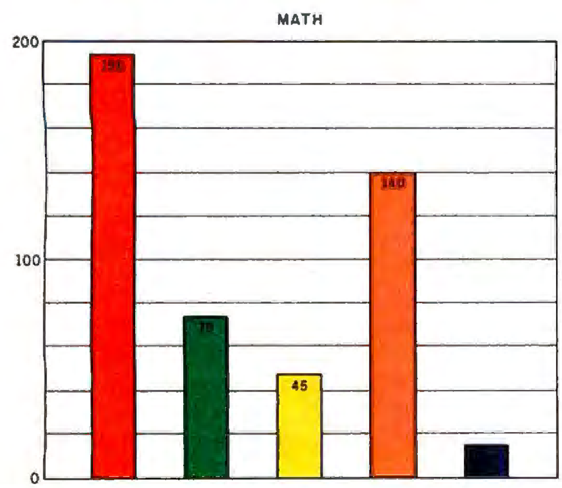
Listing 1: HIL, *a Hilbert Curves benchmark program in Logo.*

```
TO HIL :COLOR
SETBG 0                        ; SETS BACKGROUND TO BLACK
SETPAL 0                       ; CHOOSES PALETTE 0
SETPC :COLOR                   ; SETS PEN COLOR TO INPUT :COLOR
FULLSCREEN                     ; USES WHOLE SCREEN FOR GRAPHICS
HOME                           ; SENDS TURTLE TO STANDARD POS.
CLEARSCREEN                    ; CLEARS SCREEN
PENUP                          ; TURTLE WON'T DRAW WHEN MOVED
SETX 150                       ; MOVE TO X=150, Y UNCHANGED
SETY -100                      ; MOVE TO Y=-100, X UNCHANGED
PENDOWN                        ; TURTLE IS NOW IN LOWER RT.
                               ; CORNER OF SCREEN,READY TO DRAW
HILBERT 3 6 1                  ; BIGGEST CURVE FITTING SCREEN
END                            ; PROCEDURE HIL ENDS

;THE NEXT PROCEDURE DRAWS THE CURVE. EACH HILBERT CURVE IS
;DRAWN BY DRAWING FOUR HILBERT CURVES OF A LOWER LEVEL WITH
;DIFFERENT ORIENTATIONS, CALLED PARITIES. NOTE HOW THIS
;PROCEDURE "CALLS ITSELF" — THIS IS RECURSION.

TO HILBERT :SIZE :LEVEL :PARITY
IF :LEVEL = 0 [STOP]           ; LEVEL 0 CURVES DO NOTHING
LEFT :PARITY*90                ; ROTATE PARITY RIGHT ANGLES
LOCAL "L                       ; CREATE LOCAL VARIABLE L
MAKE "L :LEVEL-1               ; SO YOU DON'T HAVE TO RECOMPUTE
HILBERT :SIZE :L (-:PARITY)    ; DRAW LOWER ORDER CURVE
FORWARD :SIZE                  ; DRAW CONNECTING SEGMENT
RIGHT :PARITY*90               ; CHANGE ORIENTATION AGAIN
HILBERT :SIZE :L :PARITY       ; ANOTHER LOWER ORDER CURVE
FORWARD :SIZE                  ; ANOTHER CONNECTOR
HILBERT :SIZE :L :PARITY       ; SAME AS PREVIOUS
RIGHT :PARITY*90               ; ANOTHER TURN
FORWARD :SIZE                  ; THE LAST CONNECTOR
HILBERT :SIZE :L (-:PARITY)    ; THE LAST CURVE
LEFT :PARITY*90                ; THE LAST TURN
END                            ; PROCEDURE HILBERT ENDS

;See TURTLE GEOMETRY (Abelson and diSessa, MIT Press) for
;this and other turtle graphics projects.
```

AT A GLANCE







A COMPARISON OF four Logos for the IBM using three benchmark programs (see table 1). Sieve 50 finds the primes up to 101 (see listing 2). The Hilbert Curves program (listing 1) measures how long it takes to draw a set of curves. One thousand iterations of the MATH program (listing 3) measure each language's ability to perform real-number multiplication and division. Execution time indicated on the *y* axis is in seconds.

Name	Dr. Logo	IBM Logo	PC Logo	Waterloo Logo
Manufacturer	Digital Research Personal Computer POB 579 160 Central Ave. Pacific Grove, CA 93950 (408) 649-5500	IBM Corp. (distributor) Boca Raton, FL 33432 (software prepared by Logo Computer Systems Inc.)	Harvard Associates Inc. (distributor) 260 Beacon St. Somerville, MA 02143 (617) 492-0660 (software prepared by Gold Hill Computers Inc.)	Waterloo Microsystems Inc. 175 Columbia St. West Waterloo, Ontario N2L 5Z5 Canada (519) 884-3141
Price	$150; additional backup disks cost $25	$175	$150	$125
Computer Needed	IBM PC with at least 192K bytes of memory, color graphics adapter, one disk drive, and monitor	IBM PC XT or PCjr with at least 128K bytes of memory, color graphics adapter, one disk drive, and monitor	IBM PC XT or PCjr with at least 64K bytes of memory, 128K for full implementation, color graphics adapter, one disk drive, and monitor	IBM PC XT (PCjr soon) with at least 128K bytes of memory, color graphics adapter, one disk drive, and monitor
Contents	User's manual/tutorial, language disk and backup (CP/M operating system; kernel provided); copy-protected	User's manual and tutorial, Logo quick-reference card, and language disk; not copy-protected	User's manual/tutorial, language disk, and demonstration utilities disk; not copy-protected	User manual, Logo language disk, and demonstrations disk (DOS-file compatible); not copy-protected

List Processing

Here are some examples of lists. Notice that in Logo you enclose the lists in brackets.

[CURLY LARRY MOE]	(list of three names)
[]	(empty or null list)
[1 3 5 7 9 11]	(list of numbers)
[1 2 3 IBM PC]	(mixed list of 5 items)
[HEIDEGGER KANT [ORTEGA GASSET] 81]	(list of 4 items: two names, another list, and a number)

You can add an object to the front of a list with the command FPUT and to the back with LPUT. Note that names require a preceding double quote in Logo. FPUT "MARX [DARWIN FREUD] yields the list [MARX DARWIN FREUD], while LPUT "D'ARTAGNON [ATHOS PORTHOS ARAMIS] produces [ATHOS PORTHOS ARAMIS D'ARTAGNON].

You can also form a list from individual objects using the LIST command. (LIST "COMPILE "LINK "EXECUTE) outputs the list [COMPILE LINK EXECUTE]. And you can concatenate (string together) two lists with SENTENCE. SENTENCE [1 2 3][3 TWO ONE] yields [1 2 3 3 TWO ONE].

Given a list, you can extract its first object using FIRST (similar to CAR in LISP) and form a list containing everything else using BUTFIRST (similar to CDR in LISP). FIRST [LARRY MOE CURLY] produces LARRY, while BUTFIRST [LARRY MOE CURLY] yields [MOE CURLY]. You can work from the other end of the list using LAST and BUTLAST.

One attractive feature of lists in Logo that you don't have with arrays in most other languages is that list elements can be anything, whereas usually array elements must all be the same type. On the other hand, you can easily access and change any array element, but you can attack lists only from one end or the other. For example, suppose you want to remove the 3 from the list L = [1 2 3 4 5 6]. To get to the 3, you have to rotate the list twice. First, MAKE "L (LPUT FIRST :L BUTFIRST :L) yields L = [2 3 4 5 6 1]. Then, MAKE "L (LPUT FIRST :L BUTFIRST :L) yields L = [3 4 5 6 1 2]. (MAKE is a Logo command that assigns a name to a list, "L is the name of a list, and :L is the contents of "L.) You can now remove the 3 with a BUTFIRST. MAKE "L BUTFIRST :L yields L = [4 5 6 1 2]. Then rotate back. MAKE "L (FPUT LAST :L BUTLAST :L) yields L = [2 4 5 6 1], and MAKE "L (FPUT LAST :L BUTLAST :L) yields L = [1 2 4 5 6].

Logo also provides a REPEAT statement, so that you can write the whole procedure in the following way:

```
REPEAT 2 [MAKE "L (LPUT FIRST :L
  BUTFIRST :L)]
MAKE "L BUTFIRST :L
REPEAT 2 [MAKE "L (FPUT LAST :L
  BUTLAST :L)]
```

(continued)

Table 1: *A comparison of four Logo systems for the* IBM PC *using five benchmark tests. A complete description of the tests is given in the text. The* HIL *benchmark is given in listing* 1. *The* SIEVE *benchmark is given in listing* 2. *The* MATH *benchmark uses real-number multiplication and division and is given in listing* 3. *The* TRIG *benchmark uses sine and cosine functions and is given in listing* 4. *The* ALPHABET *benchmark (listing* 5) *prints the alphabet on the screen over and over. All times are in seconds.*

Language	SIEVE 50	HIL	MATH 1000	TRIG 1000	ALPHABET 100
Dr. Logo	264	15	196	233	27
IBM Logo	35	5	75	535	13
PC Logo	20	7	45	74	196
with 8087	19	1	19	16	210
Waterloo Logo	122	12	140	292	35
BASICA			13	43	9

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dBase Window	249	155
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These procedures are used later in the SIEVE program.

PROPERTY is another Logo list-handling feature. You can give any identifier one or more property names with single values for each property. For example,

PPROP "THISCAR "BRAND [Volvo]

gives the identifier THISCAR the property BRAND whose value is Volvo. You can then select from a list those identifiers that have certain values for certain properties and PACKAGE them under some name. The use of PACKAGE is also handy for collecting related procedures in order to save them together in a disk file.

All the Logo languages under review implement the standard list-handling features described above except for one: PC Logo doesn't have the PACKAGE command. Dr. Logo is notable because it provides some nice extra commands: SHUFFLE, which creates a random permutation of the elements in a specified list; SORT, which sorts a list into ascending alphanumeric order; and PIECE, which picks out a segment of list elements—for example, the third through twelfth elements.

The Dr. Logo instruction book has a very amusing example: a random recipe generator, which makes highly fantastic dishes by picking out random elements from lists of foods and cooking procedures.

The PC Logo utilities disk comes with a famous Logo program called Animals in which the computer tries to guess what animal you're thinking of by asking yes/no questions. Initially, it has only a small stock of questions; if it fails to guess your animal, it gives up and asks you for the answer. Then the program asks you for one question that would help it to distinguish its guesses from the correct answer in the future. It stores this question and uses it in future games; thus, the computer *learns.*

There is no doubt that speed is important for list handling. You can't learn anything waiting for the machine to move objects around lists. In keeping with what seems to be a tradition, I coded a variation of the Sieve of Eratosthenes algorithm for finding prime numbers in Logo (see "Eratosthenes Revisited: Once More through the Sieve" by Jim and Gary Gilbreath, January 1983 BYTE, page 283). While Logo is certainly not an appropriate language for doing a sieve, the very cumbersomeness of the routine gives a good workout to Logo's list-handling abilities.

Look first at listing 2 and note that the sieving program is made up of subprograms. SIEVE sets up the list and calls STRIKEOUT. STRIKEOUT finds the first nonzero entry in the list (using SKIPZEROS), makes *PRIME* the corresponding odd number, and then removes every *PRIME*th number from the list using STROLL—a combination of strike and roll. The program records the various primes and prints them out. The only arithmetic occurs in computing *PRIME* = *counter* + *counter* + 1, and in determining how many times to do STROLL (*N* divided by *PRIME* times). The benchmark results for the SIEVE program are in table 1.

Listing 2: SIEVE 50, *an iterative version of the Sieve of Eratosthenes prime-number benchmark.*

```
TO STROLL :K
IF :K 0 [MAKE "ODDS LPUT 0 BUTFIRST :ODDS]
IF :K 1 [REPEAT (:K-1) [MAKE "ODDS LPUT FIRST :ODDS BUTFIRST :ODDS]]
END

TO SKIPZEROS
IF FIRST :ODDS 0 [STOP]
MAKE "COUNTER :COUNTER + 1
IF :COUNTER :N [STOP]
MAKE "ODDS LPUT FIRST :ODDS BUTFIRST :ODDS
SKIPZEROS
END

TO STRIKEOUT
SKIPZEROS
IF :COUNTER :N [STOP]
LOCAL "PRIME
MAKE "PRIME :COUNTER + :COUNTER + 1
MAKE "PRIMES SENTENCE :PRIMES :PRIME
REPEAT INT (QUOTIENT :N :PRIME) [STROLL :PRIME]
STROLL (REMAINDER :N :PRIME)
STRIKEOUT
END

TO SIEVE :SIZE
MAKE "N :SIZE
MAKE "PRIMES [2]
MAKE "ODDS [1]
REPEAT :N-1 [MAKE "ODDS SENTENCE :ODDS 1 + LAST :ODDS]
MAKE "COUNTER 1
STRIKEOUT
PRINT :PRIMES
END
```

Editing and Debugging

You create programs and procedures (they are the same thing in Logo) two ways: typing line by line directly on the screen or working in an "editor" that allows you to go back and forth among the lines, entering, changing, and deleting as you wish. All the Logos support these two modes, but the editor is more important for developing and changing long programs. It is essential to be able to see and move several lines of instructions at a time, and the editor that makes this the easiest is best.

All editors must provide certain basic features: the ability to overwrite or insert characters, to delete or add lines, and to skip from line to line. Logo considers a line to be equal to all the characters up to and including the next carriage return. If there are more characters than will fit on a physical line on the screen, the text should wrap around and continue on the next line, while preserving its integrity as a logical line for the Logo interpreter. All the Logo editors except Waterloo work this way. In Waterloo Logo the line continues even if it goes off the screen and becomes invisible (like the turtle with a WINDOW option). In order to see what

(continued)

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you wrote, you must scroll the screen horizontally with several manual cursor moves and keystrokes. This is extremely annoying, especially with the Waterloo editor that supports lines only 40 columns wide. (The others all allow 80-column lines in text mode.) Ironically, Waterloo Logo does have line wrap outside the editor if you are entering a program line by line on the screen.

While Dr. Logo and IBM Logo have perfectly adequate and easy-to-use editors, PC Logo is really the clear winner in this category. It has SEARCH and REPLACE commands as well as the ability to move or copy large blocks of text from one place to another. PC also has various useful editorial functions assigned to nearly every key on the IBM PC keyboard including the function keys. The Waterloo editor has a nice way of moving a text block after you highlight it, but this doesn't compensate for its lack of line wrap.

A final word about editors: you can use almost any screen editor or word processor to create Logo programs. However, there are two complications: first, you must leave Logo to use your editor and return to Logo to run the program; second, your version of Logo must be able to read the file that your editor/word processor creates. The first complication is at worst an inconvenience, but the second is very serious for Dr. Logo. Dr. Logo operates under the CP/M-86 operating system. If your editor is DOS-based, as many are, the files it creates cannot be read by Dr. Logo. Furthermore, you won't be able to copy any Logo programs into your system unless the programs are on a CP/M-86 formatted disk, which is unlikely if they weren't created for using Dr. Logo. Most IBM PC users operate under DOS, so it is wise to be wary of products using other operating systems. They may work quite well but not have the compatibility you desire. (Waterloo Logo also has its own operating system, Port, but it is possible to use DOS files with Port provided the disk is formatted with 8 sectors per track.)

Because you must debug programs that don't work properly, debugging features are important. For effective debugging, the four Logos provide a PAUSE command. When you insert it in a program, PAUSE creates a temporary

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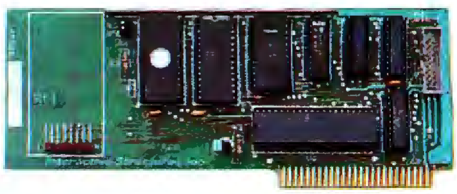

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halt so that you can print out the values of the variables on the screen and see what's going on. Then you can resume processing with the CONTINUE command.

Dr. Logo and PC Logo also provide a TRACE command which, if typed in before executing the program, displays the names and values of all variables and procedures as the program encounters them in execution. With recursive procedures, Dr. Logo prints out the level of the procedure call, too. If you combine TRACE with PAUSE, you can save time and keystrokes in debugging. However, Dr. Logo goes further and provides WATCH and DEBUG as well. WATCH puts the procedure into "one step" mode, executing only one line at a time; you then press enter to start the next line. DEBUG splits the screen, displaying the results of TRACE on the top half and the program's actual output on the bottom half. You can also invoke a combination of TRACE, WATCH, PAUSE, and DEBUG. This package of utilities makes debugging in Dr. Logo by far the most convenient.

ARITHMETIC

Except for some dedicated fans, very few people choose Logo for number crunching (extended arithmetic calculations using real numbers). Of course, turtle graphics uses real-number manipulation implicitly, but this is so tied up with screen output that it becomes a separate category. To please the number crunchers, I did a few benchmarks using only standard arithmetic and trigonometric functions, because Waterloo and PC Logos don't have logarithmic or exponential functions. This lack is quite surprising in the case of PC Logo since its 8087 support should make all types of transcendental functions easy and fast. For the sake of comparison, I also ran an exact analog of each arithmetic program in IBM BASICA and added the times to the chart. Table 1 includes the results for a program called MATH 1000, which uses multiplication and division as shown in listing 3. The TRIG 1000 program results in table 1 come from sine and cosine calculations as given in listing 4.

Notice that even without the 8087, PC Logo is the fastest for real-number manipulations. Its speed on trigono-

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metric functions using the 8087 explains why it produces graphics so quickly. You have to wonder why PC Logo is slower than IBM Logo in the Hilbert Curves benchmark when the 8087 is not present. I suspected that there might be some inherent slowness in getting information to the screen, so I tested the Logos with a simple program that just displayed the alphabet many times. The results of running ALPHABET (see listing 5 and table 1) were striking. For some strange reason, probably a bug, PC Logo actually slowed down the more alphabets it printed. (Note that this bug has now been corrected and PC Logo's screen output is notably faster.)

Memory and Performance

PC Logo is the only one of the four that needs as little as 64K bytes of memory. But it sacrifices some features (including high-resolution graphics and an 80-character screen) with that little memory. IBM Logo requires 128K bytes, while the other two require a minimum of 192K bytes. How much memory the language can use (and how efficiently the language can use it) is probably of greater interest than how much it needs.

Logo stores lists (procedures and instructions are different) in data structures called *nodes* (see reference 4). Supposedly, the number of nodes that exist determines how much space you have for writing and running programs, assuming a node means the same thing for each Logo. Since it is unlikely that you would ordinarily exhaust memory simply by writing a long program (it would have to be very, very long), the amount of memory you need to run the program is crucial.

The recursive program that uses stack memory is the most common memory gobbler (see text box, "Recursion: Therein Lies a Tail," page 300). IBM Logo is by far the most effective user of stack memory, and PC Logo the least. Furthermore, IBM can use as much as 256K bytes of memory—more than any of the others—while PC Logo can use only 128K bytes (perhaps accounting for its small stack). Waterloo can use as much as 192K bytes, while Dr. Logo implies that 256K bytes or more "enhances" its performance. On entry Dr. Logo says it has 9074 nodes free, while IBM claims to have 31,095. Since I have a 320K-byte system, what could "enhances" mean?

Instructions, Documentation, and Extras

All the Logos come with instructions for start-up and for writing programs, as well as documentation for all the commands and procedures available. They also have fairly adequate indexes. The reference manuals for IBM, PC, and Dr. Logos are thick loose-leaf books with complete instructions for getting started. Dr. Logo provides color plates showing the graphics outputs, while IBM supplies a separate spiral-bound notebook devoted to the turtle. The first part of the PC manual is an elementary tutorial; the package also includes a separate disk with examples and utilities containing the famous Dynaturtle game (which illustrates Newtonian laws of inertia), a curve-sketching program, and several others. By contrast, Waterloo Logo provides only a demonstration disk and a rather slim booklet listing and describing briefly its primitive procedures and its differences from Apple Logo. Waterloo Microsystems apparently feels that its Logo is sufficiently close to the Apple system so that you either already know how to program in Logo or will purchase an Apple tutorial; the company did suggest to me that a more extensive manual will appear in the future.

In the IBM and Dr. Logo instruction manuals, procedure descriptions each begin a page, contain one or more examples, and are arranged alphabetically. The PC manual is similar but arranges its procedures by type (e.g., list manipulation, graphics, input/output, etc.) and then alphabetically within the group. Finding a description is rather slow and often means using the index. Waterloo and IBM also provide reference cards listing various procedures with brief descriptions of their syntax.

For the serious programmer, IBM and PC Logos provide some nice extras like access to DOS services and machine-language subroutines. PC Logo lets you set the 8088 registers and call interrupts. You can extend this setting, somewhat awkwardly, to load and call a machine-language routine by using the DOS stay-resident service in your subroutine and setting an interrupt vector to point to the procedure. IBM provides

(continued)

Listing 3: MATH 1000, *a real-number multiplication and division benchmark.*

```
TO MATH :N
  MAKE "COUNTER 1
  MAKE "Q 1
  REPEAT :N [MAKE "Q (:COUNTER + :COUNTER * 3.14159)/(5 + 2.71828 *
    :COUNTER) MAKE "COUNTER :COUNTER + 1]
  PRINT :Q
END
```

Listing 4: TRIG 1000, *a trigonometric function (sine and cosine) benchmark.*

```
TO TRIG :N
  MAKE "COUNTER 1
  MAKE "Q 1
  REPEAT :N [MAKE "Q SIN(:COUNTER*2)+COS(:COUNTER*3 + :COUNTER)
    MAKE "COUNTER :COUNTER + 1]
  PRINT :Q
END
```

Listing 5: ALPHABET, *a text screen output program.*

```
TO ALPHABET :N
MAKE "A [A B C D E F G H I J K L M N O P Q R S T U V W X Y Z]
MAKE "COUNTER 1
REPEAT :N [TYPE :A TYPE :COUNTER MAKE "COUNTER :COUNTER + 1]
END
```

Circle 104 on inquiry card.

Recursion: Therein Lies a Tail

When a procedure has the command to perform itself as one of its instructions, this is recursion. Consider the very simple Logo program:

```
TO STAR
TYPE [*]
STAR
END
```

When invoked, this program types an asterisk and invokes itself again; then it types an asterisk, then invokes itself again, ad infinitum—you can stop it only with a Logo BREAK command. Not every language supports this kind of antic: FORTRAN and BASIC do not, while Pascal, C, LISP, and Logo do.

When you call or invoke a procedure by name in a program, certain information—the location of its commands in memory and the value of its variables—is placed in a special region of memory called the stack. You can picture the stack as just that: a stack of memory locations. The last item to be "pushed" or placed on the stack goes on top of the items already there; you can access only the most recently added item; and you must remove or "pop" it in order to reach those beneath it. Each time you call a procedure, its vital information is "pushed" onto the stack. Each time the computer finishes processing a called procedure, this information is "popped" off the stack. The information on the previously "pushed" procedure is now on top of the stack.

Table 2: *This table shows the point at which the* STAR2 *program dies in each Logo, which will give you an idea of the relative stack size available.*

Language	Time (seconds)
Dr. Logo	514
IBM Logo	2386
PC Logo	106
Waterloo Logo	763

If you analyze the behavior of STAR, it appears that you never reach an END. Before the first STAR can end, it must complete the second STAR, which can't END until STAR number 3 finishes, which can't end until. . . .Therefore, the vital information about each copy of STAR never "pops." The stack will grow forever until the memory allocated to it runs out and the system crashes.

The remarkable thing is that this crash never occurs. Because there are no instructions (other than the END statement) following STAR's recursive call to itself, recursive language compilers and interpreters recognize the simple repetition (or iteration) of one fixed procedure. They handle it by recording one fixed copy of the procedure and executing it over and over again. Such a situation is called "tail" recursion because the recursive call is placed at the end or tail of the procedure.

Consider the following two variants of STAR:

```
TO STAR1 :N       TO STAR2 :N
TYPE :N           TYPE :N
TYPE [*]          STAR2 :N+1
STAR1 :N+1        TYPE [*]
END               END
```

STAR1 is simply another example of tail recursion, this time with a variable N. N is a counter, which is printed with an asterisk during each repetition. I tried STAR1 in all four Logos, and it continued for more than 4000 repetitions.

STAR2 is another story. An instruction exists after STAR2's call to itself: the command to print an asterisk. This command is never executed because STAR2 never gets past invoking itself an infinite number of times. The interpreter doesn't recognize that STAR2 is intended to do exactly the same thing as STAR1; it just sees that the recursive call is not the last command in the program, so it pushes the whole mess on the stack and keeps going. Consequently, STAR2 is a good way to measure the stack size allocated or usable by the various Logos. The last number that STAR2 prints gives the

---

.BLOAD and .CALL routines—they work the same way as in BASIC—to load and run machine-language code. These will be provided in a future update of PC Logo. IBM and PC Logos also include the commands .EXAMINE and .DEPOSIT, which are the (polite) Logo versions of PEEK and POKE. Both IBM and PC Logos have procedures to redirect input/output characters and numbers to and from disk files.

Waterloo Microsystems (Waterloo Logo) and Harvard Associates (PC Logo) offer a flat licensing fee for school systems or other nonprofit groups that intend to use Logo. This enables the nonprofit user to make and use as many copies as needed for the group. Extra copies of documentation can be purchased separately. IBM also has educational discounts available to schools and universities. Only Digital Research has no similar plan at this time; furthermore, its Dr. Logo is the only one that is copy-protected. Digital Research does, however, supply one backup.

Hardware

All four Logos run on either the IBM PC or XT, although you can't load Dr. Logo onto a hard disk because it is copy-protected. While you can theoretically operate Logo without a color-graphics adapter, there is hardly any point in using it without turtle graphics. All the Logos require at least one disk drive, but Waterloo Logo appears limited to one because there is no procedure to change or reference an alternate drive from within the language.

IBM and PC Logos both run on the PCjr at this time. Waterloo Microsystems claims that by the time you read this its Logo will also. Digital Research has no immediate plans for PCjr compatibility.

PC and Dr. Logos support the use of lightpens, while Dr. and IBM Logos support joysticks.

Conclusions

As you can see, it is hard to pick a clear-cut winner from these four contenders. IBM Logo has the best balance of speed, features, and documentation. All the procedures work as advertised, and the ease of interfacing with machine language makes up for some of Logo's innate weaknesses. The amount and efficient use of stack space are strongly in its favor, as is its ability to use as much relative size of the stack. Table 2 gives the comparative stack sizes: in other words, it shows the last number printed before STAR2 dies. As you can see, IBM Logo has, by far, the largest effective stack.

It is interesting to try to determine exactly how clever the interpreter is in detecting tail recursion. Consider now the following variant:

```
TO STAR3 :N
TYPE :N
TYPE [*]
IF :N>O [STAR3 :N+1]
END
```

The last instruction is once again a call to the procedure itself, but a spurious IF :N>O precedes it in the actual instruction line. This is effectively tail recursion, but does the interpreter know? Only the IBM interpreter correctly interprets this as tail recursion and continues to execute the program; all the others die at around the same number of repetitions as they did with STAR2.

How important is stack space and its conservation? Logo depends to a great extent on recursive procedures, because it lacks the built-in control structures "WHILE . . . END" and "REPEAT . . . UNTIL" found in other structured languages. Listing 6, MSIEVE, is a recursive version of the Sieve (thanks due to Meredith Lesly). MSIEVE 100, for example, looks for primes less than or equal to 100. PC and Dr. Logos die well before 100 while Waterloo continues only to about 400. IBM does MSIEVE 1100 but finally dies by MSIEVE 1500. If you call NODES after MSIEVE dies, you find that there are 21,104 modes left (from 30,881 initially); IBM Logo has really run out of stack spaces, not memory. It is interesting that MSIEVE is also, in a certain sense, tail-recursive, but it is unrealistic to think that an interpreter could rearrange it as an iterative process. You can prove mathematically that any recursion can be recast as an iteration, but interpreters are not mathematicians.

A point of interest: SIEVE (iterative) and MSIEVE (recursive) take about the same time to execute.

Listing 6: MSIEVE, *a recursive version of the Sieve benchmark by Meredith Lesly.*

```
TO SIEVE :N
PRINT SIEVE2 BUTFIRST IOTA :N                              ; throws away 1 and starts
END                                                        ; sieving process

TO SHRINKIT :N :LIST                                       ; eliminates multiples of
IF EMPTYP :LIST [OUTPUT :LIST]                             ; first element of list
LOCAL "T MAKE "T (FIRST :LIST) / :N
OUTPUT SENTENCE (IF :T = INT :T [][FIRST :LIST])
  SHRINKIT :N BUTFIRST :LIST END
END

TO SIEVE2 :LIST                                            ; collects primes into list
OUTPUT IF EMPTYP :LIST [:LIST]
  [SENTENCE FIRST :LIST SIEVE2 SHRINKIT FIRST :LIST :LIST]
END

TO IOTA :N                                                 ; creates list of first N
LOCAL "T                                                   ; integers
MAKE "T 1
REPEAT :N-1 [MAKE "T SENTENCE :T 1 + LAST :T]
OUTPUT :T
END
```

as 256K bytes of memory. It could use a few more features in the editor, high-resolution graphics, and 8087 support. Nevertheless, IBM Logo is an impressive piece of software.

PC Logo comes in a close second with many extra enhancements, 8087 support, high-resolution graphics, and access to system-level interrupts. Its editor is very nice, especially the SEARCH and REPLACE commands, and no quotes are necessary to call up a procedure. It could use more stack space for recursive procedures and a greater ease of machine-language interfacing.

Dr. Logo, in third place, is still a very appealing product. Its debugging facilities are a pleasure to use and its manual is very easy for a beginner to read. Its list-handling facilities are superior. On the other hand, the interpreter is sensitive to whether you type upper- or lowercase letters in your identifiers—very annoying. Also, Dr. Logo's incompatibility with DOS can be a drawback, especially since it prevents reading Logo programs saved on DOS disks.

Bringing up the rear is Waterloo Logo, which has the fewest features. In fairness you can say that it works quite well—I didn't detect any bugs and someone drawing pictures will appreciate the ARC, CIRCLE, and PAINT commands greatly. It is quite close to Apple Logo, but its editor is cumbersome, its manual quite Spartan, and, like Dr. Logo, it has no machine-language or file-handling capabilities.

If you want Logo to experiment with turtle graphics or for your students or children to play with, then any of these packages is quite adequate. However, if you want some special features or need to do any serious program development, then IBM Logo or PC Logo is your best choice. ■

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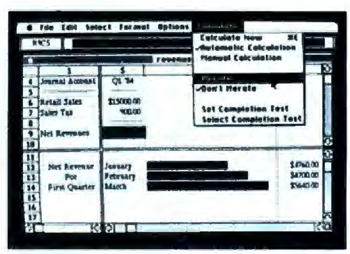

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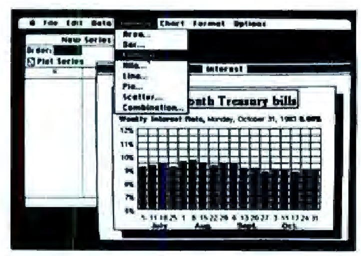

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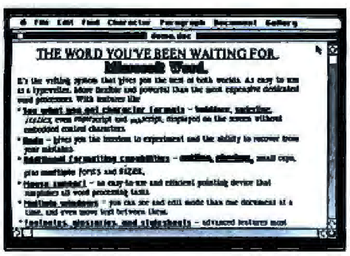
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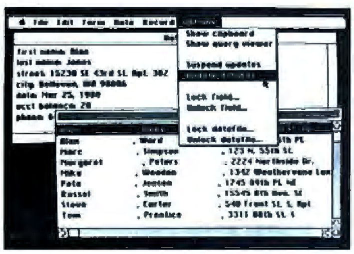
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The Juki 6100 *Printer*

A low-cost printer offering high-quality output and moderate speed

BY G. MICHAEL VOSE

Like many personal computer owners, I've waited for years for the price of letter-quality printers to drop below the $1000 barrier. I've daydreamed about the neatly crafted manuscripts I could send around the publishing world once fully formed character printers become easily affordable. (I have little need for graphics, but I enjoy the crisp, manicured, typewriter-quality look of output from a daisy-wheel printer.)

Well, that day has arrived and now I'm faced with yet another problem—choosing from amongst the many low-cost, letter-quality printers that have become available in the past six months. I can't be content daydreaming about spiffy manuscripts; now I have to evaluate pitch setting, line spacing, speed, and special-character handling. Choosing a printer is getting as complicated as buying a computer.

Letter-quality printer technology has evolved quickly. To bring these printers to market under $1000 requires a sacrifice in speed, but no sacrifice in features. Taking a close look at one low-cost, letter-quality printer, the Juki 6100, may help you to make some sense out of this confusing market.

The Juki 6100 from Juki Industries is an 18-cps (characters per second), fully formed character printer. It originally sold for $699 but now carries a suggested list price of $599.

SIZE AND FEATURES

Measuring 20½ by 6 by 14 inches, the Juki 6100 is 2 inches lower, 1 to 2 inches shorter, and 1 inch narrower than the NEC Spinwriter or the Diablo 630. At 27½ pounds, it weighs about 10 to 12 pounds less than the NEC or the Diablo. The housing is a two-color, high-impact plastic with a clear plastic dustcover above the platen.

The 100-character print wheel (Royal/Adler compatible) on the Juki offers 110 (10 pitch), 132 (12 pitch), and 165 (15 pitch) characters per line. It can also provide 82 to 220 proportionally spaced characters per line.

The Juki 6100 features bidirectional printing with friction paper feed (an optional bidirectional tractor-feed mechanism costs $149) and uses IBM Selectric typewriter ribbon cartridges (available at most office supply stores). It accepts either single-strike carbon-film or multistrike cloth ribbons. The maximum paper width is 13 inches.

The Juki 6100 comes with a standard Centronics-compatible parallel interface; an RS232C serial interface is optional. It uses Diablo 630 escape codes to control its various special functions (bold, underline, etc.). The front-panel controls for the 6100 include a three-position sliding toggle switch for selection of pitch settings and a membrane pad for the color-coded Reset, Pause, and FormFeed switches, plus three LEDs (light-emitting diodes) to indicate the machine's status. The power switch is on the left rear panel of the machine. The printer can be configured to use 110- or 220-volt AC power at 50 or 60 Hz.

PERFORMANCE

The 6100 is rated at 18 characters per second. My benchmark tests showed this to be an uncannily accurate claim. I used six of the benchmark programs developed for BYTE (see "The Art of Benchmarking Printers" by Sergio Mello-Grand, February BYTE, page 193). The unit I tested averaged 17.96 cps (see table 1) in bidirectional operation. Some word-processing programs drive printers unidirectionally, however, and table 1 also lists the speeds of the Juki 6100 in its one-way mode; the difference is nearly 2½ cps, or a 14 percent decrease in speed. This means that a 1000-word document would print bidirectionally in 5.57 minutes but require 6.51 minutes to print out unidirectionally.

I ran the benchmarks at 10 pitch using a Courier 10 print wheel. Since the limiting factor in daisy-wheel printer performance is the speed at which the print wheel can turn from letter to letter, the pitch setting shouldn't affect the outcome of the benchmarks in bidirectional mode. In unidirectional mode, performance would be slightly better in the higher pitch modes due to fewer carriage returns.

(continued)

G. *Michael Vose is* BYTE's *senior technical editor for features. He can be contacted at* POB 372, *Hancock,* NH 03449.

AT A GLANCE

Name
Juki 6100

Manufacturer
Juki Industries of America
299 Market St.
Saddle Brook, NJ 07662
(201) 368-3666

Type
Fully formed character printer

Size
20½ by 6 by 14

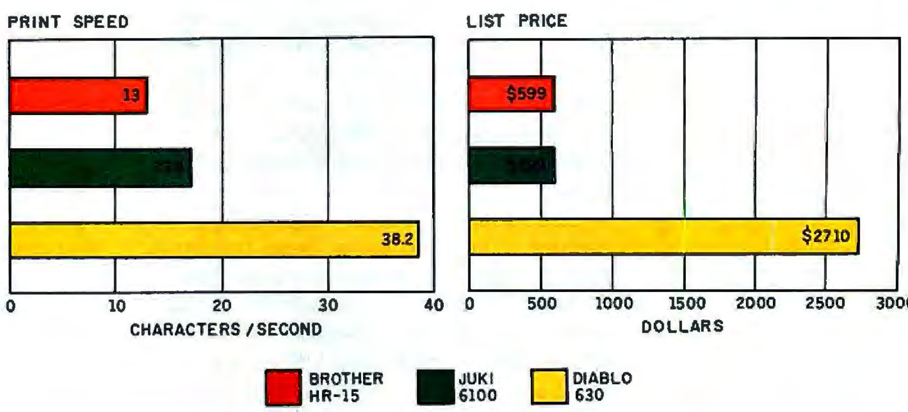
Equipment Needed
Computer with parallel or serial interface

Features
Diablo 630 control codes, sub- and superscripts, bold/shadow printing, underlining, double-striking

Documentation
44-page operation manual

Price
$599 (suggested retail)

The Juki 6100 letter-quality printer.




```
This is the Juki 6100  This is the Juki 6100
This is the Brother HR-15.  This the Brother
This is the Diablo 630  This is the Diablo 6
```

The Juki 6100 printer (using a Courier 10 daisy wheel) is compared with the Brother HR-15 (using a Prestige 1012 daisy wheel) and the Diablo 630 (using a Courier Legal 10 daisy wheel). The pitch for all printers is 10 characters per inch. The print speeds were determined by timing how long it takes the printers to print the Shannon test (573 characters; see "The Art of Benchmarking Printers," by Sergio Mello-Grand, in the February BYTE, page 193). The prices shown are the list prices, including tractor-feed mechanism.

The 6100 operates at a noise level comparable to most letter-quality printers, approximately 62 decibels. This is certainly not quiet, but neither does it qualify as a major disruption in the average office or laboratory setting.

Nuts and Bolts

The Juki 6100 uses an Intel 8051 microcontroller with on-board ROM (read-only memory) software to control the positioning of the print head, the selection of print-wheel characters, and the implementation of its word-processing functions, which include sub- and superscripts, bold/shadow printing, double-striking, and underlining. A 2K-byte print buffer, using static RAM (random-access read/write memory) chips, is standard and is expandable to 8K bytes. A circuit board located inside the rear panel holds these electronics.

The 6100's print-head mechanism is a simple design that uses a linear induction motor to ensure accurate head positioning. The head can be moved in 1/120-inch increments along the platen. The head rides in a carriage that travels along a rectangular steel guide bar. The head motor is attached to the printer's electronics by a single ribbon cable.

Lifting the cover from the Juki 6100 involves removing just four Phillips-head screws. All major parts of the printer are quickly and easily exposed to make servicing the printer a simple task. Juki Industries announced in May that it has signed a third-party maintenance agreement with Xerox Americare.

Usability

Using the Juki 6100 is simple. Set-up requires only the attachment of the power cord and the cable from your computer. You can then select a variety of special printer characteristics by setting the 10-position DIP (dual in-line pin) switch located just behind the LED/membrane front panel. The choice of functions includes automatic linefeed, impression level to control the strength of the hammer strike, continuous or cut paper, paper length (either 11 or 12 inches), line spacing (either ⅙ or ⅛ inch), and eight different international character sets (requiring special print wheels).

The DIP switches are easy to reach with a pen or small screwdriver. Once the DIP switches are set for your particular computer configuration, the printer operates under software control. For example, to use the Juki 6100 with an IBM Personal Computer and a word-processing program, you select a Diablo 630 printer driver, install it according to the instructions with the word-processing software, and the software takes care of sending the appropriate escape codes to engage the printer's functions. To engage these functions from a BASIC program, you LPRINT the escape character codes provided in the Juki manual.

Compared to other low-cost, fully formed character printers, the Juki is faster and sturdier, but also noisier and more expensive.

The 44-page operation manual provides all the information an experienced computer user will need to run the 6100. It is probably too terse for the newcomer, but novices can enlist the aid of a friend or dealer, or they can call a Juki America regional office for assistance. The manual's English is occasionally obtuse (e.g., "When data in the buffer decrease to 220 BYTE, data are sent from CPU till next buffer full."), but the information can be found with some digging. Tables provide pin-out information for both the parallel and serial connectors. The description of how to change print wheels and ribbon cartridges is clearly explained with line drawings used to enhance the text.

Conclusions

The Juki 6100's principal strengths are its affordability and its simplicity. At $599, it rivals dot-matrix printers in price while providing superior print quality. When discounted (you'll see ads listing the 6100 for as little as $449, less shipping), it is an honest-to-goodness bargain. I've compared the Juki to other low-cost, fully formed character printers and found it to be faster and sturdier, but also noisier and more expensive. It's a good buy unless you need a faster printer that can generate a lot of text in a hurry.

The Juki 6100 would be ideal for a business with a small volume of correspondence (20 to 30 letters daily) or for a writer using a computer for word processing. It is superb for applications in which first-class text appearance is required. ■

Table 1: *Benchmark results for the Juki 6100 printer. The benchmarks are from the February BYTE (see the text).*

	Bidirectional		Unidirectional	
	Time (seconds)	cps	Time (seconds)	cps
Shannon Test (80)	33.88	16.91	38.07	15.05
Shannon Test (60)	33.68	17.01	37.71	15.19
First Order English	58.84	17.00	65.93	15.17
Fourth Order Shakespeare	48.76	16.32	53.64	14.84
First Order UNIX Manual	58.14	17.20	85.25	11.73
Spreadsheet Simulation	68.65	23.31	79.28	20.18
	Average cps:	17.69	Average cps:	15.36

ADAM

In Jules H. Gilder's article on Coleco's Adam (April, page 206), Mr. Gilder did a disservice to Coleco in recommending that the purchase of Adam be delayed until all the bugs are fixed and Coleco delivers on all its promises. I represent the market for the Adam Personal Computer and I believe that the Adam works well and is just what we need. BYTE also did a disservice by publishing his bias.

It seems that the whole story is that Adam costs less than $750 complete and the nearest competitor costs three times as much. How many families are now without an Adam because of the Gilder story? It is too bad that the industry looks down on Coleco's Adam because it doesn't generate the profit of other personal computers.

STEVEN M. LITTLE
Santa Barbara, CA

We are glad to hear that Adam finally works well. Mr. Little, however, does a disservice to both Jules Gilder and to BYTE when he claims that our review was biased. Mr. Gilder carefully tested the machine and accurately reported his results. To do otherwise would have been a disservice to our readers.

—RICH MALLOY
Product-Review Editor

THE ZENITH Z-100

We read with interest Ken Skier's review of the Z-100 in the January issue of BYTE (page 268). Our DISK-TRAN series of programs meets the need for transferring files between different format media for both the Z-90 and Z-100 to read and write in various disk formats.

GEORGE J. SELLERS
Computer Consultants to Business
Cumberland, MD

TWO APLS

I'd like to convey my appreciation for Jacques Bensimon's article on APL, "STSC APL*PLUS and IBM PC APL" (March, page 246). I also wish to comment on the difficulties with APL's right-to-left notation. I believe this unfortunate choice, along with cryptic symbols, is responsible for the delayed acceptance of this language.

For the past three years, I have been developing a programming system that uses a syntax similar to APL but reads from left to right, following convention for standard text. This system, called BETA/65, also uses more familiar BASIC names for functions and keywords. This system is now available to users of Ohio Scientific Challenger computers.

In BETA/65 notation, as in APL, arguments of monadic functions appear on the right, as users expect. There is increased interpretive overhead with this convention. Interpretation of a monadic function (operator and operand) requires 170 cycles compared with 102 cycles for dyadic functions. However, monadic functions appear less frequently in programs and, when present, typically require several hundred cycles for execution. Hence, the additional overhead is usually not apparent to the user.

The cycle times quoted above are based on interpreter implementation with the 6502 microprocessor. A hardware implementation of this interpreter seems feasible. Such a high-speed interpreter combined with a numerical coprocessor would be a formidable computing machine.

An advantage of APL-like languages that was not mentioned is the direct correspondence of code text to execution sequence. This differs from algebraic notation (used by FORTRAN, BASIC, and C), which executes according to a function-precedence list. Use of direct notation should simplify work for compiler writers. Also, extensions to the primitive instruction set can be more easily assimilated into the language.

D. G. JOHANSEN
La Honda, CA

PEACHTEXT 5000

I just read the review of Peachtext 5000 by Stevanne Ruth Lehrman (April, page 186). I haven't had a chance to do much work with all of the features of my newly acquired copy of this software, but I did notice one error in your article of which readers should be aware. Peachtext 5000 no longer includes a box of 10 blank disks, as described in its catalog. I opened the package obtained from my Heath/Zenith dealer and instead of finding the disks, I found a note saying that the bonus had been discontinued.

LEE A. BEATRICE
Somerville, MA

STATISTICAL SOFTWARE

I read with great interest the excellent article, "Statistical Software for Microcomputers" by James Carpenter, Dennis Deloria, and David Morganstein (April, page 234).

A precommercial version of our product, SPS, running under Apple DOS was used for the review and it was being compared to a set of already commercialized statistics packages.

The data in the tables is accurate for the precommercial Apple version of the program. The data in table 13 on ratings of main features (page 251), however, is not representative for the commercial versions. For example, the average number of significant digits produced by SPS Version 3A.0 is 17 using all 6 independent variables in the Longley data set when this model is computed using the commercial IBM PC version running under DOS 2.0. We provide two multiple regression routines, one that utilizes a Gauss-Jordan elimination algorithm and one that uses a Singular Value Decomposition (SVD) algorithm. We obtain this 17-digit accuracy with the SVD routine, which should be used, as our manual points out, with highly collinear data since the algorithm works with original X matrix and not (X'X). In fact, even more accurate results would have been obtained for the precommercial version if the SVD procedure had been used for the Longley data.

Perhaps the ratings that SPS received in table 13 would be upgraded if the commercial version had been reviewed. We do provide a table of contents, index, and sample runs in the documentation, as well as the ability to select cases, join and sort files, and perform a wide range of transformations.

Our SPS package is currently available on CP/M, MS-DOS and PC-DOS formats. Although the Apple DOS version is no longer available, a version is still available for the Apple II and IIe machines using a CP/M card.

RICHARD TILMANN
DBI Software Products
Mt. Pleasant, MI

I commend BYTE and authors Carpenter, Deloria, and Morganstein for their comprehensive article on statistical software in the April issue. It is the first article of its kind to appear in any of the nationally circulated microcomputer magazines, and it provides valuable information to personal computer users interested in statistics.

Your readers who use the IBM Personal Computer (PC) may also be interested in SIGSTAT, the Special Interest Group for Statistics. SIGSTAT is part of the Capital PC User Group, a nonprofit association of nearly 2500 IBM PC users in the Washington, DC, area.

SIGSTAT members review statistical software for the IBM PC and report their findings in the *Monitor*, the monthly newsletter of the CPCUG. It costs $25 per year for a subscription (send a check to Capital PC User Group, POB 3189, Gaithersburg, MD 20878).

Our electronic bulletin board operates 24 hours per day at 300 or 1200 bits per second (bps) (no parity, 8 data bits, 1 stop bit). The telephone number is 301-596-3369. The bulletin board has reviews of statistical packages and some demonstration and public-domain software. Because it is difficult to fill the many requests for past reviews, we prefer that interested PC owners download the reviews from this bulletin board. We encourage PC owners to upload their comments about statistical software and to contribute nonproprietary programs to SIGSTAT. We do not accept pirated packages for the bulletin board and do not condone illegal copying of copyrighted software.

For readers who do not have access to PC telecommunications, send a 5¼-inch double-sided disk with a preaddressed, postage-paid mailer to the address below. SIGSTAT will copy onto the disk past software reviews, the list of currently available commercial statistical packages, and any public-domain statistical software we have at the time.

HARRY J. FOXWELL
Burke, VA

I was pleased to read the recent review of statistical software by James Carpenter, Dennis Deloria, and David Morganstein in the April issue. Their comparative analysis of 24 packages was very informative, especially the extensive list of tables.

I am curious, however, why the micro version of SPSS (Statistical Package for Social Sciences), SPSS-11, was not included in their analysis. It has purportedly been on the market since the middle of 1983 and runs on the DEC Professional 350. Although I have no actual experience with this package, it seems more appealing than those surveyed for several reasons. First, the mainframe SPSS has been in existence for over 14 years and, therefore, has withstood the test of time. Any of the initial bugs were located and corrected long ago. Due to their familiarity with the language, experienced SPSS users would prefer to work with this package on microcomputers.

Aside from the micro version of SPSS, I would be interested in knowing when the other major mainframe statistical software packages, e.g., SAS and BioMed, will be offered to the micro industry. This reader is anxiously awaiting a comparative analysis of their statistical software for microcomputers.

PAUL E. BURKHARDT
Stockbridge, MA

THE RAINBOW 100

David B. Suits neglected to share some of the Rainbow 100's really impressive features in his review (April, page 170), so I thought I would oblige.

Did you ever multitask on a single terminal with two computers? On my desk at work, my Rainbow looks like a mild-mannered VT52 or VT102 to my host minicomputer software. Because the terminal emulation is all contained on the ROM, there's no extra software to buy. After I start up a job stream in the Rainbow's line (terminal) mode, I can then slip back to local mode and wrap up some documentation or glance through a spreadsheet. I then return to the minicomputer, still processing, which has kept my place as a terminal while I was away personal computing.

When Mr. Suits was reviewing the documentation, he didn't discover the Rainbow's virtual disk, which is the memory drive (MDRIVE). With CP/M-86 version 2.0 and 128K bytes or more of RAM, you can configure 64K-byte increments of the RAM as a storage unit or drive. With my 256K bytes of RAM, I can set up a 128K-byte slice of memory, PIP over my Rainbow editor (RED) or Multiplan programs and the response is like lightning. When I'm done, I copy any edited files back to disk and "remove" the drive.

MELINDA HAYES
Owensboro, KY

Some misconceptions were presented to your readers in David Suits's review of the Rainbow 100. I'd like to comment on some of these.

It is not quite true that the Rainbow cannot read double-sided floppies; however, there is a catch to it. A double-sided floppy has two write-enable cutouts that inhibit the drive completely when both are present. Therefore you must cover the right-hand cutout for the upper drive and the left-hand one for the lower with some self-adhesive label (a postal stamp will do) to simulate the single-sided disk.

When you want to use the other side of the

(continued)

disk, you have to move the sticker.

The Rainbow also reads and writes VT180(ROBIN) floppies; however, its reading is prone to errors. Various Rainbows behave differently, and some produce fewer errors. Also, when writing the VT180 floppy, it has to be in the drive when the system starts, otherwise the first attempts will cause error reports.

RUDI W. STANGE
Eching, West Germany

KAYPRO 10

Steve McMahon's review of the Kaypro 10 (May, page 206) neglected to mention an important feature available for this machine, the CO-POWER-88 board by SWP Microcomputer Products Inc., of Arlington, Texas.

Available as a factory option or directly from SWP, the CO-POWER-88 upgrades the Kaypro so it can run MS-DOS and CP/M-86.

FRED L. HELMS
SWP MICROCOMPUTER PRODUCTS
Arlington, TX

ECO-C COMPILER

We would like to thank BYTE for publishing Dr. David D. Clark's review, "Two More Versions of C for CP/M" (May, page 246), which included our Eco-C compiler. We think it was a well-written and fair review of Release 1.52. However, we would like to inform your readers about several important changes in Eco-C since Release 1.52 was first distributed.

Dr. Clark mentioned our free update policy for the first year the compiler was on the market. We did this because we knew that we would be enhancing the compiler over time. The release that Dr. Clark mentioned (but did not review) reduced the limitations of Eco-C to bit fields and the #line preprocessor directive. That release (2.04) also improved code generation, especially on function calls. While most of the benchmarks have rather modest improvements (e.g., 5 to 10 percent), the Fibonacci benchmark dropped from 187 seconds to about 79 seconds.

We also dropped the price of the Eco-C compiler last year to $250 rather than the $350 mentioned in the article. At the time we reduced the price, we sent a letter to all licensed Eco-C users offering credits ranging from $70 to $100 on some of our other products.

The latest release (3.0) also increased the number of library functions to 120, added new compile-time switches (including multiple, nonfatal, error messages), and implemented several new optimizers. We began shipping this release free of charge to all licensed users on May 1 of this year.

Your readers are probably wondering why our compile times are slower than the other two compilers. Part of the reason is that subset compilers typically work with data types that fit nicely into a central processor register pair (no longs, floats, or doubles), which greatly simplifies a number of tasks for the compiler (e.g., symbol-table manipulation). Code size will also be smaller in most cases (e.g., even our integer printf() must handle the long data type). Another reason is that Eco-C does not require the source file to fit into memory, resulting in more disk I/O (input/output). Other nonsubset compilers face similar problems.

The overall compile-assembly-link (CAL) times presented in Dr. Clark's review do show a speed advantage for subset C compilers. However, the Eco-C Release 3.0 CAL times are similar to other full C compilers. See Christopher O. Kern's article "Five C Compilers for CP/M-80" (August 1983, page 110). We are currently testing a new assembler and linker that cut the CAL times almost in half.

Equally (more?) important are execution times. Eco-C now does the Eratosthenes "vanilla" sieve in 29.2 seconds while the Fibonacci ("fib") drops to 75.3 seconds. Adjusting for clock-speed differences in the Kern article, Eco-C times are first in the "vanilla", "fib", and "string-length" benchmarks. (We cannot duplicate the other Kern benchmarks since the input data is unknown.)

Finally, we appreciate Dr. Clark's inclusion of a floating-point benchmark; it represents the first such benchmark aimed specifically at a C compiler and one that deserves more attention. Unfortunately, the reader has no idea whether the Eco-C time is good or bad, since neither subset compiler can run it. Release 3.0 runs this test in 41.2 seconds generating less than 21K bytes of code (versus 48 seconds and 22K bytes for Release 1.52). As a reference, a competitor's compiler generates more than 24K bytes of code and executes the benchmark in 113.3 seconds; a 275 percent time difference in Eco-C's favor. Dr. Clark is correct that we put a lot of effort into the floating-point package.

It would also be interesting to see a benchmark for the long data type, since it is heavily used in some functions (e.g., random file I/O). Our long tests suggest considerable advantage for Eco-C here, too.

JACK PURDUM, PH.D.
ECO SOFT INC.
Indianapolis, IN

REVIEW FEEDBACK IS a new column of readers' letters. We welcome responses that support or challenge BYTE reviews. Send letters to Review Feedback, BYTE Publications, POB 372, Hancock, NH 03449. Name and address must be on all letters.

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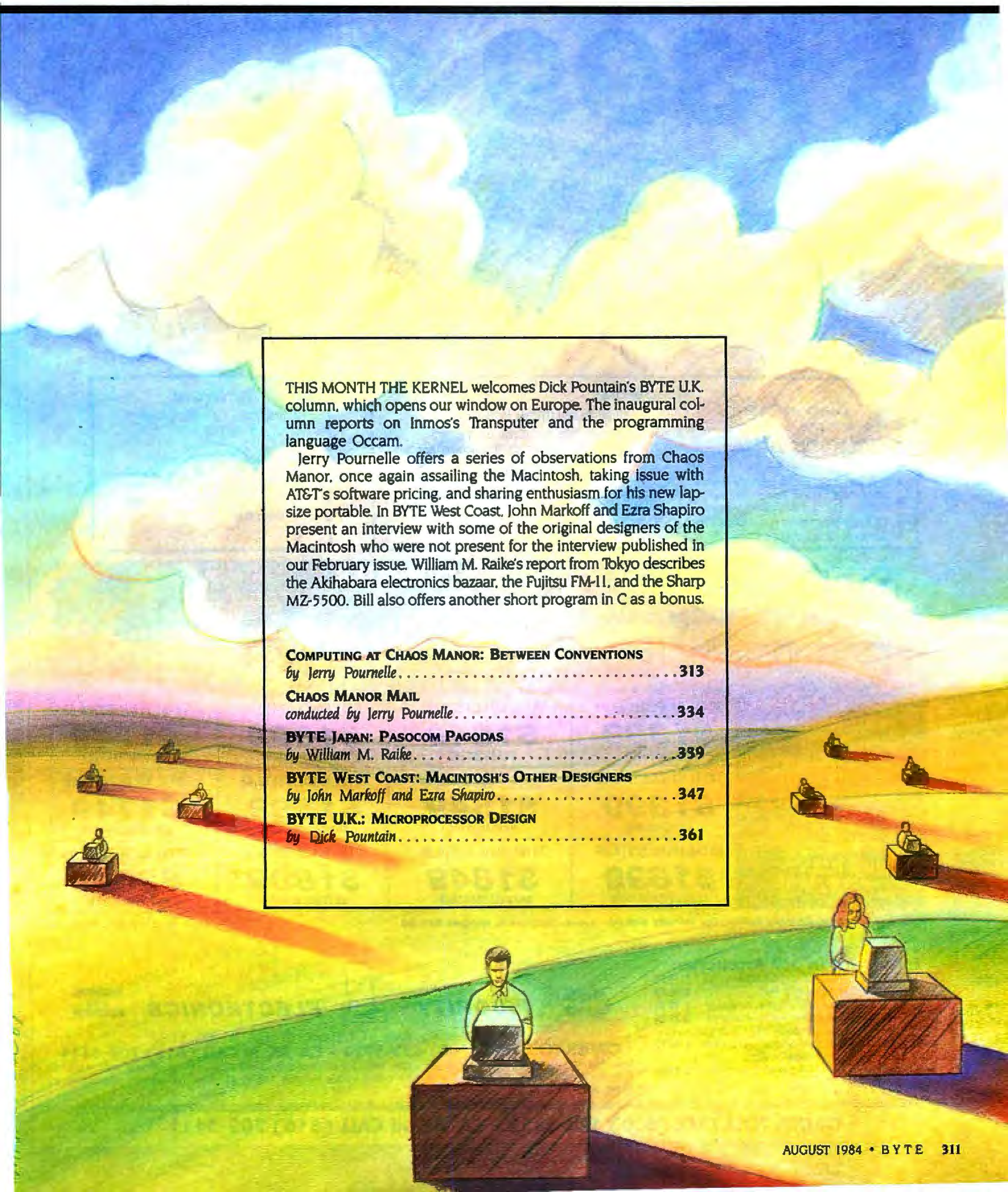
Kernel



THIS MONTH THE KERNEL welcomes Dick Pountain's BYTE U.K. column, which opens our window on Europe. The inaugural column reports on Inmos's Transputer and the programming language Occam.

Jerry Pournelle offers a series of observations from Chaos Manor, once again assailing the Macintosh, taking issue with AT&T's software pricing, and sharing enthusiasm for his new lap-size portable. In BYTE West Coast, John Markoff and Ezra Shapiro present an interview with some of the original designers of the Macintosh who were not present for the interview published in our February issue. William M. Raike's report from Tokyo describes the Akihabara electronics bazaar, the Fujitsu FM-11, and the Sharp MZ-5500. Bill also offers another short program in C as a bonus.

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COMPUTING AT CHAOS MANOR

Between Conventions

BY JERRY POURNELLE

It has been a month. First there was the L-5 Society annual convention, at which I got doused with beer during a fund-raiser. The next weekend was the Science Fiction Writers of America's annual Nebula awards ceremony. The week after was Contact, an annual meeting of science-fiction writers and anthropologists. No sooner had I returned from that but I was on an airplane to Chicago for the first BYTE Computer Show. All told, I think I've been at Chaos Manor about 12 days since I turned in the last column.

Next week I leave for a speech in Cincinnati on my way to COMDEX in Atlanta, followed by the annual meeting of the American Association for the Advancement of Science. I know I'll never cover all of what goes on in the micro world no matter how much time I have, but this is getting ridiculous.

Meanwhile, my apologies: this column is going to be choppier than usual; there's a lot to cover.

TRUMP CARD

The name went through several iterations: the first few Steve Ciarcia tried had already been trademarked. I sometimes wonder if there's a single catchy English word that hasn't been registered by someone or another. In any event, the board I reported on last January on page 61 as Quicksilver is now out as the Trump Card.

I still don't have one, but Steve brought a production model to the BYTE Show, and we talked Emil Bohach of Small Business Systems, the local CompuPro Systems Center, into letting us plug Steve's board into his PC. Trump Card has an on-board Z8000 chip running at 10 MHz. There's also a BASICA-compatible compiler that you load from disk. Steve plugged in the board and it worked as advertised: it compiles BASICA programs at an astounding rate, and after compilation they run about 100 times as fast. I didn't get to see the on-board C compiler work.

Trump Card was written up by Steve in the May and June issues of BYTE. I can practically guarantee that if you have a PC, you'll want Trump Card. More when I get mine. I can hardly wait.

GO FOR THE GOLD

For a couple of years we've had an Applicard in the Apple II+ the boys keep in the back room. The Applicard has an on-board Z80 and turns the rest of your Apple into a terminal so that you can run the Z80 under the CP/M operating system. It also speeds things up something wonderful. Our Applicard has always worked fine, but it did have one problem: we had considerable difficulty teaching the operating system how to find the serial I/O (input/output) port. I think Barry Workman finally got The File Transporter talking to the Apple, but it was no simple task.

Last January, Mrs. Pournelle got an Apple IIe to match the one that Apple gave to her school. Shortly after, we acquired a copy of Digital Research's new Gold Card. The Gold Card does the same thing that the Applicard does, but it has no difficulty finding both serial and parallel ports. Moreover, the STAT function works as you expect it to, so that you can make logical-to-physical port assignments.

Gold Card comes with CP/M+, sometimes known as CP/M 3.0. You also get CBASIC and a built-in conversion to make your Apple an 80-column machine if you like. I'm no great fan of CP/M+—I don't think it has enough additional features beyond CP/M 2.2 to make it worth installing—but it does no great harm to have it on an Apple.

Gold Card installation is simple, and once it's installed, you can boot the machine either under CP/M or as a normal Apple. The Gold Card is invisible when you're running Apple DOS (disk operating system). Our Gold Card has worked without glitches for several months now.

TURBO YET AGAIN

Phillippe Kahn, president of Borland International, always manages to call me just as I'm writing this column.

He called today to tell me about a speedy way for Turbo Pascal users to communicate

(continued)

Jerry Pournelle holds a doctorate in psychology and is a science-fiction writer who also earns a comfortable living writing about computers present and future.

with him. One of the Borland staff, generally Phillippe himself, logs onto the CompuServe net every day. You can leave messages and be certain he'll get them.

Access is through the Programmer Special Interest Group. The simplest way is, after you log on, to do GO PC5158, which will put you into a Turbo Pascal bulletin board where you can read messages and replies. Due to the large number of calls he gets and his limited staff, he'd really prefer people to communicate this way rather than over the phone. Borland will still try to give telephone support.

A couple of readers report difficulties getting Turbo to run with CP/M+. However, Phillippe himself has a Morrow system running CP/M+, so it isn't the CP/M that's doing it. He suspects a nonstandard BIOS (basic input/output system) may be at fault. Borland will refund the purchase price if you can't get it to work with your system.

I've also heard a couple of complaints from readers who bought the first edition of Turbo Pascal, liked it a lot, and now find they've got to pay $29.95 for the second edition. I confess I have little sympathy for them. Borland is giving previous purchasers a hefty discount; book publishers don't do that. When you buy a new edition of a textbook, you pay full price. Of course, Borland could have charged $99.95 for Turbo Pascal; the company could then charge initial purchasers $5.95 for the update, and everyone would think they were great guys.

As for me, I congratulate Borland for taking the micro community a giant step in the right direction.

One of the neatest things about Turbo Pascal is the overlay structure. You can have multiple overlays; the compiler automatically reserves space for the largest overlay, thus ensuring that all the smaller ones will fit. Furthermore, you can have nested overlays, as many deep as you like (until you run out of memory space; each overlay reserves space for the largest overlay that it calls). For 16-bit systems, Turbo can make use of the whole heap space, which means you can have large dynamic arrays. A Turbo program is limited to a maximum of 64K bytes of code size (as is Pascal MT+), but this turns out not to be as serious as it might be because Turbo produces such tightly efficient code. Given the easy-to-use overlays, efficient code, and integrated editor, I think Turbo is the best Pascal compiler on the market. It's also the cheapest.

Kahn says he's pretty sure the Turbo Modula-2 compiler will be on sale before the end of 1984. I hope so.

The BYTE Show

I've mixed emotions about the Chicago BYTE Computer Show.

First, the good news: a lot of people showed up. The BYTE staff, including Editor in Chief Phil Lemmons, Steve Ciarcia, me, Product-Review Editor Rich Malloy, and Senior Technical Editor Gregg Williams were on hand to answer questions. *Popular Computing's* Editor in Chief Pamela Clark was there, too. We had a good dialogue with the attendees. I sat down outside the BYTE booth at 10:00 on Saturday morning and talked with crowds until I had to leave at 2:00, and there were always lots of people to ask questions and tell me things I didn't know. The other BYTE people had much the same experience.

More good news: the seminars were interesting and well organized. The presentations were excellent. We had a couple of complaints about schedule conflicts—two of the most interesting panels were on at the same time—but that was all. People who come to computer shows for the panels seemed universally happy.

Now the bad news: there weren't anywhere near enough exhibitors. I heard a lot of explanations for this. My own view is that it was a classic comedy of errors: everyone thought it was someone else's job to let potential exhibitors know about the show. Whatever the problem, we've been told Next Time For Sure. It better be: I really hate having to face disappointed BYTE readers. Fortunately, most were not unhappy, and I had some great conversations.

The BYTE Shows have high potential value, and I think they should continue. The BYTE staff has been asked for suggestions on improvements. I've been pressing for minibooths: small, low-cost space for first- and second-time exhibitors, much as Jim Warren had for the West Coast Computer Faires. BYTE has always been the micro enthusiast's magazine, and BYTE Shows with minibooths would be right in line with that tradition. Alas, I'm not in charge, and all I can do is keep asking. I'll do that.

Late update: the L.A. show had minibooths, and I thought it was great.

People Will Talk . . .

For me, the main value of the BYTE Shows is the chance to talk with readers. Now true, I get a lot of mail and thus have some feedback; but that's no substitute for face-to-face contact, and at the Chicago BYTE Show I was able to speak with literally hundreds of you.

There were a lot of questions, but two were most frequent by miles. Readers wanted to know what I think of Macintosh and what system I recommend for writers.

Mac Reconsidered

I have a problem with the Macintosh: I don't recommend that you get one now—but now is May 1984, and by the time you read this, things will have changed drastically. I don't know what I recommend "now," meaning as you read this column. It all depends on what's available.

As I write this, the Macintosh is a bargain only if you can get it at the heavily discounted price offered to faculty and students of the favored 24 universities in the Macintosh "consortium." (Incidentally, I'm told that when you see a list of the universities within the consortium, you'll see only 23; one university made anonymity a condition of joining, and Apple can never use that university's name in any press releases or advertising.)

There are several reasons why you wouldn't want the Mac at full price just now. Some are inherent in the machine: negative features that must be overcome with something positive. The other reasons may well be temporary: they're fixable, but only if the Macintosh survives, and despite all the Machype, I'm not as convinced of that as everyone else seems to be.

First, the "permanent" problems. The chief one is that the Macintosh is a rather ill-designed machine. The Caps-Lock key is where the Control key ought to be; there is no Escape key; the Control key is badly placed. There are no cursor arrow keys, meaning that touch-typists must remove their hands from the keyboard and use the mouse even

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for small cursor movements.

The mouse itself has only one button. This, we are told, is to prevent user confusion; one button is enough. However, to use the mouse you must often do Shift-click (hold down the Shift key as you press the single mouse button) or Command-click (ditto for the Command button and mouse). This makes a two-handed operation out of what should be a one-handed affair. It would have been easy enough to put copies of the Shift and Command keys on the mouse itself. Of course, that would have cost a bit more.

The single disk drive is a real pain. For the past six weeks, I've heard stories of a new Copy routine that would use more of the Macintosh's memory and thus require fewer disk swaps for copying a disk; but I have not seen the new routine, and as of May 15 there had been no firm date set for delivery. Similarly, every week someone announces that the second disk drive will be available next week, but so far none have been delivered.

The operating system has bugs. There are a lot of ways you can trash a disk and lose all your text files. This is inexcusable, and sufficient to prevent me from using the Macintosh as a word processor. My time and energy are too valuable to gamble with. I am told there are fixes to most of the disk trashings, but since none of them are documented, they are not available to "the rest of us."

The Macintosh documents are nearly worthless. Every now and then the Macintosh will deliver messages about "Fatal Error #2" and the like, but that's interpreted nowhere. The Macdocuments are pretty, with lots of visual appeal, but they don't tell you enough about the machine. Neither, incidentally, does Doug Clapp's book *Macintosh! Complete* (Soft Talk). This $19.95 book is unreserved in its praise of the Mac but tells you little that isn't in the Macdocuments. It's often deliberately cryptic. A better book is Cary Lu's *The Apple Macintosh Book* (Microsoft), which costs less ($18.95). Though it is incomplete (any book published simultaneously with the announcement of the Mac would be), it does have a lot of useful information. However, neither book, nor the Macdocuments, will interpret the Mac error codes.

The Macintosh disk drives are painfully slow. It takes the better part of forever to load software. It's so difficult to make backup copies that one is tempted not to make them: this can result in unrelieved grief if you're then caught by one of the disk-trashing bugs.

There's nowhere near enough memory. As I write this, only two languages are available for the Macintosh: FORTH and Microsoft BASIC. I know little about the FORTH; but when you've loaded the Microsoft BASIC, you have only 14K bytes of work area left. That means you

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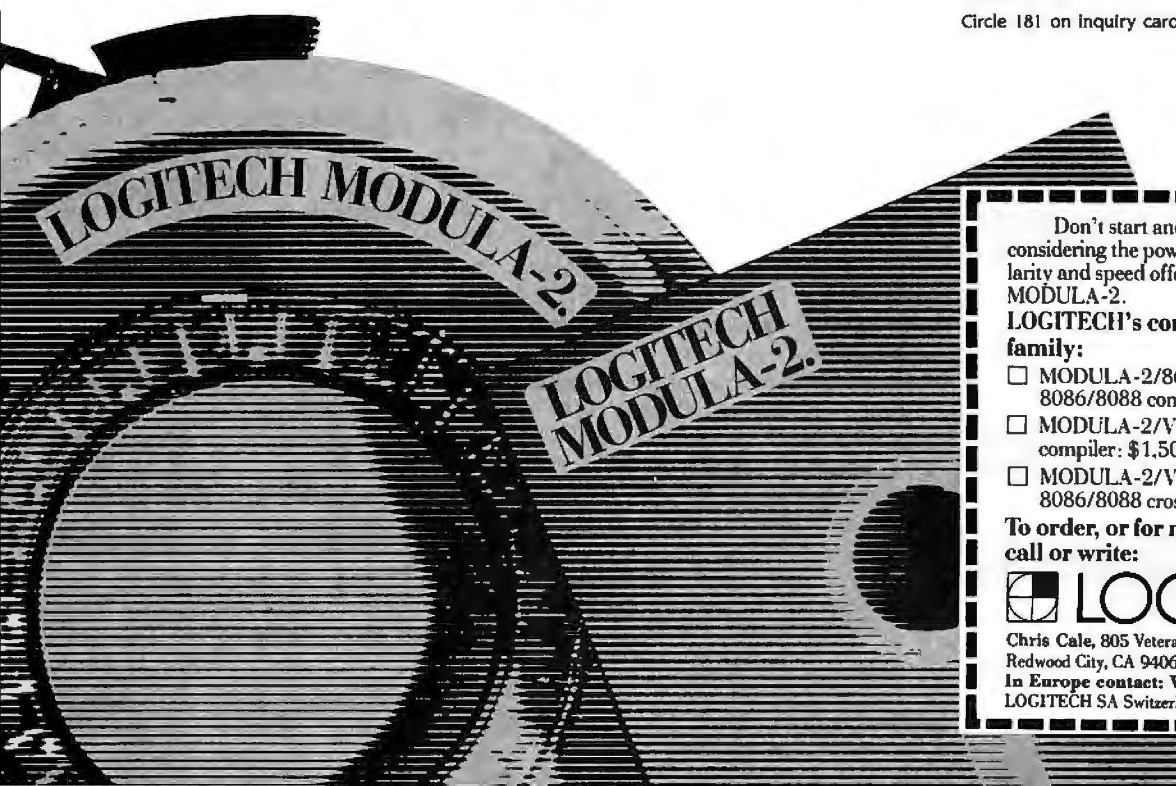

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have to write cryptic BASIC programs or none at all. Shades of the old days with 4K-byte memory boards!

I now find you can use the CLEAR command to get up to 29K bytes of workspace. It's an undocumented feature.

The "desk calculator" feature within the Mac is useless. This is a pity, because I must keep a TI calculator next to my desk in order to do the myriad computations required in daily life, and I'd hoped to replace the TI with the Macintosh. No way, though: the Mac's calculator has no memory, no change-sign key, and, of course, no scientific functions or notation. Moreover, it's very hard to use. Mice are *not* the best way to input numbers. I presume that one could write a calculator routine in BASIC, but what's the point? Both it and BASIC would have to be loaded—at painfully slow speed. You'd be better off with a lap computer like the NEC PC-8201A, which has BASIC in ROM.

As I write this, there is no application software for the Macintosh. Microsoft Multiplan was recalled, as it should have been—the version we bought crashes at the slightest mistake, losing everything you've calculated. Each week I hear announcements of an incredible pile of new software to be delivered next week, but when the next week comes, none of it is available. I've given up believing the breathless new announcements. More: the spate of announcements, followed by nondelivery, makes me wonder whether interfacing software into the Mac's operating system is more difficult than Apple wants us all to believe. Perhaps I'm an excessive worrier. Perhaps not.

Some Love It

There's a good side to the Macintosh; good enough that if Apple fixes the fixable defects, it may truly be "the computer for the rest of us."

First off, I don't know anyone—including me—who doesn't think it's fun to play with. MacPaint, with its spray can and paintbrush; MacWrite, with the ability to change type fonts and sizes; and the cut-and-paste utilities combine to let you create some remarkable graphics. The days of the illuminated manuscript have returned. It takes a long time to print a letter written with MacWrite, but it looks spectacular.

Second, for those who must write short illustrated documents, Mac is superb.

Third, the Mac attracts people who hate computers. A typical case: businessman gets Mac; finds he can't do much with it; takes it home; wants to experiment with it, but finds he can't get near it because his wife and children, who previously hated computers, have taken it over and will not let go. There is, apparently, something about mice and pull-down menus and icons that appeal to people previously intimidated by A> and the like. Experienced users may know that the Mac won't do very much, but beginners can make it do something, and that's important.

Experienced hackers tend to divide into two groups: a sizable number think the Macintosh is a ridiculously priced Etch-A-Sketch, but just about as many think it's wonderful. They don't do anything useful with it, mind you; but they cease not to explore, and they're in love with all the exciting new concepts and features. I think they're more in love with the idea of the Mac than with the actual machine, but that's irrelevant. The important fact is that knowledgeable computer wizards think the Macintosh is wonderful; they believe that it will soon have lots of excellent application software; and they passionately detest anyone who has doubts or misgivings about the Mac. This is, they say, the computer for "the rest of us"—even though they've long ceased to think of themselves as one of "the rest."

The Macdilemma

For all the enthusiasm, the Macintosh is not really all that advanced. The Modula Computer Company offers an American version of Lilith with black-and-white graphics capabilities better than Macintosh; and it has Niklaus Wirth's Modula-2 operating system, complete with mouse, pull-down menus, scroll bars, and most of the other Macgoodies. At least two firms are developing new Modula-2-based bit-mapped screen systems; one, the Sage, will use the 68000 chip, have a megabyte of memory plus two disk drives, and sell for about twice what Apple wants for the Macintosh.

Apple has decided to maximize profit rather than market share. That may

(continued)

I have strong opinions about machines and editor programs, but in reality, any text editor is much better than typewriter and paper.

not be a wise decision during this critical period. Part of the excitement of the Mac was that it truly was "the computer for the rest of us": which implied that "the rest of us" could afford it. Alas, that didn't happen. At $2500 plus tax for the basic machine, Macintosh is no bargain; and when you've bought it, you're not done.

The Mac needs an external disk—hard or a second microfloppy—and more memory. It needs, but can survive without, a better keyboard. You'll spend at least $750 for a second drive and memory update, and if Apple prices these items the way the Mac itself was priced, you'll spend twice that. Moreover, not all these items are available; and some hardware improvements will be developed only if a lot of Macs are sold.

No machine is useful without software. Apple has chosen to make "software developer" status a lot harder to get than was implied in presentations at the West Coast Computer Faire and other hobbyist/hacker meetings. To be eligible for the "developer" discount and support, you must already be in the software business—which means automatic exclusion of the innovative hobbyists who weren't interested in more traditional machines but were turned on by the Mac.

Then, too, the machine has a closed architecture, and the Macdocuments are incomplete. You can buy, for $150, *Inside Mac*, a pile of xeroxed loose-leaf fact sheets (including interpretation of the error codes), but even these aren't complete. At present there is no assembler, and when the assembler becomes available, you will need two Macs in order to run it with the debugger. All in all, Apple has told the hobbyists to drop dead. This may not be wise. TI tried it. Long live the TI-99.

So What Should We Do?

If the software does come flooding forth—after all, there are all these announcements, and there must be some substance behind them—then Macsales may soar. Hardware developers will come up with fixes for the major problems. This will generate even more sales and more software.

As that base market expands, other developers will get into the field. Last fall at COMDEX we saw nothing but IBM PC clones; if the Mac proves popular, we'll see Maccompatible machines everywhere; and since there's a considerable profit margin in the Macintosh price, competitors will be able to offer more features for the same money or, more likely, much the same features for a lot less.

So: at the moment there's no compelling reason to get a Macintosh. If you're in the mood to enthrall a recalcitrant spouse or child who now hates computers, perhaps it's worth the price; but you can get a lot more utility for what the Macintosh costs.

Things may be different later, but by then the clones will be appearing. Alexander Pope said, "Be not the first by whom the new are tried, Nor yet the last to lay the old aside." It's still good advice. Pournelle's Rule is: "If you're in the mainstream, the best business system is last year's state-of-the-art development system." Whether or not Macintosh is in the mainstream, it's still a development system. I'd wait.

Writing Machines

Half the people I meet want to know about the Mac. The other half are eager to learn about writing machines. "What," they ask, "do you recommend for a professional writer?"

The easiest answer is "That depends," but I have a better one. "Almost anything."

Assuming that a writer is making a living, any decent computer system will raise productivity enough to pay for itself. Obviously, I have strong opinions about machines and editor programs; but in reality, any text editor is much better than typewriter and paper.

There are three major considerations for a professional. First, do you like the keyboard and screen presentation? If you don't, you will probably get used to it; but you are going to be sitting there a long time, and it's worth extra bucks to get something aesthetically appealing. Borrow the money if need be, but get a machine with a good "feel" to the keyboard and well-shaped characters on the screen. Make sure the physical layout is suitable. I wear bifocal spectacles and thus dislike the usual screen, which sits too close so that I have to tilt my head back in order to read the display. My screen has big letters, sits far away, and is at natural eye level. I'd pay a lot to keep that setup.

The second principle is Pournelle's Law: "If you don't know what you're doing, deal with people who do." Buy your system from someone local, preferably a dealer who's been in business awhile; someone you can get at with a baseball bat if need be. If you're not buying brand-name equipment, be sure your dealer is familiar with the manufacturer and has reason to trust it.

Third, be sure your system can run WordStar.

I suppose that sounds like heresy. Not really, though. I'm not recommending that you write your books with WordStar; just that you be sure your new system will run it. There are several reasons for this. First, you may someday have to collaborate with another writer; and while it's unlikely that you'll both use the same text editor, it's very likely that you'll both know how to use WordStar.

Then, too, there are all those WordStar utilities. As an example, we're doing final editing of the first book in the Pournelle's Users Guide series. (Baen Books, and watch for it; the cover by Robert Tinney is worth the price of the book.) After all the tirades I've launched against books without an index, I've no choice but to make one for mine. That's no mean task, so we've turned to the computers to aid us. By judicious use of the utilities furnished with Oasis Systems' The Word Plus, plus SuperDex, the indexing program distributed by Spite Software, we've made great progress—but SuperDex wants the book in WordStar format.

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and concatenate them into one enormous WordStar file; or, of course, take a WordStar file and convert it into a series of linked WRITE files. FILTER is blindingly fast, too; so fast that for long WordStar files it's quicker to use FILTER to convert to WRITE, let WRITE reformat the file, and then reconvert back to WordStar, rather than use the WordStar global reformat command. We do have to use WordStar to generate the paper copy that the index refers to, though. Hence, the necessity for a system that runs WordStar.

There are many other word-mashing utilities, such as Footnote, and nearly all of them want to work on WordStar text files.

THE REAL QUESTION

A lot of those who ask my advice don't state their real question, "What's the cheapest computer you recommend?" Fortunately, there's a simple answer to that one.

For those without much money, there's no real choice. Unless you're willing to steal your software—a practice I don't recommend—you need a Kaypro, which has become both the VW and Chevrolet of the micro industry. Kaypro machines are rugged, reliable, and not very pretty. They come with plenty of software and will run more. Given my druthers, I'd scrape up the extra bucks for a Kaypro 4, but you can live with the 2; and when you've outgrown it, you can still sell it for half what you paid.

There are, I expect, a number of other low-cost reliable machines on the market. I can't know about everything. I do know the Kaypro line, and I have no difficulty recommending the machines.

Incidentally, a few months back I reported problems with the hard disk in the Kaypro 10. That turned out to be characteristic of some of the early machines: the software in ROM would falsely report disk errors when there were none. All those early ROMs have been replaced, and after its quick trip to the factory, our 10 has behaved flawlessly. My friend Norman Spinrad chose a Kaypro 10 as his writing engine, and he's quite happy with it.

Norman made his choice after playing around with most of the computers here at Chaos Manor. For a while, I thought he'd get an Otrona. The Otrona's built-in screen is too small for day-after-day writing, but its amber screen is excellent. You could do a lot worse than get an Otrona Attache, external amber screen, and external hard disk. The big screen and hard disk form part of a permanent base, and the Attache can be carried on trips. Incidentally, WordStar comes with both Kaypro and Otrona machines; and WRITE, my favorite text editor, is available for both.

REAL PORTABLE

It started with Pamela Clark. I noticed that wherever she went she carried her TRS-80 Model 100 lap-size portable. Then Phil Lemmons showed up with the NEC version. Both raved about how

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much time these things saved: you could work anywhere, even on an airplane.

At the BYTE Show, the Great Salt Lake Computer Company had a blowout sale on NEC PC-8201A lap-size portables, and I couldn't resist. Before I knew it, I'd plunked my plastic down and carried off the machine, which I immediately dubbed Percy.

It's wonderful.

On the way home from Chicago, I managed to write half of my *Popular Computing* column and part of this one. Oh, sure, Percy's built-in text editor is a bit limited, but by gollies it's good enough for text entry. I wrote about 4000 words on that airplane.

Getting the text out was the simplest thing in the world. Percy's documents are very complete. In particular, they explain how to set the data rate, data bits, and stop bits for his built-in RS-232C port. The Golem, my CompuPro-8/16 boat-anchor system, boasts a program called BAUDCOM that does the same thing for his RS-232C serial port. All I had to do was connect the two ports with a cable, set the system to 9600 bps, and let fly. The PIP utility on the Golem worked perfectly as the collector; I simply went

```
PIP M:MYTEXT.TXT=TTY:
```

and then followed instructions on how to send a file from the NEC PC-8201A. The only tricky part was to send, from Percy's keyboard, a Control-Z character when he indicated that he was done sending the file. That immediately signaled "end of file" to the Golem, and he closed the file. Mission accomplished.

The only real trouble with Percy is that he won't hold more than 7000 words of text before his memory is full. One solution to that is the NEC cassette recorder you can buy with the PC-8201A. This rides in checked luggage, to be dragged out in your hotel room. The problem with that is that cassette transfer is slow, I don't really trust cassettes anyway, and there's no way to edit the text you've produced. I thought about that for a while.

Then I did some experimenting: I tried sending text from Percy to Adeline the Otrona Attache. That worked. I also made a discovery: Percy fits nicely alongside Adeline in her ballistic nylon carrying case. This means I can stuff the NEC portable into the Otrona's bag until I'm on the plane; then retrieve the portable for in-flight use while the Attache rests in the overhead rack. When I get to my hotel, I'll transfer the newly written text from Percy to Adeline, where I can edit away with WRITE.

One note of caution: it's well known in the trade that the Japanese are about to introduce a new generation of lap-size portables. I have enough upcoming trips to justify buying Percy—especially at sale price—just for use in the next six weeks, by which time I'll have got my money's worth. Others with fewer trips and deadlines might want to wait a bit to see what's coming.

Botchi?

I get pretty involved at the West Coast Computer Faire. Sometimes that's regrettable. For example, while I was distracted with something else, there was put into my hands the damnedest document I ever did see. It's called a Data Passport. It was accompanied by a flyer proclaiming, "We Speak Botchi."

All this comes from an outfit called Data Conversion Inc. The company claims to have the smartest data-transformation droids in the universe. For example, the flyer reads, "We're not your average bunch of yahoos. There is no data conversion problem we can't handle. Called MASTER DATASMITHS, our droids have a certain arrogant pride."

What Data Conversion Inc. claims is the ability to transform and convert data from any media format to any other, and to do it "faster, less expensively, and more reliably than anyone else on the planet. Maybe even the Galaxy." Eight-inch, 5¼, 3½, it makes no difference: these chaps can convert it.

They also have the oddest contract I've ever seen. For example, if the conversion attempt fails, they will either refund your money or keep trying "until

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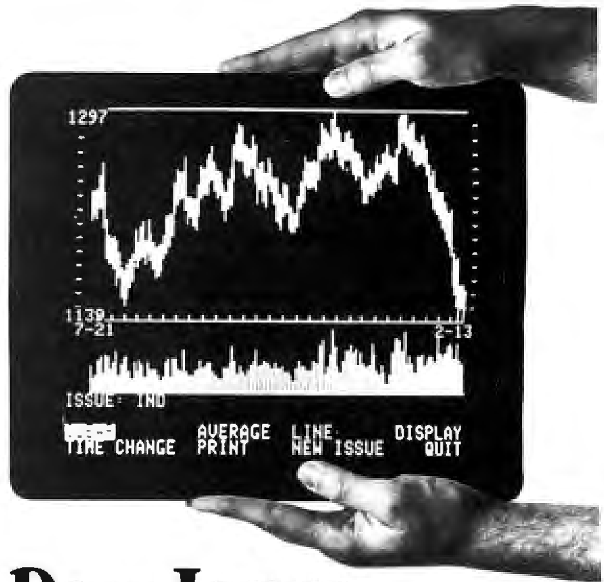

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the *stinking droids* get it right." In another section, they proclaim that "if any part of this contract is held to be brain damaged, the remaining terms remain in force." They say they're willing to collect their fees in Planet Earth U.S. Dollars, monopoles, or antigravity belts.

I haven't the foggiest notion of whether they can actually convert data or not; all I have to go on is the flyer and Data Passport. I find the documents impressive: professional writing, layout, and printing. Despite the humor, the contract is clear, precise, and fair. Since the arrival at Chaos Manor of New Generation Systems' Disk Maker I we've had no sticky data-conversion problems, so I've no longer a need for the Master Datasmiths' services; but if I did, I wouldn't hesitate to let them take a whack at it. Incidentally, they advertise that the first disk conversion is free.

MILLIONAIRE AND OTHER VICES

The word is that so many hackers at the Benton Harbor facility of Heath Company were playing Millionaire that the supervisors had to put severe restrictions on when the game could be played. I believe it. Millionaire is addictive.

Millionaire is a stock-market simulation, and it's worth playing just to learn about margins and options; indeed, I suspect that students would learn about as much from playing Millionaire and Blue Chip Software's companion games Tycoon (commodity-market simulation) and Baron (real-estate investment) as they ever learn from Econ 101. (For my sins, I was once required to teach Econ 101, so I have some right to that opinion.)

In any event, Millionaire is easy to learn and fun to the point of addiction. Try it. You'll like it.

PETER FLYNN'S NOTES

There's no way to bring order to Chaos Manor. That doesn't stop Peter Flynn, our new editorial assistant, from trying. Peter's job is undefinable: basically, he gets paid to be interrupted. One of his primary missions, though, is to make notes for my upcoming columns. From time to time I'll include some of them.

THE SWEET-P STORY

Peter's notes begin: "A couple of months ago I brought out the Sweet-P Plotter for reviewing. Ignoring the directions, I proceeded to test out the unit with the AUTOCAD software. Everything seemed to work fine. After carefully examining several drawings, I noticed stray lines between points that should not have been connected. When I took apart the printer the problem was obvious. The solenoid spring was not exerting enough force to properly return the pen to the upright position.

"I sent a letter to Enter Computer requesting a new spring. A couple of days later they called, and after listening to my description of the problem, asked us to send the plotter back for repair. Instead I put it away, since the BYTE

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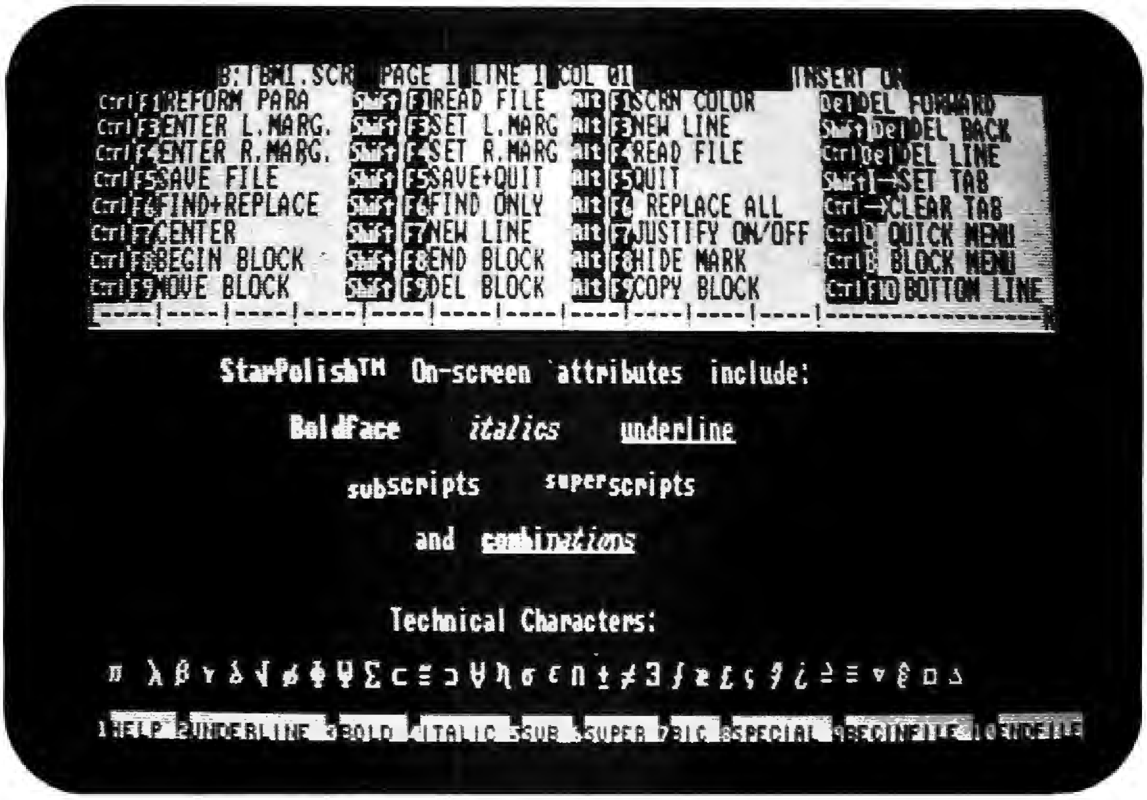

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deadline was coming up and I had other things to do.

"Two months later while organizing the attic storage I stumbled into the Sweet-P shipping box. My fascination with plotters convinced me to ship it out for service. After packing up the unit, I called Enter Computer for a return authorization number. Instead, I got Bill Winklepleck on the phone who walked me through an inspection and attempted repair. After opening the unit, he had me stretch the spring. However, the one we have is shot. No amount of stretching will rejuvenate it.

"While I was replacing the cover, it occurred to me that the Sweet-P is one elegantly designed piece of equipment. With help over the phone, almost any novice should be able to repair one. There is not even any easy way one can electrocute oneself. Mr. Winklepleck is sending a new set of springs."

He did, too. Alas, one of the staff couldn't resist opening the box and managed to lose the spring, so we had to get another.

The Sweet-P is an excellent piece of machinery, easy to hook up and use; and it's no great trick to replace that bad spring, assuming that people around here will mind their own business long enough to let it be done . . .

R Way

We're looking for a new database. Things have got into a mess, and we're hoping to get some inventory and file location control.

One product Peter examined was R:Base, from Microrim of Bellevue, Washington. You've probably noticed the ads, which contrast "d way" with "R way" of doing things. Peter concludes: "Powerful but not worth the effort if all you need is simple file management. Good if it is to be used very often. The tutorial will not easily teach a complete novice. The structure of commands will take a lot of getting used to for someone not accustomed to large databases. If there is someone in an office who will undertake the work to learn this program, he/she will be well rewarded for the effort (provided that the office has use for relational information)."

My own examination of R:Base was pretty superficial, but I agree with Peter.

(continued)

ITEMS DISCUSSED

Applicard . . . . Not available
Personal Computer Products Inc
16776 Bernardo Center Dr.
San Diego, CA 92128
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Baron $59.95
Millionaire $59.95
Tycoon $59.95
Blue Chip Software
6744 Eton Ave.
Canoga Park, CA 91303
(818) 346-0730

COBOL Syntax Checker $7500
UNIX System V for 68000 . . . $43,000
AT&T
222 Broadway
New York, NY 10038
(800) 828-8649

Data-Conversion Service . . . . . Contact for rates
Data Conversion Inc.
6310 Caballero Blvd.
Buena Park, CA 90620
(714) 522-7762

FILTER.COM
(on disk with other filters) $32.50
Workman and Associates
112 Marion Ave.
Pasadena, CA 91106
(818) 796-4401

Gold Card . . . . Not available
Digital Research
POB 579
Pacific Grove, CA 93950
(408) 649-3896

Kaypro 2 . . . . $1295
Kaypro 4 . . . . $1995
Kaypro 10 . . . . $2795
Kaypro
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Solana Beach, CA 92075
(619) 481-4318

Macintosh $2495
Apple Computer
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010

NEC PC-8201A $599
NEC Home Electronics
1401 Estes Ave.
Elk Grove Village, IL 60007
(312) 228-5900

Otrona Attache $2995
Otrona Corp.
4755 Walnut St.
Boulder, CO 80301
(303) 940-3445

R:Base $495
Microrim Inc.
1750 112th Ave. N.E.
Bellevue, WA 98004
(206) 641-6619

S-100 1-megabyte Board $2449
Z-100 High-Performance Memory $2250
Macrotech International Corp.
9551 Irondale Ave.
Chatsworth, CA 91311
(818) 700-1501

SuperDex Document Indexing System $59.95
Spite Software
13531 SE Foster Place
Portland, OR 97236
(503) 224-0137

Sweet-P Plotter $695
Enter Computer
6867 Nancy Ridge Dr.
San Diego, CA 92121
(619) 450-0601

TRS-80 Model 100 . . . . $799
Radio Shack
1800 One Tandy Center
Fort Worth, TX 76102
(817) 390-3011

Trump Card $995
Sweet Micro Systems Inc.
50 Freeway Dr.
Cranston, RI 02910
(401) 461-0530

Turbo Pascal $49.95
Borland International
4113 Scotts Valley Dr.
Scotts Valley, CA 95066
(408) 438-8400

WordStar $495
MicroPro International
33 San Pablo Ave.
San Rafael, CA 94903
(415) 499-1200

When I get *Footfall* finished, I'm going to do a systematic comparison of database programs; that will probably include some of the integrated packages that combine word processor, database management, and spreadsheet calculator into one monster program. Until then, I suppose we'll just have to limp along.

Maybe We Shouldn't Worry

I remain impressed as all get-out with AT&T's hardware, especially the desktop 3B2 (see last month's column). I'm not so impressed with the rest of what the company's doing.

Today I received two AT&T press releases. The first announces a COBOL Syntax Checker. This thing will run on the UNIX System V (AT&T's standard "commercial" UNIX). Its mission is to "reduce the chances of a program being rejected due to syntax and simple semantic errors. As a result, expensive mainframe central processing unit (CPU) time is reduced."

"The product, available in source code under license agreement with AT&T, is priced at $7500 for the first CPU and $3750 for each additional CPU."

More on that in a moment. The second press release announces UNIX System V for the Motorola 68000 microprocessor chip. Under a series of agreements with Motorola (68000), National Semiconductor (16032 and 32032), Intel (iAPX186), and Zilog (Z80000), each firm is supposed to port UNIX System V to its own chip. Motorola was the first to finish.

The press release then quotes AT&T software systems vice-president Tom Crowley: "The microcomputer market has been eagerly awaiting the results of last year's announcement [of the agreements]. The wait is now over. With this product, the power and versatility of UNIX System V will now be available for a wide range of microcomputers employing the MC68000."

Then comes the kicker. "The product, available in source code under license agreement with AT&T, is targeted to the growing number of resellers who are building hardware and software products around UNIX System V. Priced at $43,000 for the initial CPU and $16,000 for each additional CPU . . ."

That's source code, though. I called the follow-up number on the press release: after four hours, I still wasn't able to get a consistent story on the license fees computer manufacturers would pay for UNIX object code. It turns out to depend on the number of end users and can go as high as $3500–$7000 per machine sold.

Foo.

The mountain has labored, and didn't even produce a mouse. This may fly in the minicomputer market, although if it does, the minicomputer people aren't paying much attention to the micro world.

For that matter, who wants a COBOL Syntax Checker for $7500? I wouldn't want one at any price, but I know darned well that I could write a pretty good COBOL Syntax Checker to run on a micro. I'd write it in Turbo Pascal or Modula-2, and it sure wouldn't cost $7500.

Maybe Apple was right in going for profit rather than market share. With bizarre prices like those, AT&T is no threat to anyone in the micro world. Can you imagine *Concurrent CP/M* selling for $3500 a shot? Absurd. But I guess the minicomputer world puts up with it.

For instance, a couple of years ago I read about a database program for sale. The price was $795 for the MS-DOS version; $600 to $2000 for the 68000 UNIX version; $12,000 to $48,000 for the DEC PDP-11 version; $24,000 to $48,000 for the VAX; and $48,000 to $96,000 for an IBM mainframe.

Given that I could buy a pretty good micro for $5000, my question when I read that was, what could I get running this on an IBM mainframe that I couldn't have got from 20 micros? Or what does the DEC PDP-11 do for me that I can't do with a 68000? If I went the micro route, I'd have hardware and all for the price the mainframe or minicomputer EDP shop manager paid for the software alone.

The article didn't tell me the reasons for this odd price structure. I assume it's what the traffic will bear; I doubt the database-management system required 50 times as much work for the mainframe version as it did for the 68000 version. Yet, apparently, these prices are traditional among mini and mainframe users, and no one sees them as alarming.

I expect AT&T is in for a shock.

Just Lots of Memory

A while back the Macrotech troops came over, and as I watched, they pulled all the memory boards out of the Golem and dropped in their 1-megabyte

(continued)

dynamic memory. After a couple of false starts—the Golem is, after all, running CP/M-8/16 enhanced by Tony's black-magic improvements, and the timing was a bit tricky—everything fired up and ran.

The Golem has a hard disk, 8-inch disks, a 5¼-inch disk, and a megabyte of RAM (random-access read/write memory) disk; if their board will drop into that and run, it should go with any CP/M system.

It's been running for a month now. No glitches, and it's a *lot* of memory. Macrotech is no longer the cheapest source of memory; AT&T will sell you memory at $2200 a megabyte, somewhat less than Macrotech asks for the 1-megabyte board. On the other hand, AT&T makes memory only for AT&T machines, so the lower price won't do you much good; meaning that, as a practical matter, Macrotech provides the most bang for the buck.

We also have one of Macrotech's big boards in Zorro, our Z-100. The company provides software to let you use some of that memory as RAM disk, something the Z-100 sorely needs. That's been running for over a month, too, with no problems. If you need memory and don't want to pay the price for static, Macrotech is no bad place to turn to. I've been talking to key people there for a couple of years now, and they've always been straight-arrow aboveboard. If they have problems with a product, they tell me.

I still have minor misgivings about dynamic memory, and now that I've given the Macrotech board a fair test, I'm going back to my CompuPro static-memory boards; but I admit that's probably pure prejudice. The Macrotech board will stay aboard Zorro, so we'll have more tests.

The Behinder I Get

Every Monday the BYTE staff in Peterborough sends me a huge Federal Express box of my mail from the previous week. It's always full of good stuff, but lately there's been (along with about 10 pounds of mail) more software than ever. I note there's a trend toward integrated software, which combines a spreadsheet, editor, and database. We're trying to select a package.

Meanwhile, Shirley, the CompuPro four-user Model 10, is alive and well, although not much used until the architects and construction people get through building the new upstairs office suite; after that, Shirley will become the prime machine for John and Peter. I'll reserve one of the user ports for myself, simplifying communications and access to the downstairs troops.

We have the TI Professional PC, which has one of the nicest keyboards I know of and a lot of excellent features; and I'm told that the Zenith Z-150 IBM PC-compatible should arrive in the next day or so. I hope to do some hard comparisons of the two systems; they both have some excellent features, and I have every reason to think that, depending on your needs, one of these is the clone to buy if you want a PC-DOS system. The Zenith is somewhat more compatible with the IBM; the TI Professional has a bunch of interesting features, including voice recognition. A full report *Real Soon Now.*

There's still the Sage IV; I'm expecting some S-100 boards from Lomas; the software pile is growing; CompuPro has announced that Tony Pietsch's new S-100 IBM-compatible video board, with both color and high resolution, will be shown at the Atlanta COMDEX next week; I'm learning more about Percy; Alex has been happy with the U.S. Robotics 300/1200-bps modem we got at the Priority One blowout sale; and I love Thinktank, except for the stupid copy-protection scheme, which, incidentally, I've just learned to defeat.

I'm really trying to keep up. ■

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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C·H·A·O·S M·A·N·O·R M·A·I·L

Scientific Computing

Dear Jerry,

I suppose I shouldn't be as surprised as I am by your reply to Jay Pasachoff's letter in the April BYTE (page 404). I'm still waiting to see in your columns or anywhere in the microcomputer industry a serious appreciation for the computing needs of scientists and engineers. After all, we've paid our dues: computers weren't invented by programmers but by a bunch of guys who called themselves "radio engineers." Indeed, anyone who understands the needs of the scientific user would never state that FORTRAN is good only for "quick and dirty answers to specific problems" or that BASIC is just as good.

Among the many limitations of Pascal or Modula-2 for scientific work is the lack of a straightforward way to do complex arithmetic. Contrary to the view of most programmers, who often have a mathematical or engineering background and should know better, complex numbers are not an aberration but are at the core of engineering mathematics. It is ironic that microcomputers, whose performance depends so strongly upon complex arithmetic, can't do that same arithmetic in a convenient manner. Unless they have a full-feature FORTRAN compiler, that is, a commodity as scarce as oyster toenails.

I suggest that you try to write a general-purpose complex matrix-inversion subroutine in BASIC, Pascal, or Modula-2 or, better yet, evaluate a Hankel function of a complex variable. It will give you a new appreciation for FORTRAN.

Steve Maas
Torrance, CA

If, God forbid, I were ever to have to evaluate a Hankel function of a complex variable, I would probably turn first to APL.

Fortunately, I don't have such specialized problems. However, skilled programmers tell me there are ways to accomplish complex arithmetic in Pascal and more particularly in Modula-2. The library routines are not all that easy to write; but once written, they can be employed in a straightforward manner.

It's undoubtedly easier to write the programs you describe in FORTRAN. However, the structure (or lack thereof) makes FORTRAN programs hard to understand and harder to maintain; and the lack of type checking allows some pretty subtle bugs to creep in. If you know *that the FORTRAN routine you've written does what you want and nothing else, fine; but I'm not sure how to know that.*

It's a philosophical difference; but I'd rather wear a straitjacket while programming and have the compiler catch my errors, than program in free form, have it compile fine, and then later discover the program isn't doing what I thought it would.—Jerry

A Most Fabulous Object

Dear Jerry,

I enjoy your column . . . Umm . . . Each month I wait in eager anticipation with my knuckles hard and white. As the mail arrives each day . . . No, no, this is all wrong. How about, some times, as I'm thumbing through BYTE, trying to decide what I have time to read, I find myself reading your column. Yes, I think that's it—clear, honest, a little bit slang yet to the point.

In April (somewhere after December for people in lead time) you mentioned something that really caught my attention. I believe it may be at least a partial cure for my serious psychological problem. You see, I have this passion for . . . no . . . oh . . . please . . . here it comes again, that terrible madness . . .

I must have that Omnisphere!! Give it to me!! You must, even now I can see you, fascinated, thoroughly enjoying its mystical glow. I must have it! Oh, umm . . .

Sorry, uh, I'm okay now, it just happens now and then. Oh, you don't need to worry. I'm not really dangerous or anything, but I might stay more calm if you were to give me the address of the Orb Corporation. I would like one of my own.

Please, keep up the good work (play if you like) and by all means enjoy the Omnisphere a bit for me. Oh, one more thing, the white zone is for booting and unbooting only, no . . . The red zone is for loading and . . . Oh, uh, well . . .

Michael Aichlmayr
Tacoma, WA

Actually, I don't blame you. It really is the most fabulous object in the entire universe . . . and does have a calming effect. I'll go touch mine for you.

The Omnisphere is available from The Orb Corporation, 125 Elm St., New Canaan, CT 06840, (203) 966-4392. It is not cheap. I also understand there may be a waiting list.—Jerry

Writing Tool

Dear Jerry,

For two years now I have been looking at computers and reading computer magazines. To familiarize myself with the basics, I bought an Atari 400 at the time they still cost more than $250. I have learned programming in BASIC on the Atari, Apple, and the IBM PC. Still, I am unable to make an intelligent decision about buying a computer.

I am a technical writer and editor of a technical trade journal. My needs, I thought, were simple. I wanted a creative tool that would allow me to get organized and help me with my work, which is substantially more than simple word processing. Is that too much to ask from a computer? Whenever I walk into a computer store, I am overwhelmed by the enthusiastic sales pitch extolling the virtues of letter-quality print, spreadsheets, and graphics programs spitting out bar and pie charts.

In the course of my work, I do normal algebraic calculations and make numerical lists and plot curves, eventually integrating them into my articles. Occasionally, I do surveys and come up with relatively simple statistical curves and trend analyses that also must be integrated into the articles. Finally, I have a moderate database requirement, keeping track of a few hundred companies. Based on my research and the current state of the art, it seems that I would need many different software programs and would not have a chance to integrate them. To the best of my knowledge, I would forever be swapping disks, trying to keep track of what is where in what form and on what file.

It should be worthwhile for somebody to come up with integrated software to do this kind of work. Besides writers, it would also apply to college students. That ought to be worth something. In any case, would you advise me if there is anything that comes close to my requirements? That is, of course, within my budget of $3000-$5000.

Tamas Frecska
Cincinnati, OH

As the customer base grows (seemingly without bounds), there's getting to be a lot of software for the IBM PC and clones. I'd expect you to be able to find a package to meet the needs you describe. We're about to see a wide blossoming of integrated software. Realistically, the best will probably be generated for IBM PC systems and work-alikes.

Of course, that kind of computer power isn't free: to save you swapping disks, for instance, you'll need a hard-disk system. Now that we have ours, I can't think how we lived without it.

There are literally dozens of systems within the price range you quote; to recommend one is to be unfair to the others. Moreover, we can speak only of systems we've had here at Chaos Manor. Systems we're happy with include CompuPro, IBM PC, and Zenith. I don't have, but people I respect recommend, the TeleVideo and Corona PC clones. For development work, the Eagle systems are good, but

(continued)

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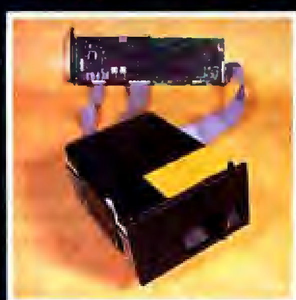

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the documents are insufficient to allow me to recommend them to new users as business systems.

If I were editing a trade journal, I'd probably go for a CompuPro Dual Processor system with a hard disk. That way, you'd have access to the best of the 8-bit software as well as the new 16-bit that's being developed. On the other hand, full PC compatibility for CompuPro systems is still in the Real Soon Now category.

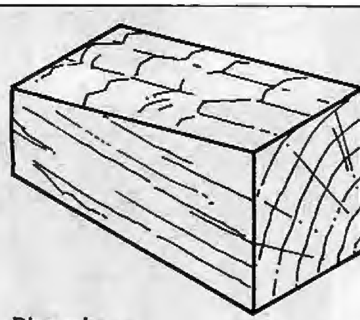
Do take the plunge. It's not so much a matter of getting the best system as getting one that's good enough; and there are a lot of them that are plenty good enough.—Jerry

Tandon and WordStar

Dear Jerry,

I have been meaning to write for some time and was finally spurred into action by the letter on Tandon disk drives ("Needed: Spare Parts," April, page 398).

I guess I was just lucky. When the drive door on my Tandon 5¼-inch floppy-disk drive broke (at an extremely critical time, naturally), I called Tandon. The first person I talked to referred me to someone in another department. That person said, "Oh, you need a new door assembly. I'll just stick one in the mail for you, free of charge." It arrived a few days later, installed quickly, and I've had no further problems (knock on wood). In the meantime, I needed the drive desperately, and my husband fixed it with a piece of wood. He cut out a wedge-shaped piece that could be pushed in to "close the door." This worked perfectly (see figure 1).



Dimensions

Length: 2 inches
Width: $^{13}/_{16}$ inch
Height at Wide End: ⅞ inch
Height at Narrow End: ⅜ inch
Material: Oak (other hardwoods probably acceptable)

Operating Instructions

1. Remove door assembly. (If piece of wood is necessary, door assembly has probably broken off already.)
2. Insert disk.
3. Insert narrow end in disk drive where door assembly was, inserting between outer drive case and the plate that clamps the disk down. Push in gently until disk engages.
4. To remove disk, reverse procedure.

Figure 1: *A piece of wood successfully used for temporary operation of Tandon disk drives.*

I'd like to put in some good words for WordStar. I learned word processing on WordStar, so I can't compare it to other word-processing software, but it has features that are absolutely vital for what I do. One thing is that I don't want my documents to be automatically reformatted if I change margins. I need to be able to have different-size margins within a single document so I can have part of the document formatted at 10 characters per inch (right margin 65), with inserts at 12 characters per inch (right margin 80). I am also writing documents where physical layout and appearance are important, so the "what you see is what you get" feature is essential. Moreover, I've done a lot of typing of business letters and reports, and I think that secretaries who type those documents take a great deal of care at the time they are typing to have the letter look nice. In my opinion, WordStar more nearly approximates the job that is already being done than other word processors without the on-screen formatting capability. I would not recommend a program without this capability to anyone in a normal business environment. IBM has already demonstrated enough disdain for the secretaries of this world by not adopting the Selectric keyboard for the PC, without word-processing software adding to the burden.

Nancy Jacobsen
Forest Knolls, CA

I'm glad Tandon was nice to you; the company took more than six weeks to deliver a shipment of door-latch parts to Barry Workman even after he'd paid for them. Meanwhile, your husband's invention may be a boon to mankind.

We've had stories of Tandon problems from China to New Zealand. Eventually things are fixed, but it takes time, and for those in foreign lands it can get awfully expensive.

As I've said in previous columns, WordStar 3.3 is something more than an adequate word processor. Do understand, though: WRITE is capable of changing margins, spacing, and such like "on the fly"; and there's a "print to screen" feature to show you what it will look like when printed out. However, I agree: if you're doing fancy formatted layouts, you'll want a "what you see is what you get" editor. Recall that most of my output is standard 60-character lines.—Jerry

Computer Security

Dear Jerry,

Do you think it will ever be possible to alert our high priests to the simple solution to computer break-ins? It appears to me that the whole security problem is due to one innocent device: the dial-up modem. I have never had any trouble with anyone breaking into my computer; they would first have to break into my home. At work I occasionally use a timesharing computer, which has dedicated terminals scattered throughout the company and will answer a dial-up modem. If the modems were not available, we would not have to worry about someone breaking into the computer. They would first have to get past the security guards.

Dial-up modems are quite convenient, and they do allow computers to communicate with each other. This could be provided in a secure system by giving the modems restricted power. For example, a salesman may call the office computer. The computer, recognizing the modem, would allow him to check current prices or stock or enter an order. When the salesman returns to the office, he would use a dedicated terminal to check and then permanently record the orders he entered. The modem has no access to sensitive information, and the salesman should check the orders before any bogus ones corrupted the company's database.

The idea of limited-power modems is not new. Many of the remote CP/M systems, and most bulletin-board systems, employ this technique. The remote CP/M systems have masked out the SAVE, ERA, and REN commands and don't have the assemblers, debuggers, or compilers on line. The caller has only those powers given by the system operator. The intelligent operator has blocked out any commands that could corrupt the system.

The idea of somebody getting into my company's computer and messing around with sensitive information makes me nervous, and I am positively horrified by the idea of calling a defense computer and messing around with it! Perhaps administrators of such systems would implement a special program to greet curious hackers. This program might give them a sales pitch or some other public information. The advertising people might even like that idea.

Tom Ruby
Freeport, IL

There are many ways that a systems hacker can thwart the break-in artist; but until recently no one thought that a desirable thing to do. For many years, it was traditional for computer nets to be completely open. Anyone could read anyone else's files or watch over someone's shoulder while they worked. This was true even on the unclassified portions of the Pentagon's ARPA (Advanced Research Projects Agency) net. The benefits of allowing bright users total access were that they would spot and fix bugs, thereby making the net operate more efficiently.

In the past few years, there have emerged a number of "crackers" who take malicious joy not only in penetrating computer systems but in altering files and even in crashing the systems. They set up Trojan horse shells that look to the casual user like the normal operating system; these collect passwords. Some of these "crackers" are quite clever and find ways to access parts of the system that the systems programmers never intended.

As an example, it's possible to install into

(continued)

your system, from outside, a program that will send me copies of your files while you think that you are playing a game of chess with me. That's not easy to do, of course, and it's harder on small micros than on big machines with highly complex operating systems. UNIX systems are particularly vulnerable to penetration since UNIX wasn't designed with security in mind.

Systems people are working on software solutions, but at the moment the only sure answer to the "cracker" problem is to be very careful what you allow telephone access to. Physically remove disks with sensitive information before plugging in the telephone connection; physically disconnect the cable to the hard disk if need be.

It's too bad; it was a lot more fun back in the wide-open days.—Jerry

MICRO CORNUCOPIA AND L-5

Dear Jerry,

I bought a Kaypro 4 and have increased its speed to 5 MHz and added a better monitor ROM. These changes were made possible by the people at Micro Cornucopia, POB 223, Bend, OR 97709, (503) 382-8048.

Micro C is a small journal the company puts out for people with single-board computers such as the Kaypro, Xerox, Big Board, and Slicer. Columns on each of these machines are included, plus columns on C, Pascal, FORTH, and SBASIC. Micro Cornucopia provides lots of technical information and has user disks for each of the above systems, consisting of the "good" public-domain software usually configured for that specific system. All in all, they are a great bunch of people and have terrific products.

Has anyone set up an L-5 bulletin board? Do you have any way of communicating with the L-5 Godbout system? I would like to help, but I'm not quite sure how to go about it. I would think a lot of people in L-5 have computers. Maybe we could form a computer tree.

VINCE BINDER
Pullman, WA

I too have heard good things about Micro Cornucopia, but I've not been able to try any of the products yet.

The Kaypro remains the entry-level system I recommend for nearly everyone.

I wish someone would set up an L-5 Society bulletin board; I keep being told it will happen Real Soon Now, but it doesn't, and I haven't either the time or the skill.—Jerry

SMALL IS NOT NECESSARILY BETTER

Dear Jerry,

I always look forward to your latest offerings. I was especially interested in April's column concerning software support. My accounting package went down last Wednesday afternoon. It is now 5:30 a.m. Monday and I am no closer to having any help—let alone an answer. I too tried to contact a software vendor. However, I am a lowly end user (ranks with sea slug I guess) and no one would talk with me. The frustration is so totally overwhelming that words fail me.

I believe our experiences are quite common in this industry. The small-scale business user like me is in a vulnerable position when computer problems arise. I am not a computer whiz; I have neither the time or inclination. But I do want my computer to be the tool it should be. Unfortunately, I am at the mercy of a bunch of computer whizzes that often do not understand or care about users' problems. The giants like AT&T will take over the industry because the small companies can't even decide on a method of talking to a customer—let alone solving his problem. AT&T and IBM are portrayed as giants walking the earth swallowing all in sight; I feel that they are giants simply because they do have some method of servicing the end user.

It does reassure me in some perverse way that you too experience these problems. Perhaps at one of the next big meetings of computer industry whiz kids someone will address this problem.

R. MAX MCCART

Sigh. One day the industry will grow up; meanwhile, I can only advise people to read those disclaimers and understand that software companies really don't promise much. The best defense is to deal with reputable dealers who will refund your money if they've sold you an unsuitable product.

A lot of us at conferences address this problem, and indeed we've made progress in the past few years; which only shows how bad things were in The Old Days.—Jerry

COMPUPRO SOFTWARE

Dear Jerry,

Since you are a well-known CompuPro owner, a number of us who own a CompuPro or are considering it follow your columns. You might want to pass on the following bit of information about better system software for those of us who don't have access to the consultants and gurus that you do. Lanier Computer Systems, 25 Laurel Dr., Langdale, AL 36864, offers a BIOS for CP/M-80 (BIOS 80, $35) and one for CP/M-86 (BIOS 86, $50). Each supports track-buffered I/O in which the disk-controller chip reads an entire track in one disk revolution. BIOS 80 requires 96K bytes and buffers four disk tracks. Any additional memory is used as a memory disk.

We find that the BIOS 80 is much faster than our original CP/M-80 BIOS from Sorcim. Compiling a one-line BDS C program took 3.75 seconds using BIOS 80.

IEEE *Micro* (December 1983) has an article on floppy-disk transfers that says a two- to five-time improvement in access time is typical in CP/M systems that use track-buffered I/O.

LAURA WALLACE
Bedford, MA

The Lanier BIOS is great for those who bought systems some time ago. I believe that CompuPro is now shipping Tony Pietsch's HMX (CP/M 2.2) and TMX (CP/M-8/16) BIOSes, which have track buffering and are very fast; so new purchasers probably needn't bother.

I've gone completely over to CP/M-8/16 on my CompuPro, and I love it.—Jerry

WORDSTAR TRICK

Dear Jerry,

There are a fair number of us around here who use WordStar still, and I thought your column might be one way to pass on a useful trick I have figured out for the scientific fraternity struggling with equations, superscripts, subscripts, and other such things.

WordStar allows you to embed control characters to roll the printer up and down, but the result (even with ^OD to turn it all off) tends to be unreadable on the screen. Further, I find on my Oz-driven Prowriter that by the time a line has been rolled up and down a few times the horizontal registration starts to wander.

I therefore hit on the use of WordStar's overprint line feature to solve it. The idea is that a complete line is used for superscripts, another one for the body, and another line for subscripts. This gives a vertically expanded display on the screen with all the columns in the right place and no messy things like backspaces to figure out. It's quite simple.

WordStar's printer driver should be installed for the half-linefeed option. Start a line on the screen with the superscript toggle (^P^T), fill it with spaces to the desired line length, finish it with another ^P^T, and go down to the next line with a ^P^M instead of a carriage return. Fill the next line with spaces again and terminate it with another ^P^M. Then start a line with the subscript toggle (^P^V), fill with spaces, and end with another ^P^V and a carriage return. The lines terminated with a ^M show up with a hyphen in the last column. The resulting three physical lines are treated as one logical line by WordStar for line counts, page breaks, etc. Filling in the equation just involves turning off insert and the control-character display (^OD) and putting the equation or whatever straight into the screen "template."

To do something like

$$y=(x_{11})^2 + (y_{ij}^{13})^{(K+1)}$$

just fill it in directly on the screen. Admittedly, all those spaces do pad out the resulting file somewhat, but I think the entry benefits make it all worthwhile.

IAN BOAG
Palmerston North, New Zealand

Thanks for the tip. Nice to see that BYTE gets so far afield.—Jerry ■

A Horrible Confession

I was overwhelmed by mail. In a blinding moment of sanity, I threw out everything dated prior to March 1, 1984. Alas, there were some self-addressed, stamped envelopes in the pile.

I do read all my mail, but alas, even with assistance there is too much to answer. I'll keep trying, though.

Pasocom Pagodas

Akihabara

Software shortage

Sharp MZ-5500

Fujitsu FM-11

DIR emulator

BY WILLIAM M. RAIKE

By the time you read this, air conditioners will be competing with personal computers for AC power, and no doubt some of us again will experience that indescribable feeling of having just one more appliance come on that will trip the breakers just *before* we save the last hour or two's worth of text editing. But as I am writing this, air conditioning is the last thing on anyone's mind; spring in Tokyo has arrived at last. The winter's dirty snowbanks have been replaced by windblown piles of cherry blossom petals, and colorful kimonos are again in evidence during strolls through the fashionable Ginza and Aoyama districts.

AKIHABARA

Kimonos are not, however, particularly noticeable in the raucous Akihabara area. (The accent is more on the "ha" than on the "ba," and the name literally means "autumn leaf field.") In fact, almost nothing is noticeable in Akihabara unless it (a) has a power cord and/or battery and at least one solid-state component, or (b) is blasting away at 90 decibels or more. This district of Tokyo, upon which at least three train lines and one subway route converge, covers roughly a three-by four-block rectangular area devoted mostly to retail consumer electronics. In addition to video, stereo, and more mundane appliances, nearly every building has at least one floor just for personal computers, and a growing number of establishments, such as Laox and Yamagiwa, have separate full-blown department stores, dedicating four or five floors to computers alone. These "pasocom pagodas" are to be found elsewhere in Tokyo, too (places like the Omron Micom Base, near Ginza), but if anyone were to make a pilgrimage to some imagined computer deity, their quest would have to end up at Akihabara.

Some knowledge of Japanese is helpful but not essential to make the most out of a visit to these showrooms. Terms such as keyboard, disk drive, monitor, RAM, and display are pronounced nearly the same in Japanese as in English; the unwary are liable to be a bit nonplussed, though, by the Japanese penchant for turning English words into contractions: personal computer becomes "pasocom" (pronounced pah-so-con), microcomputer is shortened to "micom" (my-con), operating system becomes simply "OS" (oh-ess), while software and hardware get transmogrified into "softo" and "hado" (skip the rs, please). But don't expect a sophisticated or particularly well-informed sales staff. You can find capable people, particularly in places specializing in so-called "OA" (supposedly office-automation equipment, but actually anything with two floppy-disk drives and a price of more than $1000), or in some smaller, more competitive systems houses, but they're rare. For instance, in one establishment, after a fruitless 10-minute search for a system disk to fire up a Fujitsu FM-11, I was informed that the machine had "only been here for a little over two months, so no one really knows how to operate it." (I was able to check out the FM-11 elsewhere, and it's an interesting machine; read on.)

An even more fascinating, and much more picturesque, subarea within Akihabara, not more than 50 yards from the train station, is the electronic component bazaar. Contrary to popular misconceptions, and despite the giant Japanese industrial combines, Japan is still, at heart, a nation of small shopkeepers, and that orientation is obvious in the Akihabara bazaar. Both the ground floor and second floor (8000 square feet or so) consist of a honeycomb of small booths, each about 5 feet square (including the space behind the counter for the proprietor to sit down). One booth sells only ICs (integrated circuits), the next only capacitors, followed by one with nothing but resistors. A booth selling knobs, switches, and lamps is flanked by one offering power sup-

(continued)

William M. Raike, who holds a Ph.D. in applied mathematics from Northwestern University, has taught operations research and computer science in Austin, Texas, and Monterey, California. He holds a patent on a voice scrambler and was formerly an officer of Cryptext Corporation in the United States. In 1980, he went to Japan looking for 64K-bit RAMs. He has been there ever since as a technical translator and a software developer.

plies and another supplying meters. Customers crowd the narrow corridors; proprietors seem to have memorized their entire inventories, nearly all of which are on display, and apparently shoplifting is rare enough not to be a problem.

Discounts are the rule in Akihabara, both for consumer goods and components; 10 percent is offered routinely, and 20 percent, sometimes more, is usually obtainable. Prices are reasonable, particularly on components rather than complete devices. On my most recent trip (to pick up an RS-232C cable, about $13.50), the asking price for 256K-bit dynamic RAM chips (Toshiba TMM 41256-20) was about $55 per chip; Hitachi 200-ns (nanosecond) 256K-bit dynamic RAM chips were less, about $42.50. An 8086 processor cost about $16.50, while 64K-bit *static* (not dynamic) RAM chips with 150-ns access time were going for a little over $40 each. For a hobbyist, designer, or small company, the bazaar and numerous other shops nearby are ideal sources for everything from cords to cases and components to cards.

Software Shortage

It would be nice to report on all sorts of software found here, but with the exception of the Japanese-language word processors and, naturally, games, the pickings are slim. Not surprisingly, you can forget about selling any significant number of systems here (hardware and/or software) unless Japanese-character displays, data entry, and text processing are available and of high quality. User-friendly interfaces are highly important here because a minimum of 3000 different characters or so are required. Japanese-language versions of SuperCalc and Multiplan exist and have been announced for CP/M-86 and MS-DOS. The zillions of Japanese-language word processors produced is revolutionary when you consider that, even today, Japanese-language typewriters are not common in most offices. And low-priced (and not-so-low-priced) dedicated word processors are appearing on an almost weekly basis. This culture is leapfrogging from doing ordinary business correspondence by hand to a situation in which word processing will be the rule. But for the most part, you can count the number of other generally available applications or development software packages on your fingers and toes.

Sharp MZ-5500

One of the more interesting machines to appear recently has been the Sharp MZ-5500 system, offered in three versions: 128K-byte basic memory either without a drive or with a single built-in floppy, or 256K-byte RAM (random-access read/write memory) with two 320K-byte drives. The most striking feature is their advertised list prices in Japan—about $970, $1285, and $1730, respectively—but discounts will be inevitable.

The MZ-5500 is a 16-bit system, supplied with CP/M-86 as standard and MS-DOS to be an available option. Running an 8086 at a conservative 5 MHz, it supports an optional 8087 math coprocessor and includes an 80C49 to handle the keyboard chores. RAM is expandable to 512K bytes, and a mouse is optional. The standard system also incorporates 96K bytes of video RAM, expandable to 192K bytes, which ought to satisfy most graphics requirements. Japanese-language processing options are extensive, including a 128K-byte Japanese-character ROM (read-only memory) and a 256K-byte dictionary ROM board that permits input of about 80,000 words in phonetic form. A notable feature is a dedicated large-scale integrated circuit as a "window-display controller" that enables up to four screen windows to be defined and manipulated on a color-priority or logical basis. It is capable of producing some impressive and quick 3-D graphics. The usual parallel printer port and two RS-232C serial channels are provided. And the brochures say that a 10-megabyte hard disk will be available Any Day Now.

For reasons unknown to me, hard disks for microcomputers are not common here, though a limited number provided for IBM PC and PC work-alikes are imported from the U.S.; one exception is a (presumably 5-megabyte) drive for Apple II systems with a list price of nearly $2700. Also, a company named ICM sells a 10-megabyte hard disk for NEC machines; its list price is $1600. Rumors are circulating, however, that several major manufacturers plan to introduce IBM PC-compatible machines soon.

In the MZ-5500 software department, BASIC is available in several flavors, along with a Japanese word-processing package and the Today integrated word processor/graphics/spreadsheet package. Kanji (Japanese-language) CP/M-86 also supports a RAM-drive feature, enabling up to 416K bytes of RAM to be allocated as drive M: and permitting fast file access. Various CP/M-86 utilities are provided, including a program for reading disks recorded under CP/M-86 in formats such as IBM PC, NEC PC-9800, and other Sharp formats and converting them to MZ-5500 format.

Sharp has announced a whole range of development software from cooperating vendors, presumably with the documentation translated into Japanese, but the list prices range from the unbelievable to the ridiculous. Examples include Digital Research's C compiler for about $950, SuperSoft C-86 for over $1100, CBASIC compiler for $950, and Level II COBOL for $2000. Those levels are far above the corresponding mail-order prices from the U.S., which would seem to leave plenty of room for vendors that are enterprising enough to supply at least their documentation in Japanese.

Fujitsu FM-11

The most recent in the FM series of Fujitsu personal computer systems, the FM-11, seems to be a winner. Having had the temerity to name their big mainframes the FACOM series, apparently the people at Fujitsu didn't think twice about coming out with a personal computer model called the BS. The companion AD2 model is an 8-bit system, but the BS runs a 16-bit MBL8088-2 processor at 8 MHz, plus an MBL68B09E video coprocessor, comes with 256K-byte standard RAM (expandable to 1 megabyte), 192K-byte standard video RAM, and two 5¼-inch double-sided, high-density, double-track floppies with a megabyte *each*, and a standard Japanese-character ROM for 3400+ characters. A mouse is optional. The system includes a parallel printer port and one serial port. Fujitsu has announced availability of an optional 20-megabyte hard disk.

The FM-11 BS, like the Sharp machine, is supplied with CP/M-86. It's bundled with a Japanese-language word processor called JWORD, along with FBASIC-86. MS-DOS is an announced option. The advertised list price is about $1775.

C Across the Sea

Most implementations of the C language under CP/M-80 offer I/O (input/output) redirection to permit a program to receive input and send output either to the console or, by means of a command-line parameter supplied when the program is invoked, to or from a file. The C program in listing 1 is a useful addition to CP/M that emulates the CP/M directory command DIR. Used in conjunction with pipes, also not difficult to simulate under CP/M using C, this program permits considerable flexibility in obtaining sorted or otherwise organized directories either at the console or in the form of CP/M files; the same technique illustrated in the program also can be used within other application programs to obtain easy and convenient access to a disk directory.

When the listing is compiled and assembled to produce CDIR.COM, entering CDIR (or variants such as CDIR *.COM or CDIR WS*.* using wild-card characters) produces a list of the current files on either the default or designated disk drive, one name per line. On the other hand, entering CDIR >DFILE redirects the directory listing to a file named DFILE, available for subsequent processing. The program in listing 1 produces a list of only the files under the current user number, although you can easily modify it to bypass this restriction. Also, the filenames that are out-

(continued)

Listing 1: A *program in* C *that emulates the CP/M directory command* DIR.

```
/* cdir.c – Output a CP/M file directory. Syntax as in the DIR command. */
#include tprintf.c
main(argc, argv)
int argc; char *argv[];
{       char arg[15], fcb[36], *names[255], *p, *q;
        int i, j, astflg;
        char *lookup(), *unpack();
        if (argc == 1) strcpy(arg, "*.*");
                /* all files unless there is a command line argument */
        else
                {if (badname(argv[1])) exit(); /* check for file name error */
                 for (p = argv[1], q = arg; *p; p++, q++) *q = *p;
                 *q = '\0'; /* arg contains cmd line argument */
                 if (*--q == ':') strcat(arg, "*.*"); /* handle B: as B:*.* */
                }
        makfcb(arg, fcb); /* set up a CP/M file control block */
        astflg = 0;
        for (i = 1; i <=8; i++) /* expand * in file name to ?s */
                {if (fcb[i] == '*') astflg = 1;
                 if (astflg == 1) fcb[i] = '?';
                }
        astflg = 0;
        for (i = 9; i <= 11; i++) /* expand * in extension to ?s */
                {if (fcb[i] == '*') astflg = 1;
                 if (astflg == 1) fcb[i] = '?';
                }
        j = 0;
        while ( (p = lookup(fcb)) != 0) names[j++] = unpack(p);
            /* get matching directory entries and put the
               j-th name in the char array names[j] */
        while (j--) printf("%s\n", names[j]); /* output all names found */
}
char *lookup(file) /* find next directory entry matching the file control
                      block pointed to by the argument */
char *file;
{       static int i, bdosfn = 17; /* function 17 = look for 1st match */
        bdos(26, 0x80); /* set DMA address to default buffer */
        if ( (i = bdos(bdosfn, file)) == -1) return 0; /* no match */
        bdosfn = 18; /* function 18 = look for subsequent matching entries */
        return (i*32 + 0x81); /* location of matching directory entry */
}
char *unpack(pdir) /* unpack the directory entry at pdir and return a
                      pointer to the name of the file */
char *pdir;
{       char *pname, *p; int i;
        p = pname = sbrk(15); /* get space in which to put file name */
        for (i = 1; i <=12; i++)
                { if (i == 9) *p++ = '.';
                  if ( (*p = *pdir++ & '\177') != ' ') p++;
                }   /* skip blanks and zap high bits to 0 */
        *p = '\0';
        return pname;
}
badname(arg) /* return 1 if arg string is a bad filename, 0 otherwise */
char *arg;
{       return (strlen(arg) > 15 ? 1 : 0);} /* check total length only */
#include stdlib.c
```

This culture is leapfrogging from doing ordinary business correspondence by hand to a situation in which word processing will be the rule.

put are not prefixed with the name of the drive on which they reside; that too can be changed easily.

Most of the main routine is occupied with (very limited) parsing of the command line and with expanding * wild cards to sequences of ? characters. The **makfcb(arg, fcb)** function is supplied as a library routine with The Software Toolworks C/80 compiler; it creates a CP/M file control block corresponding to the filename pointed to by **arg**. The **lookup(file)** function calls the required CP/M BDOS (basic disk operating system) service routines in order to return a pointer to the next directory entry (if any) that matches the specified file. The argument to **lookup** is a pointer to a file-control block. Finally, **unpack(pdir)** uses the standard dynamic-memory allocation function **sbrk( )** to obtain space for the filename, then extracts the filename from the directory entry pointed to by **pdir**, its argument.

One feature of C illustrated by the **lookup( )** function is the use of the internal static variable **bdosfn** and its initialization. When called the first time, **lookup** must use BDOS function number 17 to look for the *first* matching filename but subsequently must use function number 18 to continue the directory search from where it left off the last time. Declaring **bdosfn** to be a static integer enables the **lookup** function to "remember" not to repeat the search from the beginning of the directory, because static variables retain their values between function calls while still keeping **bdosfn** "private" (local) to the **lookup( )** function.

AHEAD

My next column will contain a full report on the annual Tokyo Microcomputer Show held at the end of May. ■

Circuit-Board-Design Without the Tedium

smARTWORK™ lets the design engineer create and revise printed-circuit-board artwork on the IBM Personal Computer.

Forget tape. Forget ruling. Forget waiting for a technician, draftsman, or the CAD department to get to your project. smARTWORK™ software turns your IBM Personal Computer into a professional, high-quality drafting tool. It gives you complete control over your circuit-board artwork — from start to finish.

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- ☐ Complete interactive control over placement and routing
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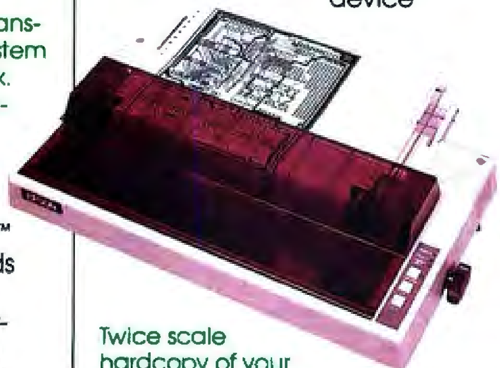

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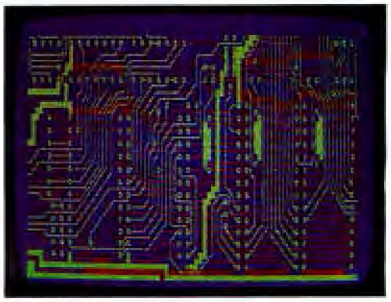

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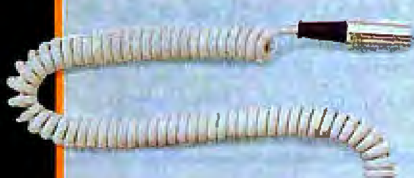

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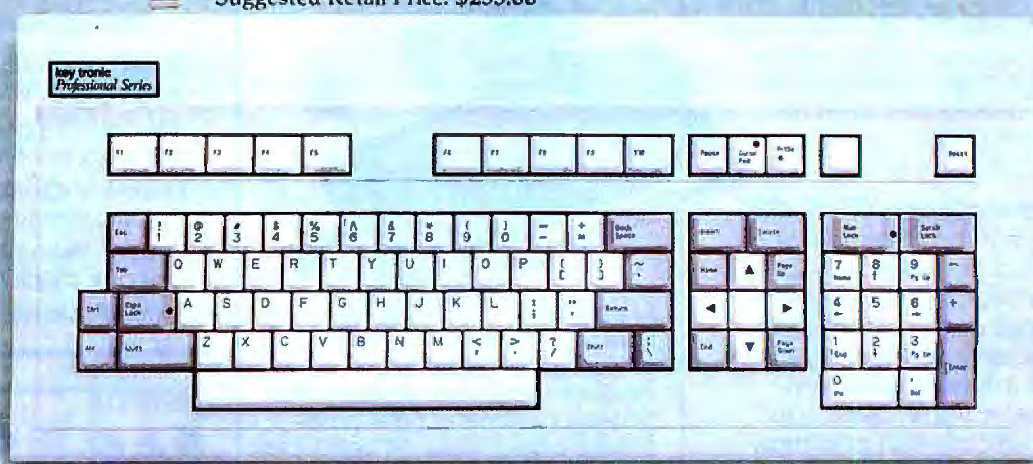

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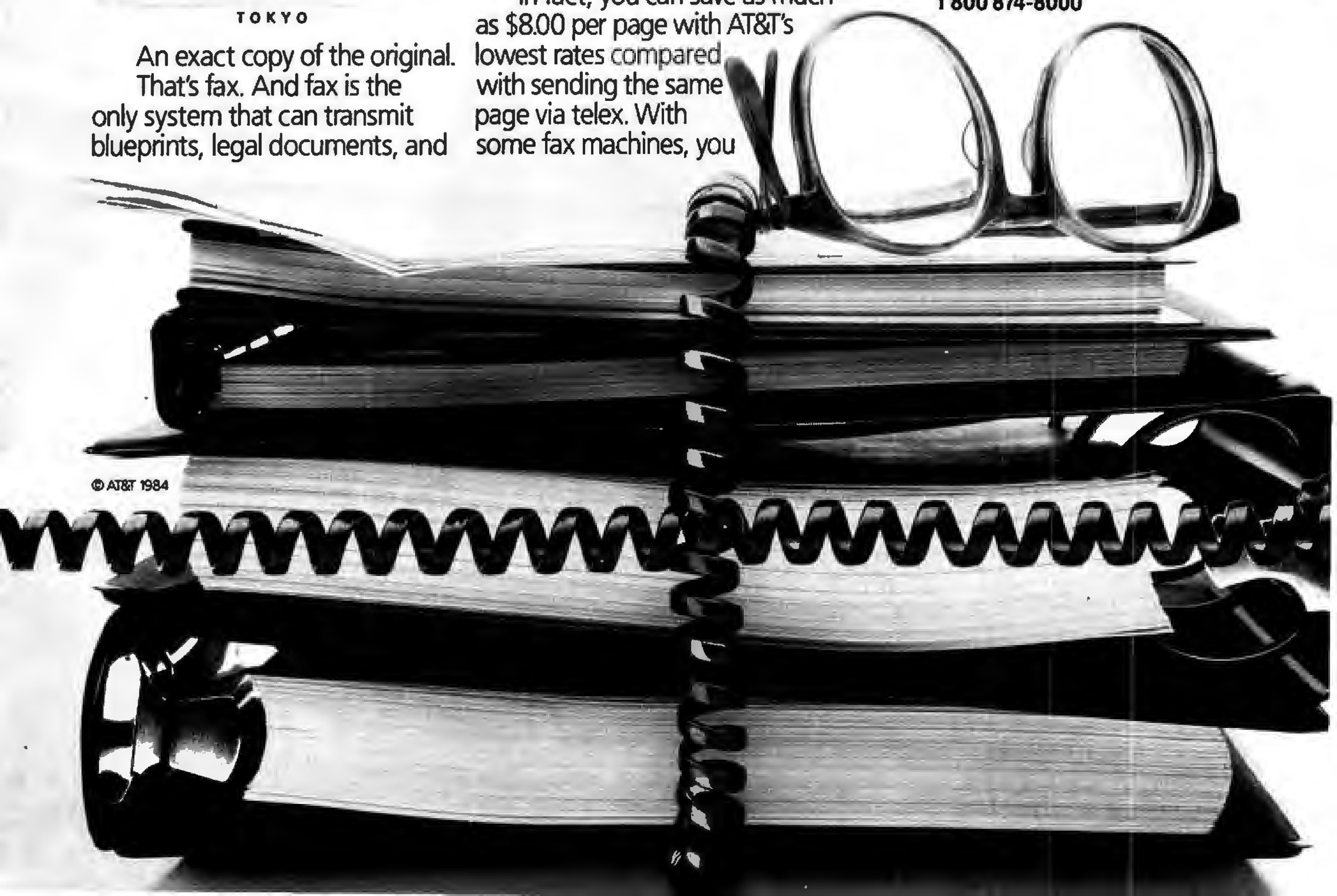

Macintosh's Other Designers

Three original designers discuss the earliest days

BY JOHN MARKOFF AND EZRA SHAPIRO

The Apple Macintosh computer has attracted so much attention that it's curious so little has appeared on the formative days of the development project. To set the record straight, BYTE *West Coast Editors John Markoff and Ezra Shapiro interviewed three of the original members of the Macintosh design team: Jef Raskin, Bud Tribble, and Brian Howard. (The fourth member was hardware designer Burrell Smith.) Two of the three left Apple before the Macintosh was introduced: Tribble switched to a new career in medicine, and Raskin started his own company, Information Appliance Inc., in Palo Alto, California. However, their recollections of the development effort provide an interesting perspective on the Macintosh as a product.*

BYTE: *We thought we could start by asking each of you to introduce yourselves and to tell about your role in the Macintosh project.*

HOWARD: I'm Brian Howard, and I joined the Macintosh project almost in its infancy to help out with documentation and publications for it. Since it turned out that there wasn't much to write about in the early days, I started to help Burrell Smith build all the original prototypes and to document the hardware, and I more or less stayed on in the hardware vein.

TRIBBLE: My name is Bud Tribble or Guy Tribble, depending on what city you know me in. I knew people at Apple for a long time, Jef [Raskin] before Apple, and Bill Atkinson down at UCSD. I heard from Jef that he was working on a new project at Apple; specifically, he was starting up a research section at Apple, and that he had some interesting ideas for making a computer that was different from what had been on the market previously. Since I was interested, I came down and talked to him. He showed me a big notebook that was the *Macintosh Document*, which had been worked on by Brian and Jef.

BYTE: *What year was it?*

TRIBBLE: I think it was 1980.

RASKIN: Sounds about right. We already had the *Book of Macintosh* at that time—400 pages.

TRIBBLE: And it was an extensive description of a cheap, user-friendly machine that went beyond what was the state of the art then (the Apple II) in terms of a personal computer. I got so excited that I told the program I was in at school—a fairly prolonged M.D. program with a Ph.D. in neurophysiology—that I wanted to take a year off, or maybe more. Finally they let me take the year off with the option of going back.

When I got here Jef's group was made up of Jef, Brian, myself, and Burrell Smith. I think Joanna [Hoffman] joined just after I did.

Burrell had already mocked up a Macintosh computer. It consisted of a 6809 processor, 64K bytes of memory, and a screen linked to an Apple II, and you could download programs into it. Jef had written down his extensive ideas about what it should look like in the end and some ideas about user interface. My first order of business was to just get this thing to be able to assemble and cross-assemble on the Apple II, to get a basic BIOS or operating system up on the machine, and also to worry about other kinds of things—whether it should have a modem, include serial interfaces, and what kind of mass-storage device it should have.

I was very impressed with the amount of work already done, before even having a machine, in deciding on a philosophy for the machine. I was also impressed with the caliber of that core group, especially Burrell.

BYTE: *Who put the* Book of Macintosh *together?*

RASKIN: I think I wrote almost all of it. Macintosh started out as my dream of what a personal computer might be. I was already thinking about it at UC San Diego back in the early seventies when I developed the "flow language," a language that was so simple that it had no error messages at all; it was impossible for a user to make a syntactic or semantic mistake. Students loved learning programming on it. Working on that and other projects had taught me that one could do things more simply than had been done and that computers had a long way to go before they were pleasant to use.

(continued)

Ezra Shapiro (McGraw-Hill, 425 Battery St., San Francisco, CA 94111) is BYTE*'s West Coast bureau chief. John Markoff (1000 Elwell Court, Palo Alto, CA 94303) is a* BYTE *senior technical editor.*

What I wanted with Macintosh was a low price. I wanted it to be all in one piece with no connecting cables, a minimum number of parts, and a minimum number of interconnects so that it would be highly reliable. Brian and I built many cardboard models and did dozens of drawings. So if the fact that it's two pieces is one of the great success factors, it's certainly not from something that I can take any credit for. I also wanted it to have a monochromatic screen that could be bit-mapped, rather than a character generator.

As a matter of fact, when I started working at Apple, the Lisa was a character-generator machine and I was the only voice saying it should be bit-mapped, and I convinced the crew working on it. I guess I was also this disembodied voice that changed it from a three-button mouse to a one-button mouse at Apple—that was a big fight.

Macintosh was started very close to the time Lisa was. Two totally separate tracks.

BYTE: *Two separate philosophies?*

HOWARD: Actually, I think Lisa had been worked on in some form for almost a year.

RASKIN: But it was a very different machine then.

HOWARD: It was going to be a bit-slice piece of hardware. They were going to do a Pascal p-machine chip set.

TRIBBLE: Since Jef was on the initial user-interface committee for Lisa, he was putting in his ideas, and at the same time he was managing the initial Macintosh project.

RASKIN: One thing I strongly believed was that Lisa was much too large and expensive a machine for a company of Apple's style and type. Lisa was definitely headed toward the business market, and I thought that it was a severe mistake to make a machine that would, in price and capability, compete head-on with Wang, DEC, IBM, and DG.

BYTE: *As a researcher, did you have an input into those marketing questions?*

RASKIN: I never hesitated to speak my mind.

HOWARD: Also, "researcher" was partly a title that was created to explain that there wasn't a production item related to his ideas.

BYTE: *Let's take a popular myth and tell me to what degree it's wrong. The myth is that Lisa*

Photo 1: *Brian Howard*

and Macintosh technology come in some sort of straight line from inside the corporate sanctum of Xerox PARC [Palo Alto Research Center].

RASKIN: Yes and no. I always thought that Babbage and Turing and Van Neumann hadn't gone quite far enough in generalizing the idea of a computer. I remember clearly enunciated—sort of the Turing principle—that memory could hold anything. A symbol is a symbol and you can interpret it in different ways. But then at PARC they had cleverly gone on to generalizing the screen. Any point is the same way as any other point. Characters just happen to be one kind of picture we can generate. The keyboard is the same way.

One of my first thoughts was that Macintosh should be the most absolutely general machine that you could conceive at that price, so that you could do anything on it you could do with any machine with that amount of hardware.

I tried for over a year to get Steve Jobs to see what they were doing at PARC because I felt that they were at least seven years ahead of their time. They had the Altos going then, with bit-mapped keyboards and screens. You could do anything you wanted on them. They also had the mouse on it. Although I couldn't stand the mouse, I was the only person at Apple who had even seen one, and certainly the only person who had ever used one. Finally Steve Jobs, Bill Atkinson, and a few others went to Xerox PARC and came back enthused.

BYTE: *What's the other side? In what sense is Macintosh a departure from what was being done and thought of at PARC?*

RASKIN: Theirs was all based on Smalltalk and had a different model of what the user interface would look like. I thought they had a lot of good ideas.

The difference between Apple and PARC is that Apple was designing things to be sold in large quantities and PARC designs things to play with. While they weren't concerned with questions of production, I very much was.

BYTE: *Why did you initially settle on the 6809 microprocessor?*

RASKIN: It's a very pleasant microprocessor. It seemed like it would be available in great abundance. It's much, much cleaner, and it doesn't segment memory into 256K-byte parcels.

TRIBBLE: Bill Atkinson was heavily involved with developing QuickDraw and working on the Lisa project. While I was working on the 6809, writing software to run on a bit-mapped screen, he was developing this neat bit-blit software to do characters and graphics on the Lisa screen on the 68000.

I realized that in terms of the cost of the machine, the microprocessor is a small percentage; it didn't make sense to limit ourselves to the 6809, and if we could use the 68000, we [also] could take advantage of a large portion of the software that was out for Lisa. I was thinking of lower-level things like the QuickDraw software. This represented a major investment; I didn't want to do it over again for the 6809.

I also figured out that the project simply could not be done fast enough on a 6809. I got together with Burrell Smith and said, "Can you hook up a machine with only 64K bytes of memory," which is what the Macintosh was supposed to have then, "and run with the 68000?" That was kind of a trick because 64K bytes done on a 64K-bit chip is only 8 bits wide and the data bus on the 68000 is 16 bits wide. It required multiplexing and demultiplexing, while at the same time trying to keep chip counts to a minimum. Burrell Smith came up with a design that did all the timing and did the multiplexing and demultiplexing in a minimalist type of way.

Burrell did nonstop wire wrapping, and I wrote programs on the Apple II to emulate the timing that Burrell was

(continued)

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programming into the programmable-array logic chips. And at the end of four days, we had a board with the 68000, 64K bytes of memory, and a bit-mapped screen and keyboard up and running the QuickDraw software. At that point we went to Steve [Jobs] with the working model, and he said, "Okay. Let's do it this way."
RASKIN: I was against the 68000 at first because I wanted a low-priced machine and the 68000 would bump up the cost. Burrell and Bud convinced me that the 68000 was the way to go, especially because of the software. It was clear that we could never catch up on the work that Bill had done.
BYTE: *What's the history of the Mac mouse?*
RASKIN: Jobs gets a hundred percent credit for insisting that a mouse be on the Mac.
HOWARD: When we chose the 68000, we did it partly so that we could use the low-level graphics routines and so on. Then the question starting coming up whether we also wanted to make use of the user interface as defined for the Lisa or maybe some parts of it. At some point, if you take enough of it, then the mouse has to come with it because that's definitely designed into the user interface in the Lisa.
RASKIN: I wasn't too antagonistic toward using the Lisa user interface since I had had a strong hand in that. It had many of the features that I wanted.

To give a little history, I had a conversation with Mike Markulla long before this about wanting to make a low-priced machine. A concept called "Annie" was developing then, and he said, "Can you design a machine to sell for $500?" I came back a week later and said, "Not one that would really be functional, but I can design one to be sold for $1000." I didn't like the names Annie or Lisa—that is a sexist kind of approach—so I proposed that Apple name projects after varieties of apples, and I called mine Macintosh.
HOWARD: Sort of a fruitist attitude.
RASKIN: Steve Jobs had named the company Apple so you get started off on a fruit image. There was a Pippin for a while and some other internal apple names.

After Steve Jobs got stronger on the project, he kept edging it toward a more expensive machine. That was the main


Photo 2: *Bud Tribble*

reason I didn't want the 68000, because there was no way I could have met the charter of a $1000 machine. It's my opinion to this day that if we had built such a machine it would have been dynamite because no one was even thinking in that price range with that kind of capability.

I happen to enjoy the 68000 far better than the 6809. It's a nice processor to work with. And they're both nicer than the ancient 6502. But as we started making those changes, the price started escalating very rapidly.
TRIBBLE: It was a domino effect. After the 68000, we started talking about putting on a mass-storage device that would be more commensurate with that—a more expensive disk drive.
BYTE: *You originally had started with a 5¼-inch drive.*
TRIBBLE: Before that there was going to be a small tape drive and that drove the price up. The screen went from a 256- by 256-pixel screen up to an intermediate screen and finally to where it is now. The memory started out at 64K bytes, but all of a sudden we got QuickDraw, which was 20K bytes, and all this Lisa software and extra pieces lying around. So the ROM [read-only memory] went from 4K bytes to 64K bytes in steps. And the price of the machine went up with that. The RAM [random-access read/write memory] went from 64K bytes to 128K bytes eventually. The keyboard became detached, which also drove up the price of the machine.

All of these things were edging the design, and the price, closer to Lisa. I think Jef was reacting against the danger of pricing the machine out of people's reach. I take some of the blame for going along with a lot of these changes because I was closely allied with Bill Atkinson, who was working on Lisa, and we thought along the same lines. The other thing is that I was, and still am, a technological junkie and like fancier bits in my computer. Not that I didn't have an appreciation for Jef's idea for a computer that people could afford.
BYTE: *Is that the central tension in the design process of Macintosh?*
HOWARD: That's a tension in any design in any project. Especially with a hardware group, there is always a tendency to use chips that are a little bit more on the leading edge of what's possible, to run things just a little bit faster, and to get a little bit more resolution out of the screen. Without strong direction from above, all projects have that tendency to float upward on the scale.

It's a little misleading now [to think that we thought] Macintosh could be sold profitably at $1000, but partly that's because it's taken about three years to get it out on the market. Three years ago, the price differential was much more astounding that it is now. Of course, the price of all those chips has dropped dramatically since we were working with them originally.
BYTE: *Is Burrell Smith as unusual a hardware designer as we have heard by reputation?*
RASKIN: I think he is very, very good. Bill Atkinson thought he had a great deal of talent. I talked to Burrell and decided he was as good a digital designer as I had ever met.
TRIBBLE: My orientation was more toward software. But I found it extremely easy to communicate with Burrell, and part of that was that the turnaround time with Burrell for trying out new hardware ideas was like the turnaround time I was used to for trying out new software. He would do it overnight. If I came up with an idea from the software standpoint and said to Burrell, "Wouldn't it be nice if we had this in the hardware?", he would come back the next day and say, "We can do that if you make this slight change in the software." In a very short time, we would get the whole thing going.

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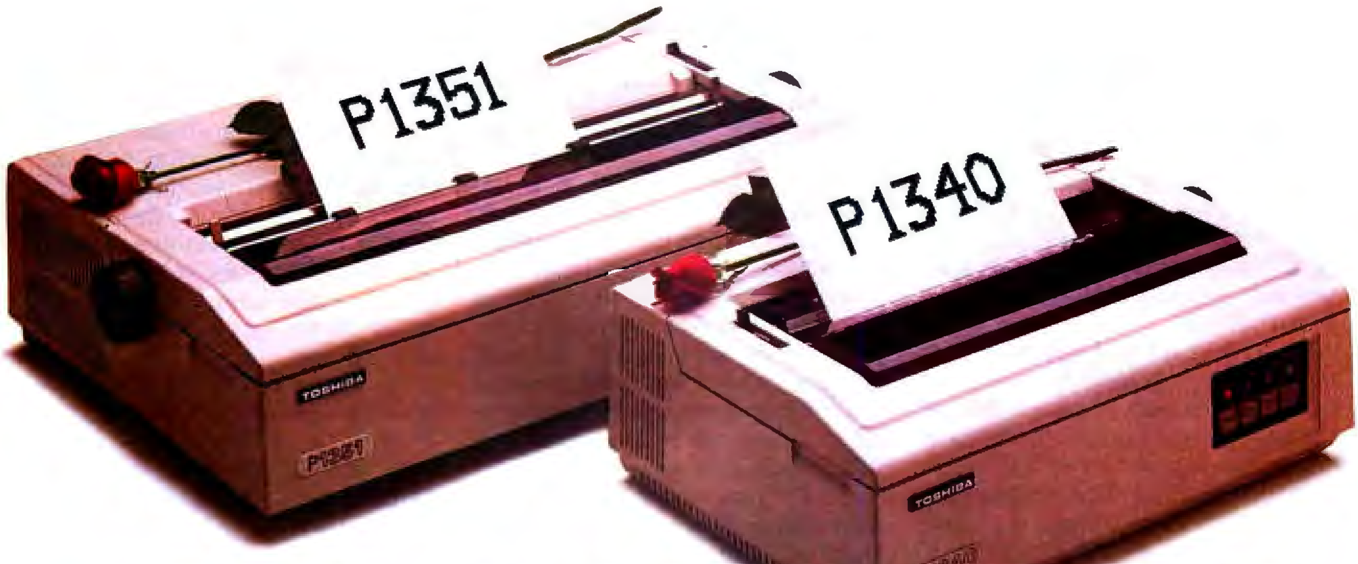

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RASKIN: That is one thing that I was pushing for very hard—the interaction of hardware and software. You don't build a hardware box just to suit some hardware engineer and then try to cram software into it. You design your hardware to support the software, you design the software to put the two together, and they grow together.
HOWARD: The constant interaction was one of the most fun things about the early Macintosh project in general. No decision was made by any one person and handed down to somebody else. The original Mac room was one big room—any discussion that took place involved everybody in the room. Even after we moved, constant group meetings coalesced everywhere. People would run in and help shape the idea.
RASKIN: I tried to keep the spirit of the group, and also my personal spirit, very playful. We were always playing music and frisbee, and shooting dart guns.
BYTE: *To what extent was Macintosh in the early days influenced by the Apple III experience?*
RASKIN: Tremendously—to get as far away from it as possible!
HOWARD: The team size was definitely reinforced by the Apple III. It was clear that a large team would tend to go off in the direction of writing mountainous amounts of code and things that were not well focused. That was part of our incentive for keeping the group small.
BYTE: *Back in the days of the* Book of Macintosh, *was Macintosh a closed system in the sense that the outside world wouldn't have easy access to the bus?*
RASKIN: No. I believed in having a bus brought out on an edge connector.
BYTE: *What happened?*
TRIBBLE: Rod Holt, who was involved with the analog design [and who was] doing the FCC certification on the Apple II, kept bringing up the point that if you bring out an 8-MHz, or whatever, bus to the outside world you're in trouble. I retrenched and said that what we needed were fingers to come out that could be used for testing purposes.
RASKIN: As a matter of fact, in the original Macintosh specification it was called the Bus Diagnostic Port. That was part of the original definition.
TRIBBLE: Then Rod said, "If we put in a knock-out plastic port, the FCC is going to say 'Obviously you are inviting people to knock that out, and we're not going to certify you.'" I think he was being a little paranoid.


Photo 3: *Jef Raskin*

It came to pass that there was no way to get into the Macintosh at bus speeds. But I went through Burrell's hardware manuals and found a serial chip that could run at 1 megahertz, which was the SCC chip. So I said to Burrell, "You've got to design this thing in." I think it's adequate. What I was worried about was not having enough bandwidth to talk to a hard disk or a network.
BYTE: *Do you think you've got it?*
TRIBBLE: I think we've got it. The bandwidth on most Winchester disks is a few megahertz. The bits come streaming out of the disk at a few megahertz, and with the SCC chip we can go in at close to 1 megahertz. We lose a small factor there, but most of the wait time on the hard disk is head motion anyway.
RASKIN: If you can get at the bus itself you have so much more control. I still think it was a mistake to not put those fingers there, even behind a hidden port.
HOWARD: Just putting in fingers doesn't come for free, though. As soon as you say it's okay for the outside world to start hanging junk on your high-frequency signals, you have to somehow isolate yourself from what they do—enough so that your machine will still work with things hanging out there. You have to take all that into account.
RASKIN: I still think you should put it on, call it a diagnostic, and use it for diagnosis. You take no responsibility because it's not a user part, but if some OEM wants to use your board or your machine and take that responsibility, that's okay. I didn't see it as something that a user would casually plug into.
TRIBBLE: I ended up leaning toward a more closed system because, as software manager, it became appealing to me to have every single one of the machines that were out there all exactly the same. If software ran on one machine, it would run on all the others. I didn't want a big proliferation of weird addresses on the bus so that if you access them with such and such hooked up it would do something funny.
BYTE: *The story of the IBM PC.*
RASKIN: The story of the Apple II.
BYTE: *One thing that surprised people, I think, when Mac was first introduced, was that it only had one disk drive.*
RASKIN: I know why there was [only] one originally. When I was there, the software was designed to work with one. But after you have the typical Lisa kind of software on it, it definitely needs more than one. Having first made the choice of putting that software in, certainly I would have put in two disk drives. It's not very convenient to use with just one.
BYTE: *Who came up with the idea of a detachable keyboard?*
RASKIN: I think Jobs.
BYTE: *What are your feelings about that?*
RASKIN: Once Macintosh grew to its present size, the separate keyboard was the only way to go.
BYTE: *Did it start out physically significantly smaller?*
TRIBBLE: Not very much smaller. The screen was a little bit smaller, but the whole box was a much lower profile.
RASKIN: But it was not like a Tandy Model 100. It did have a CRT [cathode-ray tube]. It was slightly smaller. It grew a great deal.
BYTE: *Have you seen any of the third-party software that's just beginning to emerge for Macintosh? We've seen some where we think the third-party developers have missed the point of the Mac.*
TRIBBLE: I think that's bound to happen, especially where you have so many people—a hundred companies are out there—writing software. It's a tremendous problem in communication. You have to reeducate all the people who write for CP/M, UNIX, and whatnot to write for a system that is completely different from anything they're used to.
HOWARD: It certainly takes a lot of

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TRIBBLE: Early on, designing the operating system, I decided to incorporate most of the user-interface routines and procedures almost into the operating system. It was partitioned off as something called the user-interface toolbox—a set of tools that you could use to conform to the Macintosh user interface.

RASKIN: The original design documents also said that the user interface is pretty much the operating system.

TRIBBLE: But further than that, we have a problem because it is harder to conform to that user-interface standard than it is to just treat the thing as a TTY [teletypewriter]. How were we going to get all these third-party software vendors to go along with us? The strategy was not to legislate by saying, "You must do this," but to legislate de facto by putting all those toolbox routines in ROM. Then anybody who doesn't use those routines is penalized because the 64K-byte ROM is sitting there with all these nice routines, and they're chewing up RAM with their own routines for their user interface. So it's a way of legislating a consistent user interface.

BYTE: *You started with 64K bytes and it was released with 128K bytes, and there is constant talk of a half-megabyte Mac. When did a half megabyte creep into the design philosophy?*

RASKIN: Very early on Burrell pointed out that it's very easy to make a design, once you had the 68000 in place, where you could just take out 64K-bit chips and put in 256K-bit chips. I've always believed that you just simply take the largest chip that is economically feasible to use in terms of the memory, and if they're bit-wide chips and you use 8 or 16 of them, then that should be the size of your memory. The size of memory, to be economical, should be the word length times the number of bits you have in a chip.

So it's clear that if you have 64K-bit RAMs and a 16-bit bus you get a 128K-byte machine that's really fast. Burrell loves designing for it, software people had no trouble handling that, and it's very clean. When the 256K-bit chips come you just plug in all those and everything runs just about the same.

BYTE: *What brought Jobs to the Macintosh project? Why did he get interested in it?*

HOWARD: One reason was that Apple had no new projects in that sort of low price range, and I think it was becoming obvious that at some point people were probably going to quit buying the Apple II and Apple better have some other, at least that low if not lower-priced, project in the works. And part of it is that I think he was being sort of edged out of the Lisa project. Or that he could see that it was going off in a direction, perhaps even with his blessing, that he wasn't happy being a part of and therefore it was time for him to move on to something else.

By then it was becoming clear that Mac was the most exciting thing going on at Apple. Jobs definitely loves to be in on new projects as they get going, and he's not very able to just sit back and watch that happen. [He's] a very forceful person [who] has to get in and exert his influence.

BYTE: *What happened between Raskin and Jobs as Jobs moved into the Macintosh project?*

TRIBBLE: When I went to work for Apple, I went specificially to work for Jef. And there is an incredible difference in philosophy between Jef and Steve. In my own mind I was initially more aligned with Jef's philosophy than Steve's. I have to admit that I became somewhat influenced by Steve as time went on. I also have a somewhat Machiavellian view toward the Macintosh project. By that time I was in love with it and wanted to see it happen, and here were these bad, political things happening, kind of above my head. What I saw as inevitable was that essentially the company had turned against Jef. Things were not getting done and were blocked here and there. It was upsetting. I almost decided to go back to Seattle right when Steve was taking over. But I made a decision that if Steve takes over the Macintosh project, then we'll have resources of the company available to us, and we won't be blocked here and there. At least we'll be able to get something done. That turned out to be partly true. But the flip side of that was that Steve is good at lots of things but not at being a boss on a one-to-one level.

BYTE: (to Raskin) *When did you leave the Mac project?*

RASKIN: I was sort of forced out. Like someone squeezing on a toothpaste tube. I resigned in February of 1982. It was gratifying that Markulla and Jobs did not accept my letter of resignation. While I disagree with Jobs in lots of ways, the *Rolling Stone* article [S. Levy, "The Whiz Kids Meet Darth Vader," March 1, 1984, page 36] made it appear as though he summarily fired me, which is not at all true. He has not been in general a person who does that. He and Markulla asked me if I would please stay another month even if I didn't come in to work; they knew I was very unhappy there. At the end of that time they would make me an offer that I couldn't refuse.

They went back to the way it had started. They were going to set me up with a research division. This was the third or fourth or maybe the ninth or tenth—I don't remember how many—times I had been offered that and every time I had done it, something came up. And they would say, "Oh, you've got to turn this into a product; you've got to come over and put out this fire or something."

They made me the same offer over again, and I think I had finally learned that there was little likelihood of it actually happening. So I left. . . .

BYTE: *Were any of you surprised at all by the*

(continued)

extent of the Mac hype? The scale?

HOWARD: That's something of Apple's. I guess you would call it extreme right from the start. I guess that is what has differentiated Apple from a lot of unsuccessful computer companies that have had products that were more or less comparable to Apple's—its marketing ability, its ability to really blow things up.

TRIBBLE: Apple was good at hype, for one thing. For another thing, we, the people involved in Macintosh, believed that there was something worth hyping.

HOWARD: It is a computer that you can get affectionate feelings about in a way.

RASKIN: I still think it has a lot of qualities that I wanted in it originally. Not exactly the same, many things have changed. But a lot of the feel has somehow managed to come through. I think the Mac is certainly the best of the personal computers of today.

TRIBBLE: The people who worked on Macintosh, especially that initial core group, were all emotionally involved in the machine. That is a lot of what made it turn out well.

The idea came up again and again from the early days, though, that the major problem of the Macintosh was going to be one of educating people about the machine. It's a new concept and you have to spend effort to teach people about it.

A person should be able to watch for five minutes and then sit down and do something useful. You shouldn't have to read a big manual.

Jef may not agree, but I feel that it's the mouse that allows you to do this. Because it's difficult to see what someone's fingers are doing on the keyboard when you're watching them manipulate a program, and it's very easy to see what they're doing with the mouse.

RASKIN: I don't disagree. Except I have my strong belief that that's not a convenient thing to do for very long. It's certainly great to play with MacPaint.

BYTE: *Where did the concept of the Mac division as pirates come from?*

HOWARD: It came because of an internal public relations effort to show people who were afraid that Macintosh was turning into this giant organization, like the Navy, with lots of forms, rules, regulations, guidelines, and procedures, that this was not the case—we invented the slogan of "pirates."

TRIBBLE: Well, there is the idea of Macintosh stealing from Lisa.

HOWARD: I don't think that was intentional—I think that was the way they took it. It certainly did not improve Macintosh's relations with the rest of the company—since that made the rest of the company the Navy by implication.

BYTE: *In the very first days, was it more or less unofficial? Was it all backdoor?*

TRIBBLE: It was not a product.

HOWARD: We were calling it research partly so that nobody would be upset that we were working on these ideas.

TRIBBLE: If it's not a product we can do whatever we want.

BYTE: *There were some resources committed toward your "blue-sky" research?*

HOWARD: It wasn't that many resources were being committed. There were some bodies. Four or five of us were in a room that Apple was renting. But that was about it.

BYTE: *Did you feel like you were a secret society, in a sense?*

HOWARD: Kind of.

TRIBBLE: We made no attempt to keep ourselves secret, though.

HOWARD: We did feel that we were going off in a different direction from the rest of Apple.

RASKIN: And nobody, especially Steve Jobs, believed that we could do anything useful. Maybe a few clever ideas may come out of this group but certainly not a product. They were not going to get a product out of Raskin, Tribble and Howard . . . people who play music.

BYTE: *Is Mac a product that can evolve well?*

HOWARD: In a sense that any computer can because you can write an infinite number of programs on it.

RASKIN: The Mac in particular is easier to write infinite numbers of programs on that most computers.

TRIBBLE: It's a generalist's computer. It's a bit-mapped screen with some memory and a processor.

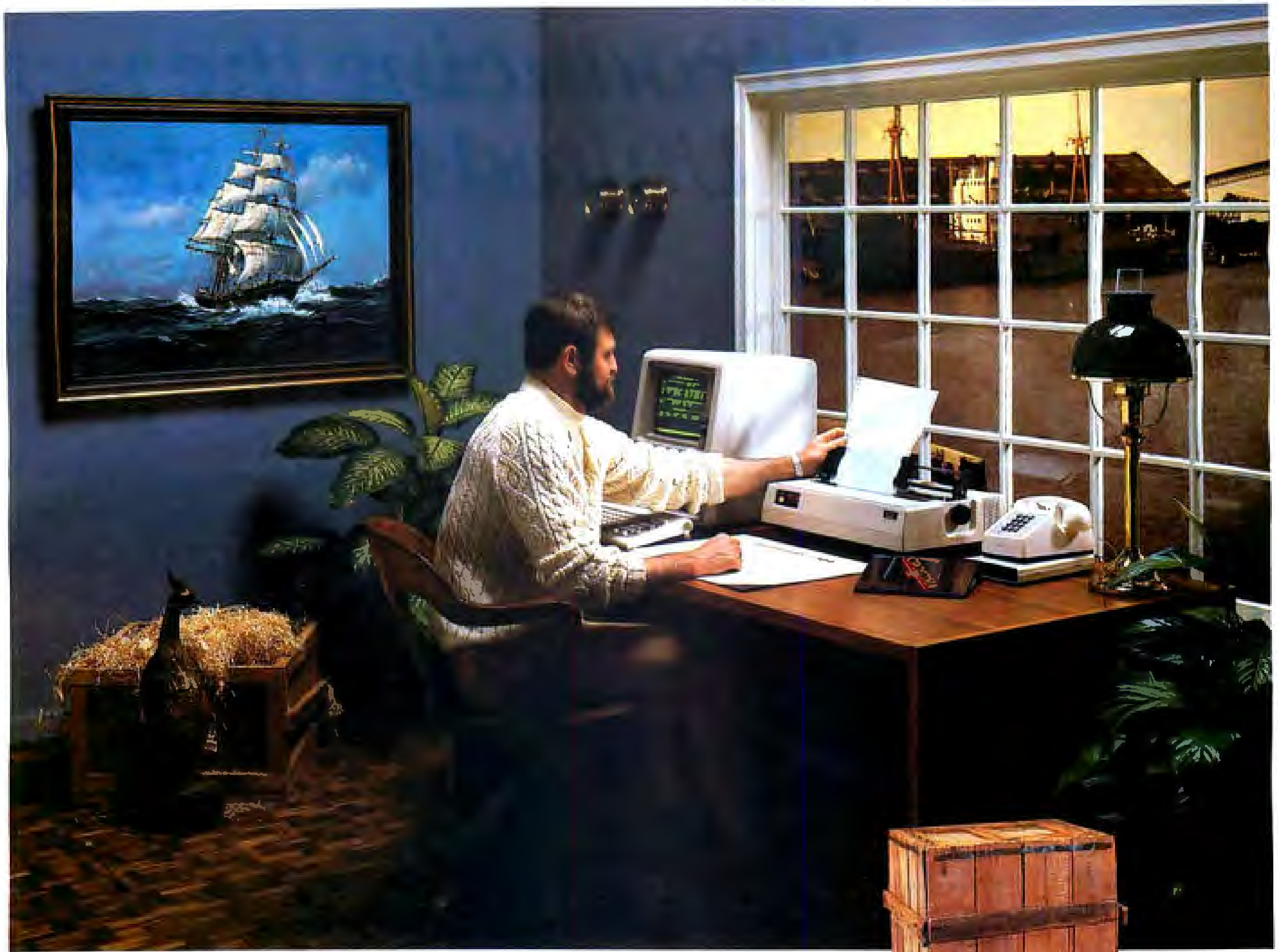
HOWARD: With some limitations, you can hook almost any piece of hardware to it through high-speed serial ports. And people will go on plugging all kinds of weird things in it.

BYTE: *Could Mac be done again in 1984?*

HOWARD: I think it could, but only by a similar process, a little group splintering off, working separate from the big group. I don't think it could be done on purpose, as Macintosh was not done on purpose.

RASKIN: From my point of view it was done on purpose, but from Apple's point of view it was an accident.

HOWARD: Actually Steve Jobs would support that kind of thing. That is the kind of thing that Jobs will go out on a limb for. ■



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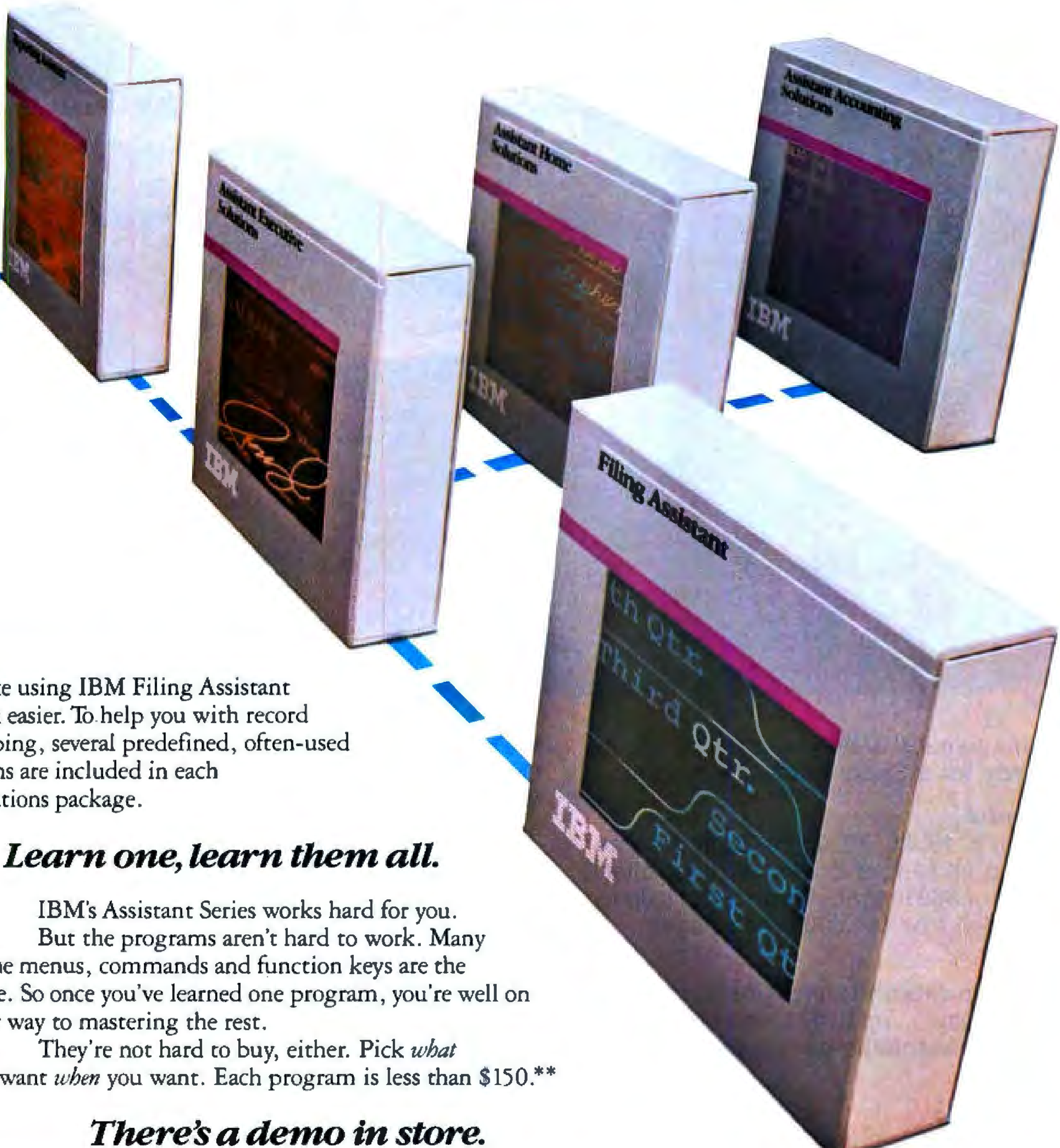

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B·Y·T·E U.K.

Microprocessor Design

The Transputer and its special language, Occam

BY DICK POUNTAIN

BYTE readers probably are not used to thinking of Britain as a source of major innovation in computer design. The cost-cutting miracles wrought by Sir Clive Sinclair are perhaps the only examples that have crossed the Atlantic, and even those computers had limited commercial success.

Nevertheless, there is a lot of innovative work going on in these depressed isles, and some of it is at the advanced end of processor design.

The most exciting work of this sort is taking place at INMOS, the transnational semiconductor enterprise set up in 1978 with part funding from the British government. INMOS has manufacturing facilities in Colorado Springs in the United States and at Newport in the United Kingdom. So far its product range has been confined to high-speed static and dynamic RAMs (random-access read/write memories) aimed at high-performance mainframe and minicomputer markets. However, at the U.K. design center in Bristol, a research program is about to bear fruit in the shape of a revolutionary VLSI (very-large-scale integration) microprocessor chip called the Transputer.

The Transputer is INMOS's contender in the struggle over the next generation of microprocessors. It is pitted against the likes of the NS 16032 and the Intel 80286. But the design philosophy that underlies it is very different from that of its competitors. It is intended to be a "programmable component," hence the name, which is an amalgam of transistor and computer. The Transputer is designed to communicate with other Transputers in parallel-processing networks so that as many of them as desired can be applied to a particular task with minimal overheads in processor time and physical interconnections. Even more important, the same program can be run on a single Transputer or a network of communicating devices.

This sort of system design, using many processors working simultaneously on the same data, is widely recognized as an essential step in building the so-called "fifth generation" of computers. Fifth-generation systems will have to search huge databases if they are to perform natural-language processing and other "intelligent" activities. VLSI guru Carver Mead has suggested that "an additional four orders of magnitude of computational capability are available through concurrent processing." Connecting conventional microprocessors together to perform parallel processing is a tedious chore, complicated by the need for (ever wider) parallel buses to be securely shared and by terrifying problems of synchronization.

The Transputer avoids these problems by communicating over high-speed serial links (running at 1.5 megabytes per second, full duplex), and by having the necessary synchronization built into its instruction set.

Engineering samples of a 32-bit Transputer (designated the IMS T424) are expected in the last quarter of 1984. This chip will have four high-speed serial links, 4K bytes of ultrahigh-speed RAM, an external memory interface, and a peripheral interface on the silicon slice. Other processors planned for this family may have fewer serial links and varying amounts of on-chip RAM.

The T424 is a reduced-instruction-set computer (RISC). It has only 64 instructions, and they are designed to render the processing of concurrent tasks as efficient as possible. INMOS achieves this by using a stack-based architecture in which the 4K bytes of on-chip RAM serve in place of the registers of a conventional microprocessor. Different concurrent tasks have their own workspace among these registers, and switching tasks is merely a matter of switching a pointer to the workspace. The processor contains its own logic to schedule these tasks. A clever choice of instruction format, whereby instructions can be built up in 4-bit chunks, allows 16- or even 64-bit designs to be added to the range and to have compatible code. Virtual memory operation has been rejected in favor of a uniform address space—a T424 can directly address up to 4 gigabytes of external RAM.

(continued)

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The Transputer's various hardware modules run concurrently. The fact that the serial links, memory interface, and processor can all operate simultaneously makes communication inexpensive. Off-chip communication between Transputers is asynchronous so they don't have to share a common clock signal, and delays in the point-to-point connecting lines can be tolerated within broad limits.

INMOS is confident that the Transputer will be capable of running at 10 MIPS (million instructions per second) with a modest 5-MHz clock—two orders of magnitude faster than current microcomputers. This will be accomplished by using 2-micron CMOS (complementary metal-oxide semiconductor) technology with silicide interconnect and a reduced instruction set with 1-byte instructions, and by having the various components of the chip all working in parallel.

Occam's Razor

Full exploitation of the Transputer's potential for concurrency requires a new programming language. Some existing languages such as Concurrent Pascal, Ada, Modula-2, FORTH, and Simula can be used to write parallel programs, but in all of these a programmer has to arrange for synchronization of parallel processes that want to "talk" to each other (usually by setting special flags called semaphores to signal that a result is ready). This makes great demands on a programmer's mental picture of the program's execution in real time.

INMOS designed a new language called Occam to program the Transputer. In fact, the Transputer and Occam were designed concurrently, so the Transputer will directly execute Occam programs. Occam is the Transputer's assembly language. It's also a general-purpose programming language that can be run on conventional processors by time-shared simulated concurrency.

Occam was developed by David May of INMOS and Professor C. A. Hoare (perhaps Britain's leading computer scientist) of Oxford. The name of the language comes from William of Occam, the 14th-century Oxford philosopher whose principle: "Entia non sunt multiplicanda praeter necessitatem" ("Keep it simple, dummy!"), is better known as Occam's razor.

With only 22 reserved words, Occam is a small and elegant language. It combines the best of contemporary thought about control structures and variable scoping with some radical new structures to handle concurrency. It can be used as a general calculus to describe concurrent activities in any field, much as pseudo-Pascal is often used to describe sequential algorithms.

Occam is based on a model of computation that is different from conventional languages in that it includes the notions of communication, parallel execution, and synchronization in its very structure. I/O (input/output) and interrupts are handled at high level and are transparent to the programmer. Occam is designed for system programming. It has only integer arithmetic and no built-in support for file and string handling or graphics, although floating-point and multiple-precision arithmetic are planned as future enhancements.

The basic unit of Occam programming is a "process" that performs a sequence of actions and then terminates. This is similar to ordinary programming languages, but in Occam there may be more than one process executing at any given moment. There are three primitive processes: input, output, and assignment. All other processes are constructed from these building blocks. The input and output processes transfer a word (32-bit in the latest version) from a "channel" to or from a variable. For example,

```
tube ! x
```

outputs the value of variable *x* to a channel called "tube," while

```
tube ? y
```

inputs the value into variable *y*. Channels, like variables, must be declared at the beginning of the process in which they are used. Physically they might be implemented as serial communications links between different Transputers or as memory locations that let independent processes inside the same Transputer exchange data—to Occam it doesn't matter. Channels are one-way (you can't input and output from one within the same process) and self-synchronizing, so that communication only occurs when both the input and output processes are ready. Some channels, such as "keyboard" and "screen," may be predeclared by the system.

The Assignment process merely changes the value of a variable as in Pascal or BASIC:

```
x: = y + 10
```

The simplest type of compound process is the kind called SEQ (for sequential). In the following program fragment:

```
VAR x:
SEQ
  keyboard ? x
  screen ! x
```

the input and output processes are executed one after the other as in any ordinary programming language. The indentation is not optional; it marks the extent of a subprocess. A two-character indent is required for each level of nesting (equivalent to begin...end). The only separator required (other than indentation) is a colon that indicates the end of a declaration. Incidentally, the preceding program merely allows you to type a single character on the screen. Processes can be given names (like procedures) so you could say

```
PROC echo =
VAR x:
SEQ
  keyboard ? x
  screen ! x:
  (— rest of program)
```

Note the colon at the end as we are declaring a process.

Two novel kinds of compound processes are PAR (parallel) and ALT (alternative). PAR indicates that the subprocesses that follow it (on paper) will be executed concurrently. If these processes have to communicate with each other via a channel, then whichever is ready first will automatically wait for the other to become ready. Synchronization is built into Occam and programmers need not worry about it. For example,

```
CHAN signal:
PAR
  VAR x:
  SEQ
    keyboard ? x
    signal ! x
  VAR y:
  SEQ
    signal ? y
    screen ! y
```

(continued)

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The two sequential subprocesses run at the same time. The first waits for an input from the keyboard, the second waits for a "signal" message on the channel. When a key is pressed, the first process can terminate, allowing the second one to do so. The net result is the same as in our first example but the character has been passed between two processes on its way to the screen. Note that all variables are local to a single process (so I could, unwisely, have declared *x* for both) and they are deallocated (cease to exist) when it terminates. The order in which the processes are written on paper is irrelevant in a PAR construct; each waits until its input or output is ready.

The ALT construct provides a novel and elegant way of choosing between parallel processes in the time dimension. It sits and watches a group of input channels and then executes the process attached to whichever one delivers an input first. If two or more inputs occur simultaneously, then ALT chooses in a way that will be implementation dependent but which avoids any channel becoming permanently locked out. There is a provision called PRI ALT for allocating priorities to the processes. Here's a typical ALT:

```
CHAN signal:
VAR y:
ALT
  keyboard ? y
    SEQ
      screen ! y
  signal ? ANY
    SEQ
      (—do something interesting)
```

As part of a larger program this will either type a character on the screen or "do something interesting," depending on whether "signal" becomes ready before you press a key. The key word ANY throws away the input value instead of storing it—the input is then merely a signal to do what comes next. Each input process in an ALT construct can also have a logical condition (called a guard) in front of it. The process can then execute only if it's the first to receive input *and* the guard is true.

More conventional selection is done with IF, although it requires no THEN or ELSE. Instead, IF is followed by a series of one or more conditions and it executes the process associated with the first one that is true (on paper this time), so it also functions as a CASE statement:

```
IF
  x=1
  output1 ! x
x=2
  output2 ! x
```

Loops can be programmed using WHILE <condition> . . . . but a far more powerful kind of repetition using the less-conventional "replicator" is available, which allows any of the previously mentioned compound processes to be cloned a stated number of times. For instance, PAR i = [0 FOR n] creates an array of *n* parallel processes whose components can be accessed by the value of the index *i*. When used with SEQ, the replicator produces an iteration equivalent to a FOR . . . NEXT loop, while ALT i = [0 for n] chooses from an array of *n* channels.

Occam's other features include the provision of arrays of variables or channels that can be passed as parameters (of unspecified size) to processes. Named constants and tables of constants (including string literals) can be defined, and string handling is done with byte arrays, as in C or FORTH.

TIME, a special input channel, caters to real-time programming; it is always ready and returns the current time from the system clock. When used with AFTER, it causes a process to wait until a given absolute time:

```
TIME ? AFTER t
```

This use of absolute times rather than relative delays simplifies the programming of device controllers because a programmer doesn't need to worry about how much time the actual control actions take. Many of the operations that are the stock-in-trade of communications engineers can be expressed in a single Occam process. For instance, a set of channels can be multiplexed with a replicated ALT, or a pipeline of filters could be set up using a replicated PAR. A sample Occam program is shown in listing 1.

Occam has an advantage over conventional languages for concurrent programming in that a program can be developed on a single processor and then run unaltered on any number of Trans-

(continued)

Listing 1: *This short program illustrates many of Occam's features. It's a simple editor that allows text to typed on the screen. However, in the background is a "time-bomb" that inserts the word "WHAM!" into the text at regular real-time intervals.*

```
PROC bang (CHAN send) =                   – PRINT STRING
  DEF bang.word = "WHAM!" :               – set up string as a byte vector
  SEQ i = [1 FOR bang.word[BYTE 0]] – first byte contains count
    send ! bang.word[i] :                  – output string to channel

PROC bomb(CHAN ready) =                   – BACKGROUND PROCESS
  DEF time.fuse = 1000 :                  – a constant
  VAR count:
  WHILE TRUE                              – an endless loop
    SEQ
      count := 0
      WHILE count < time.fuse             – a delay loop
        SEQ
          count := count+1
      ready ! 'a' :                       – send an 'a' as ready signal :
                                          – (any value would do)

CHAN scare:                               – MIN PROGRAM BODY
PAR
  bomb(scare)                             – runs continually in background
  VAR char:
  WHILE TRUE
    ALT                                   – either echo a char or WHAM!
      keyboard ? char                     – receive char from keyboard
        SEQ
          SCREEN ! char                   – echo to screen
      scare ? ANY                         – throw away the 'a'
        SEQ
          bang(screen)                    – put WHAM! on screen
```

The integrated "smart" editor understands the syntax of Occam.

puters sharing parallel processes for faster execution. This requires use of a construct called the PLACED PAR, which specifies a destination processor. The decision about how many processors to use can be left until the last minute and made on cost/efficiency grounds without affecting the program design.

Because the Transputer is not yet available, INMOS decided to produce a demonstration Occam compiler so programmers could get some experience with it now. The Occam Evaluation Kit has been on sale for about a year now and it runs under the UCSD p-System on various personal computers including the Apple II, IBM PC, and the Victor 9000. This kit implements all the major aspects of the language except for PLACED PARs, but it has only two channels to the outside world—the predefined "keyboard" and "screen." It is highly suitable for learning the language, but rather slow in compiling and execution because concurrency is only simulated on the single processor by time-slicing (p-code is not fast anyway).

INMOS currently is putting the final touches on the production compiler, which is written in Occam and will run first on the DEC (Digital Equipment Corporation) VAX, compiling to native code. It should be available to developers by the time you read this. To write the compiler in Occam, a "tiny" Occam that left out ALT and some other constructs was written; it is used to bootstrap the full compiler. The compiler is written in modular fashion, so that code generators for the Motorola 68000, Intel iAPX series, and the Transputer itself can be bolted on later. (INMOS has a Transputer emulator running on the VAXes at Bristol.) The compiler also uses concurrency with the lexer, parser, scoper, and generator passes running in pipelined fashion and communicating via channels. When Transputers are available, INMOS will use several in a development workstation to achieve compile times at least five times better than possible on an equivalent sequential machine.

The compiler has an integrated "smart" editor that understands the syntax of Occam. For example, it handles all the indentation automatically. Rather than taking the fashionable mouse-and-icon route, the design team chose to follow a less popular path: it used a "folding" editor similar to that developed in Cornell University's Program Synthesizer. The folding editor is a full-screen text editor with the facility for any process body to be folded out of sight (like an accordion) at a single keystroke, so all that appears on the screen is a dotted line bearing the name of the process. Another keystroke unfolds the procedure and reveals its code.

Folds can be nested to any depth so an entire program (with all its subprocesses neatly folded away) can be displayed on a single screen. While not as pretty as overlapping windows, this technique has the advantage of being able to work on the humblest of text-only serial terminals—it doesn't require an ultrahigh-resolution bit-mapped screen. In the final product these folds will work under a FORTH-like virtual-memory system so that when you unfold a process, its source code will be automatically retrieved from disk if it isn't already in memory.

A CHECK command performs a syntax check on the current fold using the cursor to pinpoint the site of the error, so a program should be completely free of syntax errors by the time it's really compiled. The aim is to create a programming environment that is almost as interactive as a good BASIC interpreter.

On a multi-Transputer system, recompilation should be so fast that library routines can be kept in source form and combined in the editor. For other host systems, it's likely that separate compilation (as in C or Modula-2) will be included, with the fold as the compilation unit. However, linking machine-code modules is possible through the host machine's operating system so that users who are programming processors other than the Transputer can write drivers for the serial ports that implement Occam's external channels.

Though the language itself is small, the requirements of compiling parallel processes make the compiler fairly greedy; it occupies around 78K bytes of RAM and around 90,000 words of workspace on a VAX. Ongoing optimization work is aimed at reducing these requirements, and, by the time the compiler is released (late summer target date), 68000-based systems like the Sage IV with 256K bytes of RAM should support it comfortably.

Cray on a Desk?

If all goes as planned, the Transputer and Occam promise to have dramatic effects on computer design. Initial interest is coming, predictably, from designers with a vested interest in communications. The first commercial applications probably will be in the areas of digital-signal processing, process control, and telecommunications. At London's Imperial College, a team working on a parallel supercomputer to run fifth-generation functional languages has chose Transputers as the processing elements, largely because of their fast I/O.

A network of Transputers could be indispensable in a wire-guided aircraft-control system in which each airframe subsystem could possess its own intelligence and the whole system could reconfigure itself under software control in the event of failure.

Performance projections of a two-dimensional array of Transputers in computing discrete Fourier transforms were published by INMOS at Westcon 83; these projections promise supercomputer power without custom-hardware expense. Similar arrays (or trees) of Transputers can be used for ultrafast database searches.

The Transputer also promises great things for personal computer design. The family of Transputer chips will include an intelligent disk controller (IMS M212) and a graphics controller (IMS G213) that will draw at 4 megabits per second. Both chips can act as parallel processors in addition to their specialized functions. A workstation containing these two controllers and one or more 32-bit Transputers would make a formidable CAD/CAM (computer-aided design/computer-aided manufacturing) system in a single box. The sort of advanced user interfaces presaged by Xerox's Alto and Apple's Lisa and Macintosh would barely tax the capabilities of such a machine, to which more processing power could be added as necessary in the form of multi-Transputer boards. ■


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C BASIC Compiler	√	√	√	√	√
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(continued from page 123)

an outline; an outline need not be used for frame organization. When an outline is a structural device, symbols that represent one of the various sorts of data frames appear alongside each item.

Building Relationships

Fred, a macro programming language that takes as its starting point the formula macros found in many spreadsheets, is close to the heart of Framework. Though the drop-down menus control major operations and the outline generator oversees structure, it is Fred that provides the tools for sophisticated maneuvers with frames and the data they contain.

At its simplest level, Fred provides a wide-ranging assortment of commands for manipulating data within spreadsheet and database cells; Fred is used to build computation formulas. Fred also contains a large selection of commands for formatting and displaying data and chaining frames for output.

At a more sophisticated level, Fred is capable of interpreting variables whose names are created from the names and titles of units of data within the overall structure. This facility enables you to link things: one spreadsheet to another spreadsheet, a spreadsheet cell to a selection of database cells, or a database to a graphics chart.

Just as frames can be inserted almost anywhere in the structure, so too can Fred macros be attached to individual chunks of data, frames, frame labels, and the master outline. Everything in Framework revolves around the frame concept; a formula for a single spreadsheet cell can be blown out to a full frame of Fred programming.

Finally, Fred can be used to create extensions of itself that can be stored as frames. Frequently repeated operations or complicated procedures can be reduced to one-word Fred macros.

Word Processing

The Framework word processor is used in much the same fashion as its database, spreadsheet, and graphics programs. You enter a Framework editing frame either directly from the desktop by creating an empty word frame from the Create menu at the top of the display, or in a more structured manner by building from an element in an outline frame.

Word-processing style in Framework is tied closely to outline frames. While it is possible to work with documents as long as 32,000 characters, Framework encourages a writing practice that involves beginning a proposal, report, or article by creating a preliminary list of frame titles in an empty outline frame. In practice, this means that full-length documents are composed of shorter blocks of text linked together and displayed as a seamless whole on output. This may necessitate a period of adjustment for people who don't write from a working outline. Obviously, outline-based writing requires a more organized approach, a process that some are more comfortable with than others.

The editor itself is relatively simple to master. Once inside a particular frame, the cursor appears as a bright rectangle overlaid by a flashing inverse-video cursor. To move the cur-

(continued)

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sor, you use the cursor keypad in conjunction with the control key. The cursor-pad arrows by themselves move the cursor a character or a line at a time in any direction. With the control key depressed, they move either a word left or right or a sentence backward or forward. The popular WordStar control-key sequences are not supported by Framework; however, the capability of the Fred language to make keyboard macros should simplify redefining the command set.

Cursor control also offers the capability to move a full screen either forward or backward within a frame and to move instantly to the beginning or the end of a document. Because Framework keeps all the information you are working with in RAM (limited, of course, by the available memory of your system), text-editing operations take place very quickly; moving from the beginning to the end of a large document occurs virtually immediately.

Framework uses three of the function keys on the left side of the keyboard to move and copy text either within or between frames (it also is possible to move or copy entire frames from within an outline frame). Pressing the F6 function key marks a text selection, F7 moves the block, and F8 copies it to a new location as indicated by current cursor position.

The outline frame acts as an on-line table of contents, enabling you to scan quickly your "chapters" (smaller text fragments) while working within a document. It also lets you print a finished table-of-contents page with chapter numbers and corresponding page numbers for each separate frame.

On a monochrome monitor, Framework's word processor does not produce true what-you-see-is-what-you-get output. However, given the restrictions of a character-based display, the program goes a long way toward permitting control over the appearance of text. On-screen formatting functions are accessed through a menu item at the top of the desktop called Words. You can select this menu at any time either by holding down a control key and the W key or, on the IBM PC keyboard, by using the Insert key in conjunction with the cursor keys. The Words menu lets you set a text block as normal, boldface, underlined, or italicized. Because the character-mapped display does not accurately display all of these fonts, Framework shows boldface text as highlighted on the screen. Both underlined and italicized text are shown as underlined. On a color monitor, boldface, italicized, and underlined text are all visible.

To change the display of any block of text, you first select it by using the function keys to the left of the keyboard. Then you choose a new option from the Words menu. The Words menu also contains four text-alignment commands and separate commands for setting margins, paragraph indentation, and tab spacing. You can align text as flush left, flush right, justified, and centered.

In order to reformat all the paragraphs in a word frame, you first must move out of the individual frame to the frame-label level by pressing the gray + or − keys on the right-hand side of the PC's numeric keypad and then issue the command to change the format parameters.

You can implement fancier printed output by using a special set of verbs from the Fred programming language. Language elements are put together in a formula, or program, for a

(continued)

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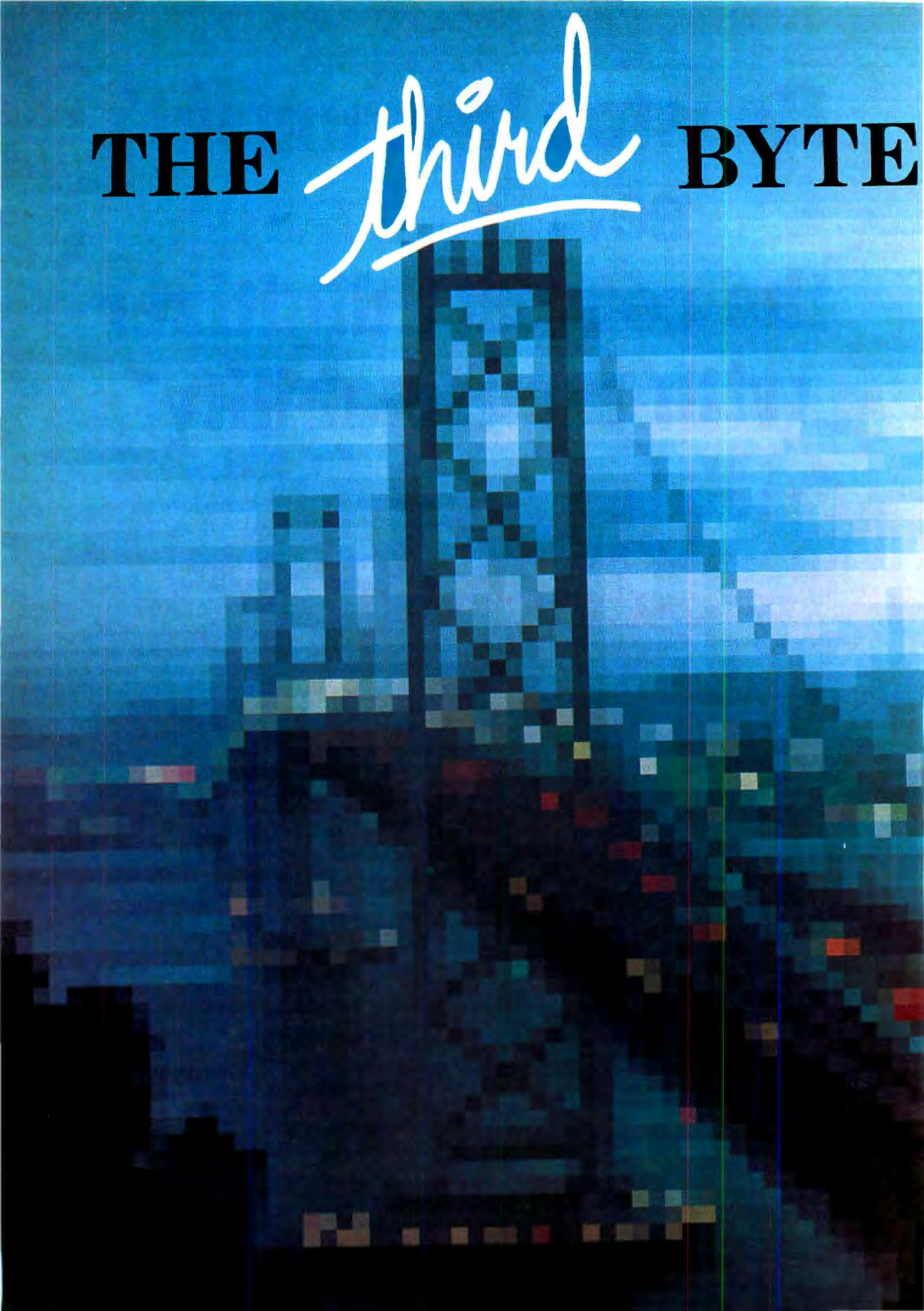


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frame. As the language is generalized throughout Framework, you can apply it to a frame whether it is a database, spreadsheet, or word frame, and frames of different types can be output as a continuous report.

The Fred printing verbs control the formatting of the final document and enable you to set margins, line spacing, headers, footers, and so on. They are essential text-oriented formula functions that are established while at the level of the frame label. These verbs affect only the printing of frame information; they do not affect the way a document appears on the screen. To insert a printing formula, you press the F2 Edit Formula key and enter the printing verbs you need to produce the desired effect. Like other verbs in the Fred language, each printing verb begins with the @ symbol and is separated from others by commas. Because frames can be nested, formatting verbs attached to the highest level of a document affect the printing of every frame the document contains. Verbs in an individual frame border supersede those at the document level, but only for the specific frame with which they're associated.

The Framework editor or independent utility programs can read WordStar or ASCII (American National Standard Code for Information Interchange) files prepared with other word-processing programs into Framework frames. Documents longer than the 32,000-character frame limit are split into succeeding frames; the initial frame is titled with the original filename, and subsequent frames are untitled.

Database Management

The Framework database manager is based on a relational database model. It is not designed as a "heavy-duty" database, in the sense of Ashton-Tate's dBASE II or III, to handle files of unlimited scope. In fact, designers at Forefront are careful to stress that the database is not meant to replace the dBASE series, both to avoid conflicts within the Ashton-Tate product line and because Framework databases are limited by RAM availability. Framework will be sold with special utilities that permit users to load in and filter either dBASE or ASCII data files; you can use Framework as a tool to view sections of large databases prepared with other programs and to incorporate that data into Framework reports.

The developers have made an effort to retain a common user interface throughout the various Framework applications, and the database manager is no exception. For example, you create a new database in Framework by opening an empty frame—the same way word-processing and spreadsheet frames are created. You select the Create menu and choose the number of columns (fields) and rows (records) your database will have. You then move to the Database menu to open a new database frame. The default number for records and fields is 14 each, but this can be changed from the Create menu at any time; however, because each Framework database file must reside entirely in memory, Forefront encourages users to start with database specifications that are limited to the current number of records. The number of records in the database can then be increased during later data-entry sessions.

What is the maximum number of records you can have in a given database? This depends largely on the total number

(continued)

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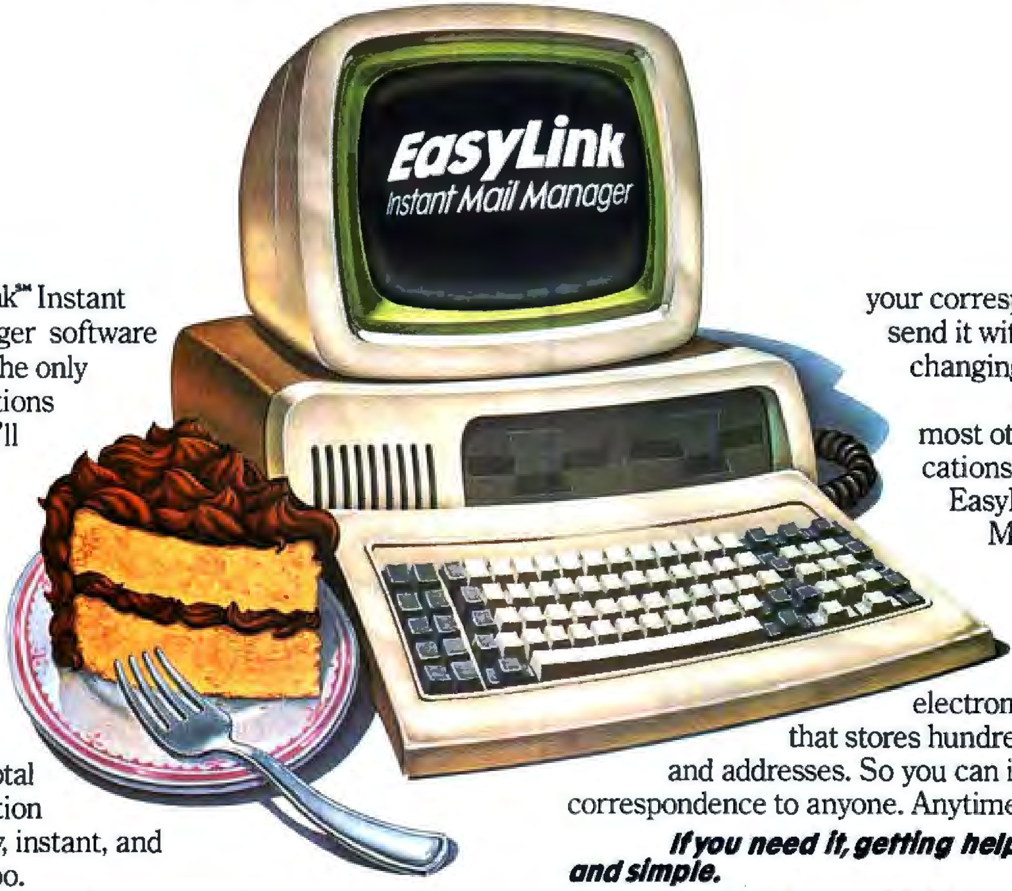

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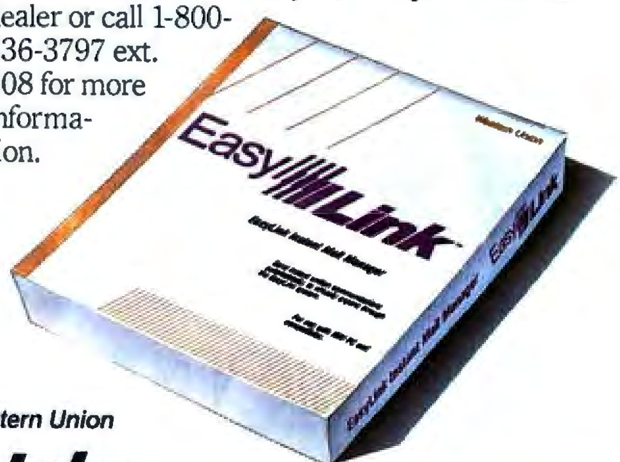

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of database fields you're using and the amount of memory available in your computer. Let's assume you have a database composed of 10 records of 10 characters each. According to Forefront, its tests indicate it will be possible to create a 2,000-record database (it is possible to get at least partially around this limit by writing macros using the Fred language). The benefits of keeping an entire database file in memory are obvious—Forefront claims that its database manager is capable of sorting 200 records per second.

An empty database frame is divided into two horizontal windows. The bottom window is the table area, in which you can enter data, and the top window is a row in which you enter field labels (and define formulas). When creating a new Framework database, your first step is to declare field names and adjust field widths. You create fields by typing in the labels that name them and then pressing the Tab or Return key. You adjust fields by selecting a field, pressing the F4 Size key, and resizing the field with the left or right arrow key on the keypad. If you need to add new fields after the database has been created, it is only necessary for you to highlight the field you want the new one to follow, select the Column Add key from the Create menu, and press the Insert key. Modifications to the structure of a database do not destroy data.

You navigate through a Framework database by using the cursor keys in conjunction with the control key. You can move to a field or record in any direction or jump to the first or last record of the database. Moving or copying information is possible either within a single database or between databases, word-processing frames, and spreadsheets. This procedure is exactly the same as it would be for copying or moving blocks of information elsewhere in Framework.

Although the default mode of the Framework database manager is a "table" view, you also can select a "forms" view by pressing the F10 View key. This lets you display each field in your database as a separate frame within the larger database frame. You also can set up customized display forms using the F3 Drag key to relocate individual fields.

To pull a particular record out of a Framework database, you use the Locate menu at the top of the screen. This menu enables you to search for a particular word, phrase, or value, as well as to perform sorts of a database. Sorts put records in ascending or descending alphabetical and numerical order. Multiple sorts require repeated sorts of individual fields.

Possibly the most intriguing feature of the Framework database manager is the capability of defining database macros using the Fred language. You also can use formulas within individual databases, as well as for automatic calculation of fields and the identification of records that meet particular criteria. Formulas can be entered in a field, at the label of a field, or at the top label of a database. At the field level, a formula is referred to as a local formula, and the formula is calculated only for that field in a particular record. At the field-label level, a formula operates on an entire column in a database. For example, to automatically calculate a 12 percent commission for each record, you could enter the following formula in the label window of a database frame:

```
@SET(COMMISSION, SALES * .12)
```

(continued)

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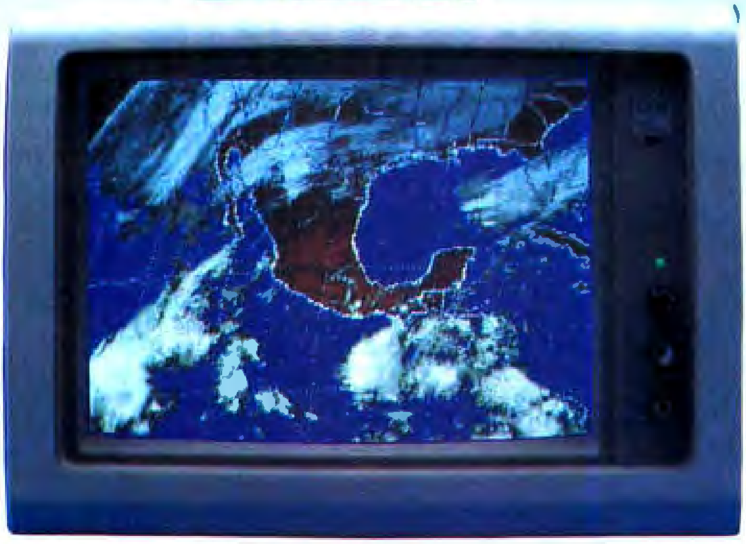

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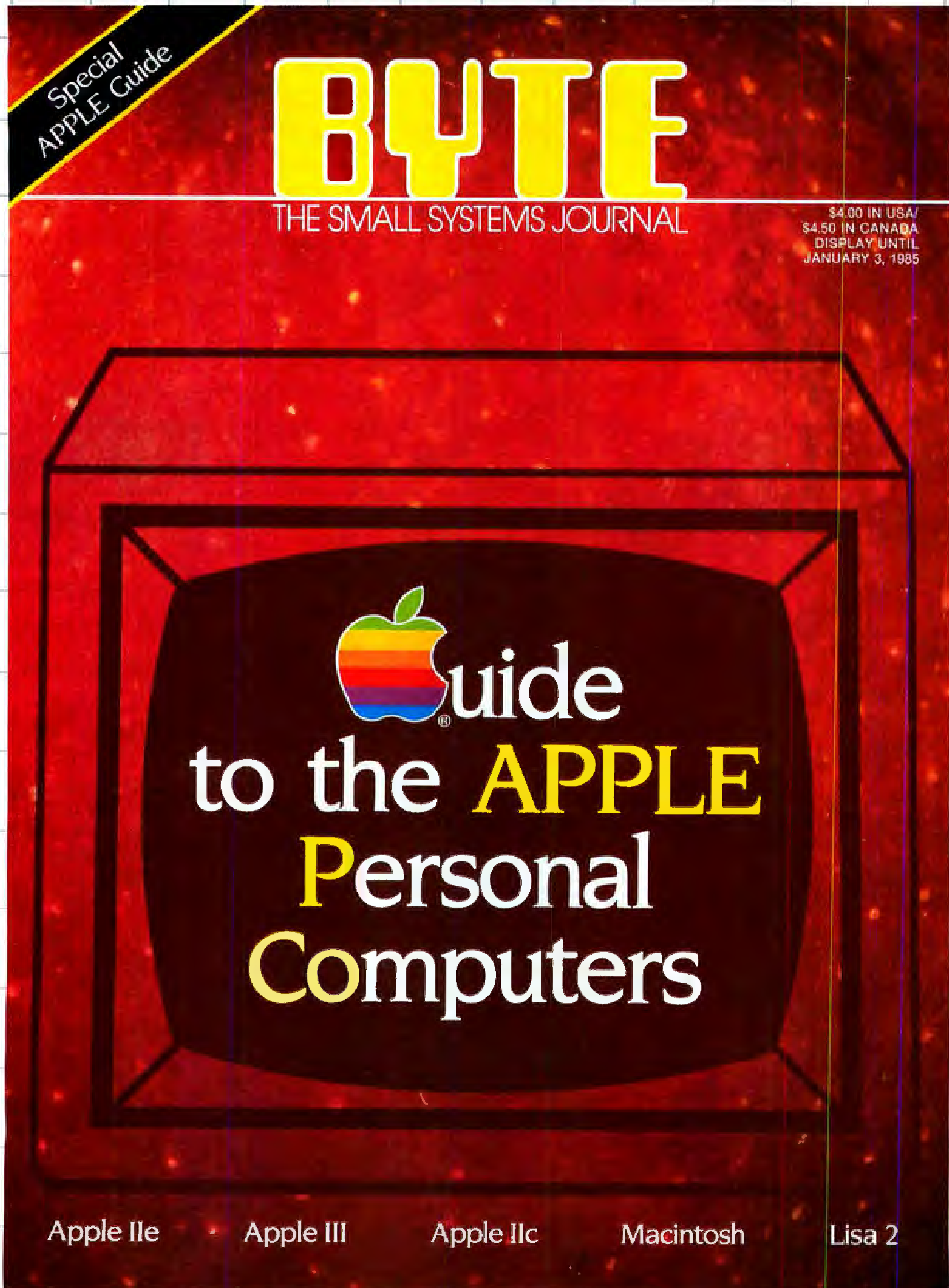

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Assuming that both Commission and Sales columns exist, this formula causes the appropriate commission amount to be automatically entered in every record. If this seems to be quite similar to the way in which formulas are used in spreadsheet operations, the coincidence is intentional.

Formulas entered at the level of the frame border of a particular database are called filter formulas. They cause the frame to hide all records that fail to meet a particular criterion; it is later possible to restore hidden records. You also can employ filter formulas to delete or move specific datasets from a database.

The Spreadsheet Environment

Within Framework, a full-featured spreadsheet environment is two keystrokes away. That's all it takes to create a spreadsheet frame that also can share data with database and graph frames and be positioned within an outline.

As with database frames, you initially determine the size of each spreadsheet by specifying the number of rows and columns desired. You can add or delete rows and columns freely as the model develops. Because spreadsheet size is dependent on available memory, this feature enables you to minimize the memory used by each spreadsheet.

Like other frames created within Framework, a spreadsheet frame can be labeled, stretched, moved, copied, saved, put away, included in an outline, zoomed to a full view, and otherwise manipulated on the desktop. You do this with the same function keys, special keys, and menus common to all frames on the desktop.

Once inside the spreadsheet frame, the same keys are again used to manipulate spreadsheet cells and data. For example, the Size function key used to stretch frames and database fields is used to dynamically stretch column widths to suit your needs. The Select function key used to highlight words and paragraphs for moving and copying in the word-processing environment is used to highlight ranges of spreadsheet cells for manipulation. The same menu items used to format text in the word processor can be used to create underlining, italics, and boldface within a spreadsheet. You can print spreadsheets using the common print option within the master set of menus. The sorting of whole or partial columns of data, and even the word-processing search-and-replace functions, operate within the spreadsheet environment. Search-and-replace also can be used to edit formulas.

You letter columns and number rows as in conventional spreadsheets. Formulas can be developed using these standard alphanumeric cell references or by using row and column labels. For example, say you were to place column headings in the topmost row of a spreadsheet as January through December and row headings in the leftmost column as Revenue, Expense, and Net. After entering revenue and expense figures for the various months, you could then reference January revenue in a formula as +January.Revenue. You even can use cursor pointing to construct formulas and have the row/column name references appear as you point to various cells.

You can tie spreadsheets to other spreadsheets or databases quite freely, eliminating the need to construct massive grids merely in order to link variables. The

(continued)

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Framework philosophy holds that giant spreadsheets are rarely used; most output fits onto 8½- by 11-inch sheets of paper and, by extension, can be held in a single frame.

Let's say you labeled the spreadsheet frame (in the preceding example) Income. The label you give to a spreadsheet frame serves as a pathway into that frame. If you were in another spreadsheet on the desktop and wanted to bring in the January revenue figure described above, you would simply enter the formula +Income.January.Revenue. To bring in the total of a column of figures in the Amount field of a database frame labeled Clients, you would enter the formula @SUM(Clients.Amount). It's that easy. You can even jump in and out of different frames while pointing to variables to construct your formula.

In the process of developing formulas, you can zoom the formula to full-screen size for a clear view. Comments can be placed in formulas using semicolons. If you were to begin a long formula and start to get confused, pressing the Zoom function key would give you a full-screen view of your formula, whereupon you could place comments within the formula and further develop it over several lines. A single formula, therefore, can be a rather sophisticated data-manipulation program—a very powerful feature.

Absolute and relative references are considered when formulas are copied. You denote an absolute reference by prefacing either the row number or column letter or both with a $. Using the # places the results of the computation of the formula into the cell and then removes the formula.

Framework spreadsheets are certainly not lacking in built-in functions. All of the standard functions (@ functions) available in the best spreadsheets on the market are present in Framework. Not only is there an Internal Rate of Return (@IRR) function, but a Modified Internal Rate of Return (@MIRR) as well. @MIRR uses a combination of safe and risk interest rates to more realistically calculate return when negative cash flows are involved.

Date and time functions include @TODAY and @DIFFDATE functions and a variety of date formats. Financial functions include future, present, and net present value in addition to return and loan amortization functions. All the logical Boolean operators are available, including error-checking functions. The full complement of standard arithmetic and trigonometric functions includes ceiling, floor, and random-number generation. Standard statistical functions are also included.

Strings can be freely used in formulas as long as you enclose them in double quotes. For example, you might want to say

```
@IF(January.Income > $80,000,
"Thank you very much", "More please")
```

You are not restricted to a specific small number of characters, and you can use spaces in the text string. A variety of built-in string functions also are provided for converting text to values and vice versa. You can concatenate values to other labels. Best of all, you can develop your own @ functions, which you can then freely use in formula development.

Once your own functions and templates have been implemented, you can serialize them with a special utility; this means that only the copy of Framework you used to produce them can be employed to examine or edit the formulas in them. Cells can be protected as with conventional spreadsheets. After protection, you can use a Blank command to remove all data from a template so you can store it empty for later use.

Macro command files can be developed within the spreadsheet environment to control complex procedures, and they can be loaded each time you wish to use them. These command files can be associated with single-letter mnemonics preceded by the Alt key; Alt-keystrokes then execute a whole series of commands, relieving you of having to enter them one at a time from the keyboard.

Business Graphics

Graphing data from a spreadsheet or database can take less time than rebooting your computer. The easiest way is to use the Select function key to highlight the range of data you want to graph. Then simply choose the Graph menu option and tell Framework to draw by pressing the Return key a couple of times. A graph frame is created automatically with your graph displayed inside. Scaling is calculated, and the column headings placed in Row 1 of your source are used as period labels. Of course, you can polish up the graph, but a quick-and-dirty preview is close at hand.

Once a graph has been derived from a particular spreadsheet or database and you want the graph to be recalculated as you edit your source data, simply enter the name of the graph frame in the lower right-hand corner of the source frame.

On the IBM PC's color monitor, Framework displays the desktop in black-and-white, high-resolution mode; when graphics frames appear scaled down on the desktop, they also appear in those two colors. If you zoom in to a full-screen display, however, you can view your graph in four colors. On monochrome monitors, the different colors are indicated with different textures and shading.

Putting It All Together

There's a lot to Framework, and the diversity of its capacity might make learning to operate it seem like a major undertaking. However, the common command structure and the similarity of procedures from one application to another should cut down on the learning curve significantly.

This is the first time that outline processing has been brought into integrated business software as a major organizing feature. It is unfamiliar and not necessarily suited to the working styles that the software marketplace has caused many users to adopt; in that sense, it marks a radical break with the past. Rather than letting you continue with old habits, outline processing may force you to think about your work in an entirely new way. This may mark a change as striking as the one brought about by the introduction of the first computerized spreadsheets.

Framework offers an important pathway into outline processing that may make the transition easier. The outline structure need not be called into play until it's required. Framework's application elements are strong enough standing alone to be used independently. You don't have to use the outlines to accomplish real work—you can sneak up on them bit by bit as you go about your tasks. When you're ready for the full power of outline processing, it's waiting for you. ■

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(continued from page 126)
is now "X." On the 6502 (and on the 65816 in its 6502 emulation), X indicates a BRK (Break) instruction. A software interrupt, it transfers control to the same routine as does the hardware interrupt, IRQ (masked by flag "I"). When not emulating a 6502, the 65816 adds a separate vector (see figure 2) that defines the software interrupt routine's location. This vector relieves the routine from having to determine which type of interrupt invoked it.

The new "M" flag, as well as X, is used when the 65816 is not emulating a 6502. They both determine whether operations treat the accumulator and index registers as 8- or 16-bit entities. The M flag, when set to "1," indicates that the accumulator is to be treated as an 8-bit register; when set to 0, the accumulator is 16 bits long. The X flag has the same effect on the index (X and Y) registers.

The added "E" flag determines whether the 65816 emulates a 6502 or acts as a 16-bit processor. Since the status register is defined as having only 8 bits, the E flag is conceptually an extension of the C flag. While E cannot be directly tested, set, or cleared, XCE (exchange C and E flags) permits swapping with the C flag, which can.

The additional 16-bit register, called the "direct register," determines placement of the "direct page" in bank zero. As on the 6502, one special page in memory is designated for the most frequently used or most time-critical portions of a program. Because the address within this page can be completely specified in a single byte, instructions can be shorter. This arrangement results in smaller programs, and, since the processor fetches one less byte per instruction, execution is faster. On the 6502, the direct page (also called "zero page") resides permanently at the beginning of memory; that is, the high-order byte of the address is 0. On the 65816, the direct page can appear anywhere in bank zero, even across normal page boundaries. This feature permits more flexibility in context switching and sharing of data between subroutines or coroutines. Also notable, if the low-order byte of the direct register (DL) is nonzero, the 65816 needs an extra cycle for every instruction that has any form of direct page addressing. The additional cycle is used to add DL to an offset. If DL is zero, the 65816 has special circuitry to skip that cycle. Except in special cases, therefore, the direct page should begin on a page boundary. The direct register can be accessed by transferring data to or from either the C accumulator or the stack.

The two new 8-bit bank registers give the 65816 its ability to access a full 16 megabytes of memory. As shown in figure 1, the program bank register (PBR) is an extension of the program counter. A program can read the register's contents only after pushing them onto the stack and then loading them into another processor register. PBR is modified by "long" forms of the jump and jump-to-subroutine instructions. Although its contents can be pushed onto the stack, PBR cannot be loaded except when it is also loading the program counter. If PBR were ever loaded independently, the next instruction after the one that loaded it would be fetched from the "following" location—but in a different bank. This unfamiliar instruction, in turn, would most likely lead the processor off into never-never land.

In some addressing modes, such as direct page addressing, the data bank registers explicitly specify the bank number. In any case, where the bank number is not laid down precisely, the data bank registers assign one. Strictly speaking, they are not extensions of the index registers, except in the sense that they help form those addresses that use the indexed addressing modes. The data bank registers are accessed through the stack and can be modified by the block move instructions described next.

New Instructions

In "The CMOS 6502" (December 1983 BYTE, page 443), I pointed out that the newer version added a number of instructions to those of the NMOS (negative-channel metal-oxide semiconductor) 6502. Those instructions filled gaps in the instruction set and rounded it out for the 6502.

The 65816 goes a step further by adding some nice-to-have instructions plus some others needed for the change to 16 bits and the addition of new registers. The op (operation) codes corresponding to hexadecimal codes 7x and Fx ("set and reset individual bits in page zero" and "branch if bit set or reset in page zero") are present only on the Rockwell version of the 65C02. Western Design Center, the designer of both the 65C02 and the 65816, does not specify them. On the 65816, Western reserves the 7x and Fx equivalents for "long" addressing modes of existing instructions. A description of the long addressing modes follows.

Figure 3 shows the complete instruction set of the 65816. The hexadecimal code for each op code is given by the digit at the left end of the row (most significant digit) and the digit at the top of the column (least significant digit). The op-code mnemonic is three capital letters, followed by the addressing mode in lowercase. The number at the lower left of each box gives the number of bytes for the op code plus its operand(s) (address or data). In the case of the immediate addressing mode with 16-bit data, one additional byte is required. The number in the lower right of each box gives the basic number of clock cycles required for the instruction.

Additional cycles are required for a variety of cases, since this figure is merely the number of cycles for executing that instruction in the fastest case. For example, add one cycle for instructions using the direct register for part of an address if DL is not zero; add a cycle for read or write operations using 16-bit data; add two cycles for read-modify-write instructions, such as shifts, using 16-bit data; add one cycle for branch instructions (including BRA) when the branch is taken, and another if the branch crosses page boundaries in the 6502 emulation mode; add one cycle for indexed addressing modes where the indexing causes a page boundary crossing; and add one cycle for REP or SEP (reset or set status register flags) instructions using the immediate addressing mode.

The NMOS 6502 allows several types of conditional program branches but does not include an unconditional form. Since this is the only type of position-independent program transfer on the 6502, some programs use a sequence such as SEC, BCS (set the carry flag, branch if carry set, respectively) to achieve an unconditional branch. The 65816 instruction BRA (branch relative always) fills this gap in the instruction

(continued)

Table 4. W65SC816 Microprocessor Op Code Matrix

MSD \ LSD	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
0	BRK s 2 8	ORA(d,x) 2 6	COP s 2*8	ORA sr 2*4	TSB d 2•5	ORA d 2 3	ASL d 2 5	ORA(dl) 2*6	PHP s 1 3	ORA imm 2 2	ASL acc 1 2	PHD s 1*4	TSB a 3•6	ORA a 3 4	ASL a 3 6	ORA al 4*5	0
1	BPL r 2 2	ORA(d),y 2 5	ORA (d) 2•5	ORA(sr),y 2*7	TRB d 2•5	ORA d,x 2 4	ASL d,x 2 6	ORA(dl),y 2*6	CLC imp 1 2	ORA a,y 3 4	INC acc 1•2	TCS imp 1*2	TRB a 3•6	ORA a,x 3 4	ASL a,x 3 7	ORA al,x 4*5	1
2	JSR a 3 6	AND(d,x) 2 6	JSL al 4*8	AND sr 2*4	BIT d 2 3	AND d 2 3	ROL d 2 5	AND(dl) 2*6	PLP s 1 4	AND imm 2 2	ROL acc 1 2	PLD s 1*5	BIT a 3 4	AND a 3 4	ROL a 3 6	AND al 4*5	2
3	BMI r 2 2	AND(d),y 2 5	AND(d) 2•5	AND(sr),y 2*7	BIT d,x 2•4	AND d,x 2 4	ROL d,x 2 6	AND(dl),y 2*6	SEC imp 1 2	AND a,y 3 4	DEC acc 1•2	TSC imp 1*2	BIT a,x 3•4	AND a,x 3 4	ROL a,x 3 7	AND al,x 4*5	3
4	RTI s 1 7	EOR(d,x) 2 6	WDM RESERVED*	EOR sr 2*4	MVP xyc 3*7	EOR d 2 3	LSR d 2 5	EOR(dl) 2*6	PHA s 1 3	EOR imm 2 2	LSR acc 1 2	PHK s 1*3	JMP a 3 3	EOR a 3 4	LSR a 3 6	EOR al 4*5	4
5	BVC r 2 2	EOR(d),y 2 5	EOR (d) 2•5	EOR(sr),y 2*7	MVN xyc 3*7	EOR d,x 2 4	LSR d,x 2 6	EOR(dl),y 2*6	CLI imp 1 2	EOR a,y 3 4	PHY s 1•3	TCD imp 1*2	JMP al 3*4	EOR a,x 3 4	LSR a,x 3 7	EOR al,x 4*5	5
6	RTS s 1 6	ADC(d,x) 2 6	PER s 3*6	ADC sr 2*4	STZ d 2•3	ADC d 2 3	ROR d 2 5	ADC(dl) 2*6	PLA s 1 4	ADC imm 2 2	ROR acc 1 2	RTL s 1*6	JMP (a) 3 5	ADC a 3 4	ROR a 3 6	ADC al 4*5	6
7	BVS r 2 2	ADC(d),y 2 5	ADC(d) 2•5	ADC(sr),y 2*7	STZ d,x 2•4	ADC d,x 2 4	ROR d,x 2 6	ADC(dl),y 2*6	SEI imp 1 2	ADC a,y 3 4	PLY s 1•4	TDC imp 1*2	JMP(a,x) 3•6	ADC a,x 3 4	ROR a,x 3 7	ADC al,x 4*5	7
8	BRA r 2•2	STA(d,x) 2 6	BRL rl 3*3	STA sr 2*4	STY d 2 3	STA d 2 3	STX d 2 3	STA(dl) 2*6	DEY imp 1 2	BIT imm 2•2	TXA imm 1 2	PHB s 1*3	STY a 3 4	STA a 3 4	STX a 3 6	STA al 4*5	8
9	BCC r 2 2	STA(d),y 2 6	STA (d) 2•5	STA(sr),y 2*7	STY d,x 2 4	STA d,x 2 4	STX d,y 2 4	STA(dl),y 2*6	TYA imp 1 2	STA a,y 3 5	TXS imp 1 2	TXY imp 1*2	STZ a 3•4	STA a,x 3 5	STZ a,x 3•5	STA al,x 4*5	9
A	LDY imm 2 2	LDA(d,x) 2 6	LDX imm 2 2	LDA sr 2*4	LDY d 2 3	LDA d 2 3	LDX d 2 3	LDA(dl) 2*6	TAY imp 1 2	LDA imm 2 2	TAX imp 1 2	PLB s 1*4	LDY a 3 4	LDA a 3 4	LDX a 3 4	LDA al 4*5	A
B	BCS r 2 2	LDA(d),y 2 5	LDA(d) 2•5	LDA(sr),y 2*7	LDY d,x 2 4	LDA d,x 2 4	LDX d,y 2 4	LDA(dl)y 2*6	CLV imp 1 2	LDA a,y 3 4	TSX imp 1 2	TYX imp 1*2	LDY a,x 3 4	LDA a,x 3 4	LDX a,y 3 4	LDA al,x 4*5	B
C	CPY imm 2 2	CMP(d,x) 2 6	REP imm 2*3	CMP sr 2*4	CPY d 2 3	CMP d 2 3	DEC d 2 5	CMP(dl) 2*6	INY imp 1 2	CMP imm 2 2	DEX imm 1 2	WAI imp 1*3	CPY a 3 4	CMP a 3 4	DEC a 3 6	CMP al 4*5	C
D	BNE r 2 2	CMP(d),y 2 5	CMP (d) 2•5	CMP(sr),y 2*7	PEI s 2*6	CMP d,x 2 4	DEC d,x 2 6	CMP(dl),y 2*6	CLD imp 1 2	CMP a,y 3 4	PHX s 1•3	STP imp 1*3	JML (a) 3*6	CMP a,x 3 4	DEC a,x 3 7	CMP al,x 4*5	D
E	CPX imm 2 2	SBC(d,x) 2 6	SEP imm 2*3	SBC sr 2*4	LPX d 2 3	SBC d 2 3	INC d 2 5	SBC(dl) 2 6	INX imp 1 2	SBC imm 2 2	NOP imp 1 2	XBA imp 1*3	CPX a 3 4	SBC a 3 4	INC a 3 6	SBC al 4*5	E
F	BEQ r 2 2	SBC(d),y 2 5	SBC (d) 2•5	SBC(sr),y 2*7	PEA s 3*5	SBC d,x 2 4	INC d,x 2 6	SBC(dl),y 2*6	SED imp 1 2	SBC a,y 3 4	PLX s 1•4	XCE imp 1*2	JSR(a,x) 3*6	SBC a,x 3 4	INC a,x 3 7	SBC al,x 4*5	F

* New W65SC816 Op Codes

• W65SC02 Op Codes

Figure 3: *The 65816's instruction set with hexadecimal equivalents, mnemonics, addressing-mode number of bytes for the op code and operand, and the basic number of clock cycles required for the instruction.*

set. Not only is BRA position independent, it requires 1 less byte than the alternative JMP (unconditional jump) instruction. It is limited to destinations within 126 bytes before and 129 bytes after the branch instruction, but this range is frequently wide enough for loops within a program.

Because the 6502 has a limited number of registers, the index registers are frequently turned to general-purpose uses. Since there are no instructions to directly transfer data between index registers and the stack or between each other, the accumulator sometimes is used to mediate transfers. The sequence PHA (push the A register on the stack), TXA (transfer the contents of the X register to A), PHA, TYA (transfer the contents of Y to A), PHA is common in subroutines that must preserve all processor registers for the calling routine. The sequence for restoring the registers is equally clumsy. Also, the data in the A register is destroyed, and it is tricky for the subroutine to recover this data from the stack without destroying data for the index registers. The 65816 adds the instructions PHX, PHY (push index registers to stack), PLX, PLY (pull index registers from stack), TXY, and TYX (transfer X to Y and Y to X, respectively). This sequence lets a subroutine save just those registers it needs to use and restore, or save them in a different sequence on the stack so that the data is available later in the correct sequence.

The 6502 has found applications both in general-purpose systems and in special applications, such as printer controllers. Most general-purpose applications don't often need the ability to set or reset specific bits of memory or input/output ports. Such dedicated applications as printer or appliance controllers, on the other hand, frequently rely heavily on this ability.

Multiple-processor systems need the

ability to set and clear semaphores to arbitrate the use of resources such as memory and peripherals. Furthermore, they must be able to do it in such a way as to change a bit and then have access to its previous state. The requirement is made even more demanding by the stipulation that no other processor can also get to the semaphore during such access. The TRB (test and reset bits) and TSB (test and set bits) instructions provide this capability. Bit 7 of the addressed memory location is copied to the C flag, and bit 6 is transferred to the V flag. TRB then computes the logical AND of the memory data and the inverse of the accumulator data, while TSB computes the logical OR of the memory data and the accumulator. Either instruction then stores the result back in the memory location and sets the Z flag to indicate whether or not the result was 0. The effect is to set or clear the bits corresponding to "1" bits in the accumulator, while loading the N and V flags with the previous state of bits 6 and 7 of memory. Two similar instructions, REP and SEP, use a byte of immediate data to determine which status register bits to change. Using immediate data is more economical than adding distinct instructions for controlling each such bit. There is still no instruction for complementing any of the flags.

Eight new instructions permit new types of stack accesses. Five of the eight transfer registers to and from the stack: PHB and PLB for the data bank register, PHD and PLD for the direct register, and PHK for the program bank register. Again, there is no instruction to pull just the program bank register from the stack.

The three other new stack instructions permit pushing computed data onto the stack and then later pulling it back into one of the processor registers or accessing it through new stack-relative addressing modes. The simplest of the three is PEA (push effective absolute address). This instruction pushes the third byte and second byte of the instruction, in that order, onto the stack. The name implies that the instruction is meant to be used to pass a data block's address to a subroutine. However, it might also be used to pass any fixed 16-bit data. The effect is the same as loading the accumulator with 16-bit data and then pushing the accumulator to the stack, except that data in the accumulator is left intact and PEA executes faster.

The PEI (push effective indirect address) instruction is only slightly more complex than the PEA instruction. The second byte of the instruction is used as an offset into the direct page (pointed to by the direct register), and the two bytes of data at that and the next-higher memory location are pushed onto the stack. The effect is to save the contents of two memory locations in the direct page, just as if they

(continued)

made up a 16-bit processor register.

PER (push effective program-counter-relative address) passes the address of a data block to a subroutine. The data is then stored within the calling routine, and the address is given as an offset from the PER instruction's location. The calling routine treats the second and third bytes of the instruction as a 16-bit quantity and adds them to the program counter. The 16-bit result is the data to be pushed on the stack. PEA and PER both pass data stored in the calling routine's code. While PEA can be used to pass a single 16-bit quantity to a subroutine, PER passes the address of a whole block of data.

Since the 65816 has several more internal registers than the 6502, it needs some new instructions for transferring data inside itself. Transfers between the X and Y index registers were covered above. The TCD (transfer accumulator C to the direct register) and TDC (transfer D to C) instructions provide the only way to set or read the direct register without using the stack. The 65816's TCS (transfer accumulator C to stack pointer) and TSC (transfer S to C) instructions ease the 6502's bottleneck of being able to access the stack pointer only through the X register. XBA (exchange B and A) lets you flip-flop the upper and lower 8-bit halves of the accumulator to help it handle mixed 8- and 16-bit data. The Z and N flags are set during the exchange to indicate the new status of the accumulator. The XCE (exchange carry flag with emulation flag) is needed because the emulation (E) flag does not actually belong to the status register proper.

The RTL (return from subroutine—long) instruction is needed because a new absolute long addressing mode has been applied to the JSR (jump to subroutine) instruction. In addition to restoring the program counter, RTL also restores the program bank register from the stack. In keeping with the convention that higher-order bytes appear higher in memory, RTL pushes the program bank register before and pulls it after the normal program counter. RTI (return from interrupt) is always treated by the program as a long return, since interrupts, by their very nature, must specify the full address of the interrupt routine, possibly changing the program bank register in the process.

Several new instructions deal with control of the system bus and clocks. The COP (coprocessor) instruction supports coprocessors and acts like a software interrupt, except with its own vector. The STP (stop the clock) instruction stops the system clock with the phase two clock high. This state can be released only by a reset, which then functions as a high-priority interrupt, with the stack set up correctly for the RTI instruction to resume processing with the instruction following the STP instruction. The WAI (wait for interrupt) instruction stops execution and waits for either the maskable or nonmaskable interrupt (IRQ or NMI). One additional code (WDM) is defined as a no-operation instruction, but it is reserved for future use. The mnemonic comes from the design engineer's initials.

The new block-move instructions, MVP and MVN, are reminiscent of the block moves of the Z80 processor, except that they can be used to move a block of memory anywhere within the full 16-megabyte address space. MVP (move preceding) is meant to move data higher in memory. The move starts at the top end of the block and proceeds downward. This procedure avoids overwriting data that has yet to be moved in cases where the old and new block locations overlap.

MVN (move next) is similarly intended for moving data. In this case, however, data is moved to a position that is lower in memory, starting at the low end of the block and working upward through it. The second byte of the instruction gives the bank address of the destination memory area and the third byte gives the bank address of the old location in memory. The X register contains the low-order 16 bits of the first byte's current address. The Y register contains the low-order 16 bits of the new address. The C accumulator contains the number of to-be-moved bytes minus one. Each byte moved requires seven clock cycles, and the move can be interrupted and resumed through the normal interrupt mechanisms. After completion, the data bank register contains the destination memory area's bank address. This is an important consideration since the program will normally need to operate on the data after moving it. The X and Y registers are incremented or decremented as the move proceeds. As a result, the Y register will hold the 16 low-order address bits of the next byte beyond (above or below) the new area. The A register contains hexadecimal FFFF. The 65816 boasts versions suitable for clock rates from 1 to 10 MHz. This capacity allows a system using the slowest clock to move a complete 64K-byte data block (characters to a very high resolution memory-mapped video display, for example) in just under half a second. With a 10-MHz clock, the same transfer would take somewhat less time than a complete screen refresh (standard monitor with interlaced scanning).

Addressing Modes

The 65816 includes all the addressing modes of the standard 6502 plus a number of new ones. The existing addressing modes were extended to allow for 24-bit addresses and 16-bit data where appropriate. Internal operations employing implied addresses take the data width corresponding to the specific registers being used. Most of the 6502 addressing modes now have separate long addressing modes, allowing them to use either a 16-bit address within the bank specified by the data bank pointer or a 24-bit address within the full 16-megabyte address space.

The immediate mode of the 6502 assumes that one of the operands is an 8-bit quantity stored immediately after the op code. For operations on 16-bit registers, the 65816 lets you store 16-bit data in the two bytes following the operation.

The addressing modes—absolute, indirect indexed, and absolute indexed with X (but not Y)—have new long forms as well as standard forms. Their standard addressing modes specify the low-order 16 bits of the address; the high-order 8 bits come from the data bank register. The zero page designation on certain modes has been replaced by direct page. The change is consistent with this special page's new mobility as granted by the direct register but leads to such double-talk as "direct indirect indexed" for an addressing mode description. To translate, keep in mind that "direct" always refers to the direct register or page, "indirect" refers to the memory location(s) holding a further address rather than data, and "indexed" means adding an index register to the address formed up to that point. Also, the name of the addressing mode describes, from left to right, the order in which the operations are performed. Thus, the example "direct indirect indexed" means that the instruction's operand specifies a direct-page location (direct), which contains only an address (indirect), and to which the Y register is added (indexed). Adding the Y register forms the data's final address for that particular instruction. Other addressing modes use these terms in different sequences and in combination with other, more self-explanatory terms. For all cases, the same general idea holds.

The branch, jump, and jump-to-subroutine instructions each retain their old 6502 addressing modes. The jump and jump-to-subroutine instructions also have new long addressing modes that load both the program counter and the program bank register with new values. In addition, both jump and jump-to-subroutine have new indexed addressing modes that use the X register as the index of a subroutine address table. The unconditional branch instruction's long addressing mode specifies a 16-bit displacement from the current location. This displacement can be positive or negative and wraps around within the current program bank. Conditional branches have no analogous long addressing mode.

Expanded stack addressing modes complement the new stack manipulation instructions. With parameters passed to it on the stack, a subroutine can read or modify them as easily as it can access those parameters stored in a fixed block of memory. It can pop or push parameters as before and can also access them without moving the stack pointer. All it has to do is specify a displacement ranging from 0 to 255 bytes above the stack pointer. Using the "stack relative indexed" addressing mode, a subroutine can use a stack parameter as the table address to be indexed by the Y index register. Since the stack pointer can now be transferred directly to or from the accumulator, a simple arithmetic operation can allocate or delete large stack areas. Combined with the long relative branch, the new stack-addressing modes herald the 6502 family's move toward position-independent, reentrant, and even recursive routines.

With its enhanced instruction set, new addressing modes, expanded interrupt handling, and 24-megabyte address space, the 65816 enters the 16-bit arena on equal footing with the 8086 and 68000. Its one handicap is its lateness, but that might be offset by the familiar, compact, and powerful 6502 instruction set that it brings along. Next month I will show you some hardware enhancements that ease the system designer's burden when using this 6502 cousin in boxes ranging from dedicated controllers to multiuser, multiprocessor systems. ■

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Circle 184 on inquiry card.

(continued from page 130)

Is there a simple way to test the assembled system to verify that the components were not defective or damaged during system assembly?

By the way, Radio Shack (Canada) informs me that the 273-100 has been discontinued and will not be available after current inventories have been exhausted. Can you suggest an alternate unit?

Thanks very much. Your articles are one of the main reasons I don't like to miss an issue of BYTE.

TERRY J. DEVEAU
Armdale, Nova Scotia, Canada

Three MOVs are required to protect against common-mode transients as well as differential-mode transients. Common-mode transients occur from either side of the line to ground; differential-mode transients occur across the line. MOVs are cheap—use three!

A line filter, like other filters, has a characteristic impedance. Placing two in parallel will half the input and output impedances and reduce the effectiveness of the filter. It would be better to split the outlets into two groups and feed each half with a 5-A filter.

There is no simple way to test the MOVs after assembly. They fail in a short-circuit mode, so an ohmmeter check might turn up a defective unit. Visual checks in service (similar to a fuse) will reveal a unit that has absorbed too much energy.

Several companies manufacture power-line filters that are suitable for your applications. They include type 5VK1 or 5VK3 from Corcom Inc., 1600 Winchester Rd., Libertyville, IL 60048, (312) 680-7400; type APF511L from Cornell-Dubilier Electronics, 150 Avenue L, Newark, NJ 07105, (201) 589-7500; type 05DBAG5 from Delta Electronic Industry USA, 1355 Yosemite Way, Hayward, CA 94545, (415) 785-5231; and type 600A5 from Potter Company, POB 337, Wesson, MS 39191, (601) 643-2215. These filters are equivalent to the Radio Shack 273-100.—Steve

I NEED AN MOV

Dear Steve,

Help! I've gone to five Radio Shack stores to try to buy a V130LA10A MOV to build your power strip. I couldn't find this part. All they had was the V8AZ1 MOV.

What should I do? Can something else be substituted? Thank you for any information.

GERALD CARON
Berkley, MA

Radio Shack still sells the V130LA10A MOV transient protectors (part number 276-570) but could not anticipate the demand caused by my article. In fact, I was surprised by the number of letters I received on this subject. It's nice to know so many are interested in power-line protection.

I chose the Radio Shack MOVs because they were easily obtainable, but there are several other sources. The V130LA10A is manufactured by General Electric and should be available from a local GE distributor or electronics-parts supply house. In addition, Panasonic and General Instrument manufacture similar units. The equivalent Panasonic part, number ERZ-C14DK201, is available as part number P7063 from Digi-Key Corporation, Highway 32 South, POB 677, Thief River Falls, MN 56701, (800) 346-5144. The General Instrument equivalent, part number S14K130, is available from Active Electronics, POB 8000, Westborough, MA 01581, (800) 343-0874.

The V8AZ1 MOV is designed for 5-V DC circuits; the V130LA10A is designed for 130-V AC circuits.—Steve

WRONG FREQUENCIES

Dear Steve,

I just purchased the ECM-103 modem kit. Following an expensive confrontation with the customs department, I set about putting it together. Then, to my surprise, a local guru on computing advised me that Australian frequencies for modem channels 1 and 2 are 980 to 1180 Hz and 1650 to 1850 Hz, respectively.

Is there any way the ECM-103 can be modified to operate at these frequencies? Is it possible to change the crystal? I'm hopeful that you will be able to help me.

GEORGE HENDERSON
Turramurra, New South Wales, Australia

Texas Instruments, the supplier of the IC that forms the heart of the ECM-103, produces another chip that should solve your problem. I believe that the frequencies you describe are the European standard versions for data transmission. TI produces a chip that is pin compatible with the device used in the ECM-103, and it covers the European standard. The part number you want is TMS99534. Be sure to get an application note, as this will let you know if different passive component values are required.—Steve

CP/M IN ROM

Dear Steve,

I hope to put together a Z80-based system and intend to use the interface found in "Build a Super Simple Floppy-Disk Interface" (May and June 1981). I want the system to run under CP/M 2.2, but I do not have another system with which to generate the CBIOS (custom basic input/output system). I do have an EPROM programmer that runs on a ZX81. In "Build the Circuit Cellar MPX-16 Computer System, Part 1" (November 1982, page 78), I saw an ad for CP/M-86 BIOS in ROM. Could I program the CP/M 2.2 CBIOS into an EPROM? And if I do, what is to be done to interface with the remainder of CP/M?

The system will also use your E-Z Color Graphics Interface ("High-Resolution Sprite-Oriented Color Graphics," August 1982, page 57). I would like to use its external video input to display text from a 6845 CRT controller, giving a backdrop plane of 80-column text. Do you have any advice that would help interface the two? I am concerned with the need for synchronization and an appropriate video output from the 6845 circuitry to the 9918A.

Thanks for your time.

R. A. PEDERSON
Orleans, Ontario, Canada

The CP/M BIOS-support ROMs for the MPX-16 provide only boot and device support for CP/M. The BIOS actually comes in off the disk itself. This is a change from the original implementation, made to enhance the flexibility of the system. Now, PC-DOS and 5¼- and 8-inch CP/M all run off the same ROM set.

It is certainly possible to code a BIOS in ROM, but I understand that the newest version of CP/M requires that device drivers be loaded externally from the disk at initialization. It may be possible to do this in ROM, too, but I am not enough of a CP/M user to say for sure.

As far as actually setting up a machine, I have found that it is virtually impossible to set up a new BIOS if you don't already have a running system to create it on. I suggest getting in touch with your local CP/M users group for technical assistance in this area.

The question you raised about the TMS9918A is a good one. While TI claims that it can be set up to accept an external video source, we have had a lot of trouble setting up synchronization circuits that work reliably.—Steve

GIVE THE RTC-4 A DATE

Dear Steve,

I am a research assistant at the University of Petroleum and Minerals. I read your article "Build the RTC-4 Real-Time Controller" on page 26 in the July 1983 BYTE. I am interested in the fixed-time programs capability of the RTC-4. Is there any way to add the date to the fix program if I wish to program the RTC-4 to do a function after one month or more?

I understand that I can change the day or time by the keyboard. Is there any mechanism to connect a receiver to this circuit so that I can change this data by wireless? If so, would you please provide me with the necessary information?

Thank you.

WASIM RA'AD
Dhahran, Saudi Arabia

The TMS1121 chip used in the RTC-4 real-time controller is a preprogrammed version of the Texas Instruments TMS1000 4-bit single-chip microcomputer. It is therefore not possible to change the internal program, and no additional features or functions can be added. The chip was designed as a universal timer controller but could not anticipate every possible requirement.

It is relatively easy to control the RTC-4 by wireless. My article in the February 1981 BYTE ("A Computer-Controlled Tank," page 44) describes a method to control a Texas Instruments TMS1000-series microcomputer with a citizens band walkie-talkie. Other transmitting frequencies can easily be adapted as necessary.—Steve

LIKES THE MPX-16

Dear Steve,

I built the blank MPX-16 board and am pleased with its performance. I used sockets for ICs of ≥20 pins and for RAM. This was successful except for one bad IC.

I reduced R21 to 1.8k ohms because the 4.9-MHz crystal tended to go into the third overtone with R21 = 33k ohms. I designed my own 8-MHz oscillator using the same design you chose for the 4.9-MHz crystal.

I intend to design a keyboard interface and a video adapter using an Intel 82720.

I'm delighted with the educational value of this project.

I speak highly of your product where I work (I'm an IBM hardware/software engineer).

Since I will be making some changes to the BIOS, I was wondering if I could have an assembly-language listing?

R. A. FAUST
Tucson, AZ

The original BIOS for the MPX-16 was written in PLM-86. It has since been expanded from 4K to 8K bytes and rewritten in 8088 assembly code. The source listings are available on two disks for $20 from The Micromint (25 Terrace Dr., Vernon, CT 06066).

The new BIOS allows the MPX-16 to operate either as a terminal-based machine or PC clone with a color graphics/monochrome board and keyboard. PC-DOS can be booted and executed in either configuration (the terminal configuration can't duplicate graphics functions, of course).—Steve

SWEET TALKER CONVERSION

Dear Steve,

I am having trouble interfacing the I/O bus on my TRS-80 Model III. I am trying to convert or redesign the Sweet Talker speech box ("Build an Unlimited-Vocabulary Speech Synthesizer," September 1981, page 38). I built the parallel port and it works great, but I would like to change it to the I/O bus port, if possible. Can you tell me where to find a schematic of the interface? Thank you.

BILLY BISHOP
Sachse, TX

Use of the I/O bus port on the Model III requires that you enable the external device-driver chips by writing to a latch inside the TRS-80. Also, external logic must drive the direction line of the bidirectional buffers. Other than this, there are no special tricks to using the interface.

William Barden has written several articles for BYTE on how to construct and drive devices attached to the TRS-80 Model I, Model III, and Color Computer. You can find back issues of BYTE at a local library or order them from BYTE. (See the December 1982 cumulative index update for a listing of Barden's articles.)

Be sure to remember to include the 100-ms pulse extender and to have your software check the A/$\overline{R}$ line of the Sweet Talker, or the device will not function correctly.

The Model III Technical Manual contains the schematics of the I/O bus interface as well as functional descriptions of how it works. It might be a good idea to secure a copy of this from your local Radio Shack store.—Steve

ADAPTING MICROVOX SOFTWARE

Dear Steve,

For several months now I have been using my VIC-20 with a Sweet Talker speech synthesizer. While I have enjoyed the many applications I have found for this versatile circuit, I now see the need for a more general-purpose stand-alone unit such as the Microvox text-to-speech synthesizer presented in the September and October 1982 issues. However, being a basically lazy guy, I would like to avoid a major construction project, if possible.

Would it be possible (and not too difficult) to adapt the Microvox text-to-speech algorithm to run on a SYM-1 microcomputer, and, if so, is the Micro-

(continued)

vox software available either as a listing or in EPROM?

I realize that this would involve some timing and other modifications to the SYM, but if it's easier than building the Microvox from scratch, I would like to give it a try. Any suggestions you might be able to provide would be greatly appreciated.

RON HACKETT
Port Jefferson, NY

It is possible to adapt the Microvox text-to-speech algorithm to any 6502-based computer, provided that memory space at C000–CFFF and E000–EFFF hexadecimal is available for the two 2732 EPROMs containing the algorithm. In addition, RAM is required at 0000–0FFF hexadecimal, and the SC-01A interface hardware must be duplicated.

The Sweet Talker I presented in September 1981 also has a text-to-speech algorithm for the Apple II. The interface hardware and algorithm are much simpler than the Microvox's and therefore possibly easier for you to convert to the SYM-1. I refer you to that article.—Steve

MICRO D-CAM SECURITY SYSTEM

Dear Steve,

The first part of your article, "Build the Micro D-Cam Solid-State Video Camera," on page 20 in the September 1983 BYTE was very interesting. I would like to use the IS32 optic RAM, which you described in the article, in an alarm system. Specifically, I want to monitor an area with the IC so that whenever the scene changes, an alarm sounds and the image of the area is displayed.

How can I overcome the problem of changes in ambient light? Could I build such a system at a reasonable price? Thanks for any help you can give.

O. N. G. FERRAO
Doonside, Republic of South Africa

Using the Micro D-Cam as the sensor in an alarm system sounds like an interesting experiment. I assume you are talking about intrusion alarms, where the basic requirements for a successful system are that the system must detect intruders and that it must not give false alarms. The first condition could be easily met with the Micro D-Cam by storing a reference picture in memory and comparing subsequent pictures with it. Any change would signal a possible intruder. Saving a reference picture can be accomplished by copying the contents of screen memory to another block of memory or by modifying the Micro D-Cam software to put the picture at any convenient location. It isn't really necessary to ever see the picture.

Avoiding false alarms is another problem, however. If you simply make a pixel-by-pixel comparison, changes in ambient light will be bothersome, as you suspected. In addition, you will get spurious responses scattered randomly over the picture area due to electrical noise and temperature changes. This happens because some cells in the detector will normally receive almost, but not quite, enough light to turn on. These cells will occasionally give a signal that will be interpreted as an intrusion. Your software must be designed to ignore these isolated signals as well as compensate for ambient light variations.

More sophisticated software might eliminate these problems. Some methods include periodically changing the reference picture to compensate for ambient light variations, ignoring any changes involving single or very small groups of pixels, and, hardest of all, distinguishing real movement from apparent changes in the appearance of stationary objects.

It is possible to design an alarm system such as you envision, and much of the needed software is included with the unit. Good luck.—Steve

Z8-CONTROLLED LAB SCALE

Dear Steve,

I am in the laboratory balance business and am working on a micro-balance of my own. Presently, most lab balances measure from 0.1 microgram to several kilograms and use a digital display. I have designed a weighing mechanism accurate to a microgram at 20 grams; this range is good for most lab use.

I would like to have a balance with an on-board computer, capable of options not found on other balances. I thought of your Z8 BASIC system controller.

The servo amp of my system has an analog output of 0–2 V DC or whatever I need.

Could you tell me how I could interface your system and also how to use a small monitor as a readout? I would like the system to be complete.

Thanks.

PAUL BIANCHETTI
McCall, ID

A Z8 BASIC system controller could be used for your application. Since the original article, the system has been expanded to include a variety of Z8 cross-assemblers and extra memory, I/O, EPROM programmer, and serial boards. There is also a 10-V 8-channel 8-bit A/D board.

While a 0–2-V servo-amp output could be resolved with the present 10-V range of the A/D, it might be better to amplify the signal (by 5) or reduce the span of the A/D from 10 V to 2 V.

Regarding the display, my January and February articles described a single-board intelligent terminal, Term-Mite ST-1000, which can be configured with a keyboard to function as a terminal or simply to drive a monitor to report computed results. While Term-Mite is a stand-alone system, it is coincidentally Z8 BASIC system-compatible and can be plugged into the same backplane with the system controller and A/D to drive a monitor.

Finally, projects such as the Z8 BASIC board are frequently just the beginning of my interest in a subject. Often, many enhancements are made after the original article. The latest addition is a 4K-byte FORTH chip that is interchangeable with the Z8671 BASIC chip. This modification should allow the board to be used in more sophisticated applications.—Steve

AND A Z8-CONTROLLED SOLAR COLLECTOR

Dear Steve,

Boy, am I ever in trouble. I'm a senior in high school in the middle of a science project for a science fair. My physics teacher and I are building a hot-air solar collector, which will have fairly high efficiency, contain some solar-heat storage, and be controlled by a small dedicated processor.

We have purchased a Micromint Z8

controller, have on order the basic analog-to-digital converter, and are presently assembling eight operational amplifier circuits on a vector card. These circuits are those you used in controlling your wood stove (February 1980, page 32). We are presently communicating with the Z8 by way of the serial port using a modem program and a Heathkit H-89. The modem software allows transmission of programs to and from disk files and the Z8. I've also ordered the new Term-Mite card to hopefully replace the H-89.

I have two problems. We have a fairly good idea on how to use the tiny BASIC in the Z8. What we can't seem to figure out is how to write the subroutines to read the temperature probes. Somehow, the A/D converter has to be addressed, a port opened, and data read and stored somewhere. This data would then be compared to cause something to happen or not happen. We've gotten quite a few booklets from Zilog concerning the Z8 and we still can't seem to get the picture.

I'm hoping that you might share some code with us. I feel that if we can at least get some idea of what the code should look like, we should be able to make some adjustments.

The second problem has to do with controlling a few fans. What can I buy or make to interface with the Z8 that would enable me to turn these items on/off?

KENNY LANGO
Amenia, NY

The routines needed to get at temperature probes are really not hard things to write. The A/D board looks like a memory location and requires no special configuration to get at. Using the @ or ^ functions of the Z8 BASIC, you can directly access the board from within a BASIC program. You can evaluate the value in the A/D converter and use BASIC to make decisions on what to do inside the system.

To control fans and the like, use the port-2 output lines to drive a solid-state relay. You can get them from Radio Shack.

The hardest part will be calibrating the A/D output with real temperatures. The standard sensor described in the example that comes with the A/D board uses Kelvin temperature, which is the Centigrade temperature offset 273 degrees. The program listing does show an example of Kelvin to Fahrenheit conversion, and I'm sure your physics professor can modify anything necessary.
—Steve

To Build an MPX-16

Dear Steve,

I thought you might like to hear from someone who had constructed an MPX-16 from a bare board. I have done so and survived to tell the tale.

I ordered the bare board and the manuals for the MPX-16. The manuals are legible, well organized, and written for the most part in English.

Let me skip ahead a bit and give you an overview of how I spent my time on the MPX-16 project: 50 percent chasing down parts, 5 percent loading and soldering the board itself, 10 percent in mechanical assembly (drilling square holes in chassis, etc.), 10 percent doing electrical (versus electronic) chores (harness, cables, fuses, etc.), and 25 percent making it work after it was together.

The system includes Chassis 1: MPX-10 Switching Power Supply, MPX-16 Main Circuit Board, fully loaded except for no 8087, muffin fan, and miscellaneous harness, fuses, switches, and sockets; Chassis 2: two Tandon TM-100-2 (powered off the MPX-10); a Heath H-19 terminal; and a pTi Industries Data Shield Line Filter (which has four out of six sockets wired with hot and neutral reversed!).

Even though I live close to Silicon Valley and did my buying before the current economic recovery caused eager OEMs to buy up all the chips in sight, I still spent most of my time chasing down parts. ICs were not generally a problem, though 8288s were scarce when I needed one and it took a while to find anyone who realized that a 629 was a TTL part and not a commuter train. The real headache was some of the linear parts. Nobody stocked all the precision resistor values I needed in the tiny physical sizes intended to be used on the board. Nobody stocked the Erie trimmer capacitor. Nobody stocked the right SIP (single-inline package) resistors. Nobody had any 62-pin card-edge connectors. And so on. I fixed these problems by an assortment of kludges, lead-bending, and ingratiating smiles. (Speaking of kludges, did you know that you can trim extra resistors off an SIP with a hacksaw? All you do is notch the case a bit, snap off what you don't need with pliers, and daub some epoxy over the broken end. Steve, is something the matter?)

I decided to use high-quality sockets: Augat 5XX-AG19Ds throughout. With more than 2000 IC pins on the board, the prospect of having some of them in intermittent contact was terrifying.

I also bought a good soldering iron, an Ungar 9100 with adjustable temperature. It spoiled me very quickly; my previous iron has been demoted to wood-burner.

With everything in hand, the board loaded very quickly—a few evenings of manic soldering, followed by an hour or two stuffing in ICs. I made one modification as I worked (besides the jumpers Micromint said to put in): I anticipated that the kind of programming I like to do would crash the system frequently, and I am skeptical of the practice of cycling the power too often, so I installed a Reset button. There's a cap on the $\overline{\text{RESET}}$ pin of the 8284. I came off it with a 4.7k-ohm resistor, through a big red normally open push button, to ground. That works just fine. I brought the leads from the resistor and from ground to a two-pin header in the breadboard area at one edge of the board, so that I could get to the push button by a detachable plug.

So far, so good. I decided I wanted a compact power supply, and I was too scared to try building a switcher, so I ordered an MPX-10 from Micromint. It came, and I tried to make it work. I knew you had to load a switcher properly, but I did not realize that you have to load all three positive supplies on the MPX-10 before any of them will regulate correctly. I am sufficiently an ignoramus that I will forgive myself that error, but I was amused to find that the Micromint engineer I talked to didn't know it either. Between my ignorance and his, a perfectly good switcher made an extra round trip to the East Coast before I stumbled across the solution. Live and learn.

I bought the biggest LMB Unipac chassis I could find—7 by 12 by 17 inches—and mounted board, power

(continued)

supply, and a 4.75-inch muffin fan inside. The big fan works beautifully at keeping the temperature down (even the bipolar 8288 is no more than lukewarm when it is stabilized at operating temperature), but the chassis holes for air inlet and exhaust make so much noise that I wear a hearing protector when I use the system.

I bought a little bag of cable ties and used them freely. It is amazing how professional a kludge can look when everything is routed neatly.

I bought two Tandon TM-100-2s from Jade at a computer fair and found an appropriate chassis for them at a swap meet. One drive refused to read, but Jade fixed it promptly.

I cut, stripped, crimped, soldered, and cursed up the necessary cables, then came to the astonishing realization that it was all done. I spent several days finding excuses not to turn it on, then fired up the H-19, closed my eyes, and flipped the switch. Nothing happened.

I found three elementary assembly errors by looking for pulse activity with a logic probe. I had made one cold-solder joint that was interfering with the buffering of SYSCLK0 (if a bad connection at pin 1 of U1 isn't an ill omen, I don't know what is), one solder bridge that had tied an address line high (I replaced the drivers for that part of the bus as a precaution), and had incompletely crimped one of the ribbon-cable connectors in the disk-drive harness.

By this time, the system booted CP/M-86, and the real work began. I tried to back up the system disk, and although the format program ran to conclusion, the disk-copy utility crashed with a track-read error as soon as it tried to write onto the newly formatted disk. I fussed with the logic probe and traced signals with a borrowed oscilloscope. I disassembled the format routine with DDT86 and stared at it. I assembled little BDOS and BIOS calls, again with DDT86, and ran them. Not a clue. Micromint's imposingly thick BIOS listing got thinner and thinner and simpler and simpler as I studied it. I nosed about in the BIOS with the debugger and set breakpoints at judicious locations, ignoring the looming specter of nonreentrant code.

The disk controller thought it was doing a fine job of formatting the disk: it reported all zeros in its status registers after each track-format command. But when the same chip tried to read the same disk later on, it claimed that it couldn't find any sector identification.

I bought another $40 disk controller and plugged it in. That bug expired, but others sprang valiantly forth to take its place.

But let me get back to the hardware. My system now appears to run fine, and so far I have nothing but praise for its design. As you correctly pointed out, bringing a system of this complexity up from a bare board is not a simple task.

(continued)

Circle 75 on inquiry card.

My present plans for the MPX-16 are varied. The real reason I wanted a home computer was that I have become interested in the creation of programming languages. In spare time at work, I have kludged up a threaded interpreter (not FORTH, but an emulation of the keyboard language of my old HP-65 programmable calculator—in a FORTRAN shell, yet!); brought up a RATFOR translator to the point where it would bootstrap; and even written a teeny compiler (for "WHATDUZITDO," which you will find in your back files of BYTE). I am presently trying to write a decent 8086 macro assembler, using the MPX-16. The only good one that exists seems to be Intel's ASM86, which I use daily at work, but that costs a jillion trillion dollars and runs only on Intel equipment, under ISIS. Odds are less than even that I can do such a thing, I suspect, but it will be fun to try.

Is there an MPX-16 users group?

JAY REYNOLDS FREEMAN
Belmont, CA

Yes, there is a users group. The newsletter can be obtained for $5 a year. Contact Michael Bamberg, 1059 NW Danielle St., Hillsboro, OR 97124.

Readers should know that the MPX-16 can also now emulate the IBM PC directly using the IBM color graphics/monochrome board and keyboard rather than a monitor as originally described.—Steve

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To receive a complete list of Ciarcia's Circuit Cellar project kits available, circle 100 on the reader-service inquiry card at the back of the magazine.

Editor's Note: Steve often refers to previous Circuit Cellar articles. Most of these are available in reprint books from BYTE Books, McGraw-Hill Book Company, POB 400, Hightstown, NJ 08250.

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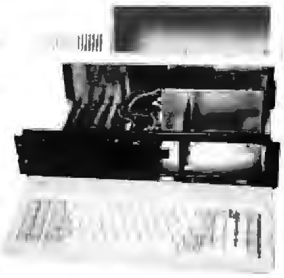

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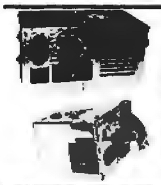

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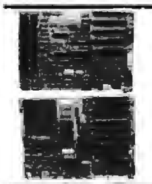

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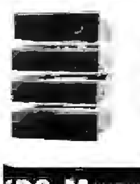

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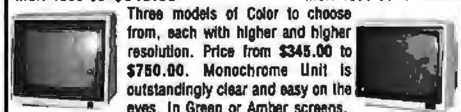

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(continued from page 135)
features can make slow hardware seem fast. If implemented poorly, they can make even the most elegant hardware seem archaic. UNIX benchmarks should concentrate on some critical areas.

UNIX was developed on a small machine with limited memory and is disk intensive by its very nature. Therefore, we should test features of UNIX that use the disk.

The user interface to the UNIX system is called the shell (several common varieties exist). Since all requests made by the user are processed by the shell, it should be tested extensively.

The UNIX pipe qualifies on all the above criteria. A pipe is an I/O channel that is written into by one program and read by another. Pipes are used by a number of UNIX utilities, the shell in particular. Pipes are also often buffered on disk. A UNIX benchmark using a pipe is given in listing 1. The program creates a child process to read the pipe using the **fork()** system call and then crams 0.5 megabyte through the pipe. What do the results tell us? The two times of interest are the system and elapsed times. The system time, for all practical purposes, is a measurement of how long it took to set up and perform the piping. It thus is a direct measurement of pipe efficiency. The elapsed time is of interest because it helps give a good measurement of how slow the disk is. Elapsed time minus system time minus user time is essentially the disk-overhead time. Since microcomputers usually don't have the fastest disks, this is an important measurement for them. User time by itself is of little importance.

So you can get some idea of the time required to execute this and other benchmarks discussed in this article, table 1 shows the timings for some common minicomputers and microcomputers running UNIX. These times are average times on an otherwise idle system, as per the guidelines established above.

In the pipe benchmark, we measured the time it took to perform certain system calls (**fork()**, **read()**, **write()**, etc.) that were related to pipe implementation. The time to perform just one system call can be divided into several components:

1. The time required for the user-program system-call library interface to set up and execute a trap (an SVC to IBM 370 users) to the kernel so that privileged instructions can be executed. When this happens, the registers needed by the processor (stack pointers, program counter, etc.) to run the user program are saved so that they can be restored after the system call is complete.
2. The time the processor is performing the desired function.
3. The time required for the user-program registers to be restored and control transferred so that the user program can resume computation with the result from the system call in hand.
4. The time used when a context switch between processes is required.

It would be nice to measure 1, 3, and 4, since they can be considered the majority of the overhead in making a system call. The program in listing 2 does just that. It does nothing but repeatedly (25,000 times) query the operating system concerning its process identity with the **getpid()** system call. This information is kept in an in-core process table, so access is extremely fast and actual computation very small, as long as no other processes are competing for the processor. (See the need for an idle system?) Since we're interested in measuring overhead, and the program doesn't do much other than system calls, the elapsed time is important here. System time should be close to the elapsed time, and user time should be very small. Both are insignificant. Again, the results of this benchmark are shown in table 1.

Now that we've benchmarked system-call overhead, the overhead involved in an ordinary user function call and return naturally follows. This benchmark may initially seem superficial but consider that it is compiler implementation that to a large degree determines object-code efficiency, and the same compiler (C in our case) is probably used to compile the operating-system kernel. If so, it *should* be considered when evaluating the operating system. It should also be noted that an inefficient compiler can nullify any speed gained by structured-programming techniques. Benchmarking compilers is a topic by itself and will be left alone here. Let's just measure function-call overhead and consider it representative of compiler efficiency.

It is possible to determine the overhead involved in a function call in a number of ways. The method used here is believed to be more accurate than others. Since our comparison is two-way, two programs should be written: one that uses a function to achieve a goal and one that does not. The two programs, however, should perform the same task. After these programs are run, the user-execution time from the program not using the function is subtracted from the user-execution time of the program that does. This difference is the function-call overhead involved. This number can be divided by the number of times the call was made to arrive at a seconds-per-call overhead value, which can be enlightening when compared from system to system. An example of how this is done is shown in listing 3. Even though the program could have been made simpler by not passing a value to the function **empty()**, in real life all functions return at least one value, whether examined or not, and most functions pass at least one value (which is overhead, really). Using the C preprocessor, it is possible to write two distinct programs in one text file, depending on how the text file is compiled. The program in listing 3 is either compiled with **-DEMPTY** to generate the empty function program or with **-DASSIGN** to generate the program that doesn't use a function but achieves the same goal.

As mentioned above, the user time, not the real time, is used in the calculation. This is because the real time is accurate only to the second, whereas the user time is accurate to the tenth. And, since we're generating a nonrelative numerical result, where virtually no system time is used, the measurement with the greater precision is needed.

Let's turn our attention to the C compiler. When most people think of compiler benchmarks, they think of the Sieve of Eratosthenes, which tests compiler efficiency and processor throughput quite well. It's an excellent test for looping, testing, and incrementing. The program in listing 4 is a slightly modified copy of the Sieve presented in the January 1983 BYTE (page 283). Since we're not using a stopwatch, all unnecessary I/O has been removed. Also, by the guidelines established above, register declarations have been added. The time to be interested in here is the elapsed time. The user time should be about the same as the elapsed time, while the system time should be quite small.

We briefly touched on disk performance with the pipes test, but disk performance deserves a more in-depth evaluation. UNIX provides methods for both sequential and random-access files, and both should be tested. Listings 5a and 5b are benchmarks that test random-access disk implementation. The program in listing 5a creates, opens, and writes a 256- by 512-byte file. The number of blocks manipulated is specified by a #define statement and can easily be changed if it is too large for a small microcomputer implementation. The program in listing 5b randomly reads the file created in listing 5a and removes it afterward.

While sequential access should be tested, it is not presented here since disk access is by and large random access. It should be easy to derive a sequential-access test from the random-access program given in listings 5a and 5b. Since the file created by benchmark 5a is relatively large, it's doubtful that it could be stored on one large, contiguous chunk of disk. More than likely, it will be segmented into several pieces, depending upon how full the filesystem is. Most efficient UNIX (and UNIX-like) implementations segment a physical disk into more than one logical disk partition. Each partition is called a filesystem. When the filesystem is created, all disk blocks are contiguous. As the filesystem is used more and more, it becomes more splintered with many small chunks of contiguous space.

Since we would like to run the bench-

(continued)

Listing 2: *The system-call benchmark.*

```
/*
 *              UNIX Operating System Implementation Test #2
 *
 * This program compounds the kernel overhead involved in executing
 * a system call. Making a system call involves a 'trap' to kernel
 * or supervisor mode, performing the desired function, and returning.
 * Context switching is, when it occurs, also overhead. The getpid()
 * system call is used because all it does is look in an in-core table
 * for the numeric process id.
 *
 * Instructions:
 *     Compile by:                  cc -O -s -o scall scall.c
 *
 *              The -O option says to use the optimizer.
 *              The -s option says to strip the namelist from the
 *                  object file after linking.
 *              The -o option says to place the object file in the file
 *                  specified by the next argument.
 *
 *     Time by:                     /bin/time scall
 *
 *     Results:
 *          Since we're testing system overhead, the elapsed time is of
 *          interest here.
 *
 */

#define TIMES  25000

main()
{
                /* take advantage of the hardware */
        register int i;
        for (i = 0; i < TIMES; i++)
                getpid();

}
```

marks under normal operating conditions, benchmark 5 should be executed in a filesystem that is used regularly. Several UNIX implementations place the directory /tmp in a filesystem of its own, since **/tmp** is used frequently under normal conditions. In any case, this benchmark should be run in an active filesystem in order to give a more realistic result as to what the response time under a real user load would be. This benchmark, of course, is extremely disk dependent, but that's what we're testing. As implied, the elapsed time is important here because the time spent waiting for I/O completion is not charged to either user or system time.

One of the things programmers do best is compile programs, and the compiler is a good operating-system exercise because of it. The command to compile a C program under UNIX is cc. This command is actually a small C program that invokes the C preprocessor, the compiler proper, the assembler, and the linker in succession. To time the compilation process, just place **/bin/time** in front of the cc command line. Naturally, the C compiler is disk intensive, and with today's fast microprocessors, the disk is often the bottleneck in compilation throughput.

Something needs to be said about the size of the object files that the compiler leaves us with. It can be found by direct examination that the size of the object files compiled on comparable microcomputers can vary by an order of magnitude. In early UNIX days, when memory address space was limited, the loader didn't include a lot of unused code in the object file when it resolved all function references. With today's microcomputers having more memory than minicomputers of a few years ago, some implementations include unnecessary system-call hooks that are never referenced in the program. A good way to test this is to compile the following program:

```
main ()
{
}
```

which is the shortest C program possible. To tell how much memory the object file will use when loaded into memory, look at the size of the object file with the UNIX size command. Size reports the size of the text, data, and bss segments. The text segment is composed of program instructions. The data segment contains initialized program data. The bss segment contains uninitialized program data. The total size is usually given in both decimal and/or octal or hexadecimal. Another command of interest is **nm**, which *will list* the symbol table (NaMelist) of an object file. Some of the library modules loaded will be present in any program, and with good reason (**__exit**, **__environ**, **__cleanup**, **__main**, and **crt0.o**, for example). Some are pure excess (**malloc.o**, **isatty.o**, **write.o**, and **stty.o**, for example) and usually result from one library func-

Listing 3: *The user function-call benchmark.*

```
/*
 *                UNIX Operating System Implementation Test #3
 *
 * This program enables precise arithmetic calculations of user function
 * overhead by subtracting the execution user time when compiled without
 * using a function from execution user time using a function.
 *
 * Instructions:
 *     Compile by:            cc -O -DEMPTY -s -o fcalle fcall.c
 *           and
 *                            cc -O -DASSIGN -s -o fcalla fcall.c
 *
 *           The -O option says to use the optimizer.
 *           The -D option specifies C preprocessor action.
 *           The -s option says to strip the namelist from the
 *              object file after linking.
 *           The -o option says to place the object file in the file
 *              specified by the next argument.
 *
 *     Time by:               /bin/time fcalle
 *           and
 *                            /bin/time fcalla
 *
 *     Results:
 *          Since the user time is more accurate than the real time,
 *          and since system time effectively does not contribute to
 *          the real time number, we can use the difference between
 *          the user times in seconds as an accurate numerical account
 *          of function call overhead.
 *
 */

#define TIMES  50000

main()
        /* The first way of doing things — use a function call */
#ifdef EMPTY
{
        register unsigned int i, j;
        for (i=0; i < TIMES; i++)
                j = empty(i);
}

        /* the empty function */
empty(k)
register unsigned int k;
{
        return(k);
}
#endif
#ifdef ASSIGN
        /*  The second way of doing things — without a function call */
{
        register unsigned int i, j;
        for (i = 0; i < TIMES; i++)
                j = i;
}
#endif
```

tion referencing another in a larger module, creating a cascade effect. The compactness of the code generated says something about the efficiency and implementation of the compiler and loader.

We've covered most of the more frequently used aspects of UNIX individually up to now. Let's develop some tests for the UNIX system interface, the shell. The best way to test this is by having a shell program do what users normally do when they sit down at the keyboard.

A good general UNIX benchmark is the shell script, or program, in listing 6a. This program, named **tst.sh**, invokes several commonly used UNIX commands and exercises disk access with them. This program was originally written for use in evaluating UNIX microcomputers at the '83 USENIX (an association of UNIX users) conference. In retrospect, it should have contained some commands to run concurrently in the background, such as the compilation of one of the C benchmarks described above. This benchmark makes use of the shell's I/O redirection and indirection (indirection being the ability to take input from the current input stream instead of a file) to sort, save on disk, manipulate, and ultimately remove from disk a list of English words. The utilities used (**sort**, which sorts; **od**, which gives an octal listing; **grep**, which does pattern matching; **tee**, which makes a disk copy of the input given it; **wc**, which counts words, lines, and characters; and **rm**, which removes disk files) are all standard UNIX tools. The shell variable $$ is the current numerical process ID and is used to make unique filenames. The shell benchmark is run with the command **/bin/time /bin/sh tst.sh**. Execution times for even this simple benchmark varied widely, as shown in table 1.

A few words should be said about determining how many users a small multiuser system can support. With small multiuser systems, accurately simulating real user load is more important than with large multiuser systems because of the limited amount of memory, disk, and processor resources. You can simulate a real user load in several ways, but the only true way is to have someone at another terminal executing the same program you are at the same time. Why can't a process running in the background simulate a real user load? Because background processes usually run with a lower priority. Additionally, some multiuser microcomputer implementations limit the amount of memory an individual user can use at one time, even if no other user is on the system! What's more, some implementations impose an incredibly small limit on the number of files you can have open or the number of processes you can have running at any one time, again regardless of the number of other users or processes on the system. Watch out for these systems.

Since we're mainly concerned with microcomputer implementations, where there may or may not be additional terminals, and since we want portable benchmarks that can be run on any

(continued)

Listing 4: *The Sieve of Eratosthenes benchmark.*

```
/*
 *              UNIX Operating System Implementation Test #4
 *
 * No benchmark suite would be complete without the ever-popular
 * sieve benchmark. It is a good test of compiler efficiency and
 * CPU throughput. Below is a sieve benchmark as presented in the
 * January 1983 issue of BYTE, with some minor changes: Register
 * declarations have been added, and some unnecessary (from our
 * standpoint) printf() statements removed.
 *
 * Instructions:
 *    Compile by:               cc -O -s -o sieve sieve.c
 *
 *           The -O option says to use the optimizer.
 *           The -s option says to strip the namelist from the
 *              object file after linking.
 *           The -o option says to place the object file in the file
 *             specified by the next argument.
 *
 *    Time by:                  /bin/time sieve
 *
 *    Results:
 *       In the past, the elapsed time has been used, since most
 *       operating systems can measure real time. Actually, user
 *       time is a better value.
 *
 */

/* Eratosthenes Sieve Prime Number program in C */
#define TRUE    1
#define FALSE   0
#define SIZE    8190

char flags[SIZE + 1];

main() {
        register int i, prime, k, count, iter;
/*      printf("10 iterations\n"); */                /* We don't need this */
        for (iter = 1; iter <= 10; iter++) {         /* do program 10 times */
           count = 0;                                /* prime counter */
           for (i = 0; i <= SIZE; i++)               /* set all flags TRUE */
              flags[i] = TRUE;
           for (i = 0; i <= SIZE; i++) {
              if (flags[i]) {                        /* found a prime */
                 prime = i + i + 3;                  /* twice index + 3 */
/*               printf("\n%d", prime); */           /* Nor this */
                 for (k = i + prime; k <= SIZE; k += prime)
                    flags[k] = FALSE;                /* kill all multiples */
                 count++;                            /* primes found */
              }
           }
        }
/*      printf("\n%d primes.", count);*/             /* primes found on 10th pass */
}
```

UNIX system no matter how small, our only recourse is to benchmark a varying number of background processes (i.e., a multitasking benchmark) and assume that the results can be extrapolated to a multiuser environment. Even if the benchmark is used to help decide which single-user system to buy, evaluating background-process performance is beneficial since the ability to have many background processes is a strong point of UNIX.

Using the shell benchmark in listing 6a as a starting point, we can invoke that script in the background a number of times to see how long it takes to execute one, two, three, four, five, and even six of these identical background processes. The shell script in listing 6b does just that. Contained in a file called **multi.sh**, it executes the shell test found in listing 6a in the background a number of times. The number of background processes created is determined by the number of command-line parameters given the shell script. The actual values of the command-line parameters are not important, it's the quantity of positional parameters that the shell script uses. Although any character would do as a positional parameter, for readability it is convenient to use the characters "1," "2," "3," etc. as those parameters. The benchmark is run as shown in table 2.

The shell statement **wait** causes the shell script to pause until all background processes have terminated. Invoking **tst.sh** more than six times may not be possible (depending upon your operating system) if a "per-user process limit" is defined.

Table 3 shows the results from the multitasking shell benchmark given in listing 6b for a variety of UNIX-based systems. The table is sorted on the fastest elapsed time for six background processes. Remember, this benchmark does not measure how many users the system will support but is rather a measure of how many processes the system will support comfortably.

By plotting the number of invocations versus execution time, you can graph how a multitasking load varies with response time. See figure 1 for a plot of the results of table 3 in this manner. With fast disks the graph should be linear, with a change in slope when there are more processes than can remain concurrently in memory.

Listing 5a: A *benchmark to create and write a disk file.*

```
/*
 *                UNIX Operating System Implementation Test #5a
 *
 *  This portion of the disk throughput benchmark creates and writes
 *  a 512x256 byte file. Since UNIX is so disk intensive, it is important
 *  to have some general idea of how fast (or slow) disk operations are.
 *
 *  Instructions:
 *     Compile by:              cc -O -s -o dwrite dwrite.c
 *
 *              The -O option says to use the optimizer.
 *              The -s option says to strip the namelist from the
 *                 object file after linking.
 *              The -o option says to place the object file in the file
 *                 specified by the next argument.
 *
 *     Time By:                 /bin/time dwrite
 *
 *     Results:
 *        The time to observe is the elapsed time, as we are trying to
 *        gauge disk throughput.
 *
 */

#include <stdio.h>

#define BLOCKS  256

main()
{
                /* the buffer for writing */
        char buffer[512];
                /* the filename */
        char *filename = "a_large_file";
                /* a counter to keep up with the blocks written */
        register int i;
                /* file descriptor for the disk file */
        int fildes;
                /* create the file */
        if ((fildes = creat(filename, 0640)) < 0) {
                printf("Cannot create file\n");
                exit(1);
        } else {
                close(fildes);
                        /* open the file for writing */
                if ((fildes = open(filename, 1)) < 0) {
                        printf("Cannot open file\n");
                        exit(1);
                }
        }
        for (i = 0; i < BLOCKS; i++)
                        /* write the file, one block at a time */
                if (write(fildes, buffer, 512) < 0) {
                        printf("Error writing block %d\n", i);
                        exit(1);
                }
                /* close the file now that we're done */
        close(fildes);
}
```

Listing 5b: A *benchmark to randomly read the disk file created by listing 5a.*

```
/*
 *           UNIX Operating System Implementation Test #5b
 *
 *  This portion of the benchmark opens and reads a 256x512 byte
 *  file. This benchmark uses a random instead of sequential access
 *  read, since the majority of disk access is random. Due to differences
```

(continued)

```
 * in the rand() routine between UNIX versions, you need to determine if
 * the rand() on the machine to be tested generates numbers in the range
 * 0 — 2^15 or in the range 0 — 2^31, and compile the benchmark accordingly.
 *
 * Instructions:
 *    Compile By:          cc -DSIXTEEN -O -s -o dread dread.c
 *              for machines with rand() in the range 0 — 2^15
 *
 *                         cc -DTHIRTYTWO -O -s -o dread dread.c
 *              for machines with rand() in the range 0 — 2^31
 *
 *              The -O option says to use the optimizer.
 *              The -s option says to strip the namelist from the
 *                  object file after linking.
 *              The -o option says to place the object file in the file
 *                  specified by the next argument.
 *
 *    Time By:             /bin/time dread
 *
 *    Results:
 *         The time to observe is the elapsed time, as we are trying to
 *         gauge disk throughput.
 *
 */

#include <stdio.h>

#define BLOCKS 256

long lseek();

main()
{
                /* the buffer for writing */
        char buffer[512];
                /* the filename */
        char *filename = "a_large_file";
                /* a counter counting blocks read */
        register int i;
                /* the file descriptor */
        int fildes;
                /* offset to seek into file */
        long int offset;

                /* open the file */
        if ((fildes = open(filename, 0)) < 0) {
                printf("Cannot find '%s'. Run 'dwrite' first.\n", filename);
                exit(1);
        }

        for (i = 0; i < BLOCKS; i++) {
                        /* pick a byte, any byte */
#ifdef SIXTEEN
                offset = (long)rand() * 4L;
#endif
#ifdef THIRTYTWO
                offset = (long)rand() / 16384L;
#endif
                        /* seek to it */
                if (lseek(fildes, offset, 0) < 0L) {
                        printf("Lseek to %ld failed i=%d\n", offset, i);
                        exit(1);
                }
                        /* read a block, starting with the current byte */
                if (read(fildes, buffer, 512) < 0) {
                        printf("Error reading block at byte %ld\n",offset);
                        exit(1);
                }
        }
                /* get rid of the file */
        unlink(filename);
}
```

A short benchmark that tests incrementing and looping is shown in listing 7. It originally appeared on UNIX USENET news (article megatest.186) in February 1983. This little benchmark tests long integer arithmetic (increment and test) and is totally processor bound. It is a lot like the functional benchmarks shown earlier; it tests long integer arithmetic but does little else. It could be improved by multiplying by 2, dividing by 2, adding 2, and then subtracting 1 to better test long integer arithmetic functions. The benchmark is presented here in its original form because I had already tested a number of machines with that particular version. See the results in table 1.

Results

A lot has happened in the last nine months during which this article was written. Several UNIX implementations now exist for the IBM PC. Microcomputer UNIX systems continue to infiltrate the business environment, and the UNIX application-software market seems to be developing at a good pace. Both DEC and IBM have embraced UNIX as an alternative to their own proprietary operating systems, which lends legitimacy to the claim that UNIX is an industry-standard operating system. There does not yet seem to be a clear winner in the UNIX microcomputer marketplace though several vendors are in the forefront of the cost/performance ratio contest.

Judging from the systems I've seen, the best performance comes from the Altos 586. It has less memory and fewer I/O ports than the Altos 986 but is otherwise identical. For about $10,000, you get an excellent multiuser UNIX system (512K-byte RAM, 40-megabyte [formatted] Winchester, and six serial ports) that under moderate load approaches DEC VAX performance for most tasks that a user would normally invoke. Some may argue that if the operating system isn't spelled U-N-I-X, it isn't real UNIX. That's just not the case. Altos XENIX *is* Version 7 UNIX with some useful extensions, including a screen-oriented editor, record and file locking, and semaphores. Although AT&T no longer markets Version 7 UNIX, it is well established in the marketplace and will be around for quite a while.

(continued)

The Sun-2/120 and Masscomp computers *are* VAX-class machines, but their cost is beyond the reach of most prospective microcomputer owners. They both offer superb graphics and excellent response time under loading.

The TRS-80 16B is a usable multiuser microcomputer system, but its response time is hindered by the relatively slow internal 15-megabyte Winchester. Thus, depending upon the applications run, it may not be desirable for more than a two-user load.

The SCI-1000 system benchmarked is still under development, and the times reported here should not be taken as gospel. This system, with an 80186 chip, has the potential for better performance than the Altos 586 at less cost and offers System III UNIX.

IBM's UNIX, PC/IX, was not developed in house. It is a System III port with added features (a vi-like full-screen editor) done by Interactive Systems Corporation. It is a complete, usable single-user implementation that does what can be done with the 8088. It's interesting to note that both IBM PC (16-/8-bit 8088) implementations performed better than did the old reliable 16-bit F-11 chip used in the PDP-11/23 and DEC Professional.

The Omnibyte OB68K with Idris was one of the first UNIX work-alike systems around. As such, the implementation is not the de facto Version 7 standard. I understand that a new version of Idris is coming out (to borrow a phrase from Jerry Pournelle) Real Soon Now for the Omnibyte that increases performance substantially.

The VENIX implementations on the DEC Professional and IBM PC perform adequately but seem to have a problem with multiple background processes. Although it makes sense to limit the number of processes a user may have on a multiuser minicomputer, it doesn't make much sense to impose those

Listing 6a: A *general-purpose shell benchmark. The shell script shown is contained in a file called* tst.sh *and is invoked by* /bin/time /bin/sh tst.sh.

```
sort >sort.$$ <</*EOF
Now
is
the
time
for
all
good
men
to
come
to
the
aid
of
their
country
/*EOF
od sort.$$ | sort -n +1 > od.$$
grep the sort.$$ | tee grep.$$ | wc > wc.$$
rm sort.$$ grep.$$ od.$$ wc.$$
```

Listing 6b: A *multitasking benchmark with a variable number of background processes. This shell script is contained in a file called* multi.sh. *The number of concurrent processes created is determined by the number of command-line parameters, such as* /bin/time /bin/sh multi.sh 1 2 3.

```
for i
do
        echo $i
        /bin/sh tst.sh &
done
wait
```

limits on a microcomputer that will probably never be used by more than one person. What's more, no message is given the user when the number of processes reaches the per-user process limit. Instead, quite literally, nothing happens. Granted that the multitasking benchmark is a little esoteric, it is the only way to simulate a multiuser/multitasking load short of having multiple users and is a good measure of how efficiently or inefficiently competing background processes are handled.

And then there's Apple's Lisa. Due to disk I/O limitations, Lisa's in a class by herself when it comes to disk-intensive tasks, as can be easily seen from figure 1. This exemplifies my claim that disk I/O is the single most limiting factor in overall response time and system throughput. If Apple could improve the disk throughput for Lisa to the same as an Altos, Lisa would rival the Altos in the best-value category, not to mention the possibility of excellent graphics.

It should be noted that some of the systems above that were implied to be single-user are really multiuser, but the response time is such that they would not be usable in a multiuser environment. This is the case with such computers as the IBM PC, DEC Professional, and Apple Lisa.

Conclusions

Some words of caution: a few microcomputer systems that claim to be

(continued)

Table 2: *The shell benchmark run sequence.*

```
/bin/time /bin/sh multi.sh 1
/bin/time /bin/sh multi.sh 1 2
/bin/time /bin/sh multi.sh 1 2 3
/bin/time /bin/sh multi.sh 1 2 3 4
/bin/time /bin/sh multi.sh 1 2 3 4 5
/bin/time /bin/sh multi.sh 1 2 3 4 5 6
```

Table 3: *Results for the multitasking* UNIX *benchmark in listing 6b with a variable number of background processes. The data are the elapsed (real) times for the benchmark to complete. The table is sorted on the fastest execution times with six background processes (the last column) where possible.*

System			Elapsed (Real) Time in Seconds					
			Number of Concurrent Processes					
No.	Machine	UNIX Version	1	2	3	4	5	6
1	VAX-11/780	4.1 BSD	4.3	5.5	7.8	9.0	11.0	13.8
2	VAX-11/750	4.1 BSD	4.3	5.5	8.8	10.3	13.3	15.0
3	PDP-11/70	2.8 BSD	5.0	7.8	9.3	11.8	14.3	16.7
4	Masscomp	Sys III+	4.2	5.5	9.1	11.8	14.5	17.8
5	Sun-2/120	4.2 BSD	3.6	6.2	8.7	11.8	14.4	18.0
6	Altos 986	XENIX	6.3	7.3	9.3	19.3	27.2	36.0
7	TRS-80 16B	XENIX	20.0	24.5	33.0	56.5	1:10.5	1:39.3
8	SCI-1000	Sys III+	15.1	28.6	51.8	1:17.4	1:34.8	1:57.2
9	PDP-11/23	V7	22.3	37.3	52.3	1:14.8	1:31.0	2:05.0
10	IBM PC XT	PC/IX	10.6	23.4	42.8	1:14.1	1:24.2	2:10.7
11	Apple Lisa	Sys III+	38.1	1:14.8	1:54.5	2:34.2	3:14.6	3:48.6
12	PDP-11/23	VENIX	14.0	32.8	—	—	—	—
13	IBM PC XT	VENIX/86	15.0	23.5	39.0	—	—	—
14	DEC Pro/350	VENIX	26.0	41.0	1:22.3	—	—	—
15	Omnibyte	Idris 1.2(•)	—	—	—	—	—	—

\+ Indicates UNIX System III plus some Berkeley enhancements.
– Indicates a benchmark that would not complete.
• The Idris shell command **wait** did not appear to function properly, and thus the benchmark could not be run.

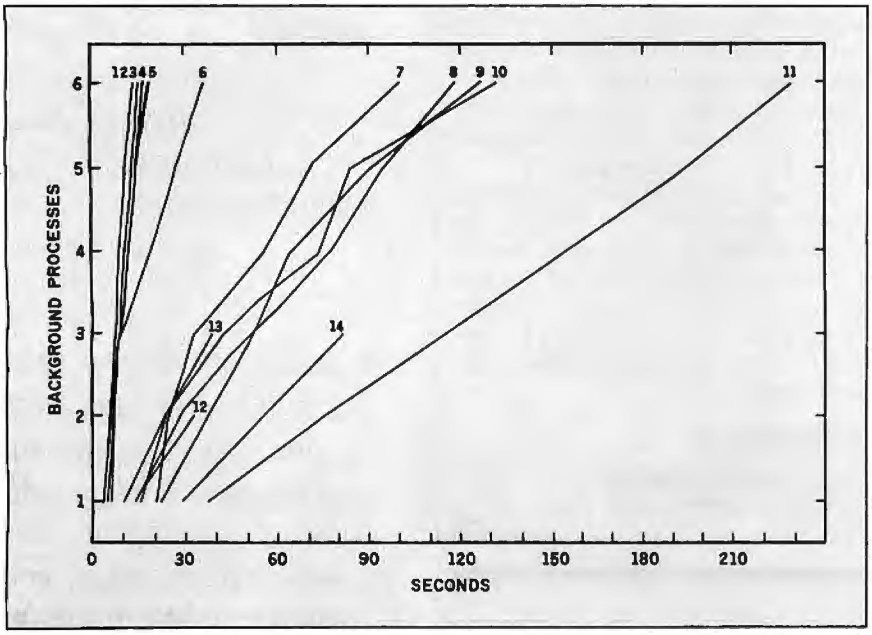

Figure 1: A *graph of the multitasking benchmark data in table 2 with the number of background processes versus elapsed time for each computer. The numbers at the top of each line correspond to the computers as listed in table 3. It is interesting to note the cluster of high-performance systems on the left-hand side and the cluster of other systems on the right.*

Listing 7: A *simple benchmark to test incrementing and looping.*

```
/*
 *          UNIX Operating System Implementation Test #7
 *
 * This program tests long integer incrementation. It is
 * taken from USENET news article "megatest.186".
 *
 * Instructions:
 *    Compile by:              cc -O -s -o loop loop.c
 *
 *          The -O option says to use the optimizer.
 *          The -s option says to strip the namelist from the
 *              object file after linking.
 *          The -o option says to place the object file in the file
 *              specified by the next argument.
 *
 *    Time by:                 /bin/time loop
 *
 *    Results:
 *       Although not very significant, it does say something about the
 *       speed of the processor, since the compiler would hopefully
 *       compile the "i++" as an INCR instruction and not an ADD
 *       instruction. The benchmark is presented here for historical
 *       reasons.
 *
 */

main()
{
    long i;
    for (i = 0; i < 1000000; i++)
        ;
    printf("Done\n");
}
```

multiuser and UNIX-like do not swap. That is, they cannot swap a process out to disk and bring in another user's process. A system that cannot swap is neither truly multiuser nor UNIX-like. When a process runs out of primary memory in these systems, it dies. These implementations are substantially cheaper than most others, so be suspicious of low-cost UNIX-like systems.

As mentioned earlier, some systems implement a relatively low predefined limit on the amount of memory or number of processes one user can have, regardless of other system activity (or inactivity). Once this limit is exceeded, activity grinds to a halt, as a deadlock has been reached. Each blocked process (blocked in the sense that it is waiting for resources before it can continue) is waiting for the other to terminate before it can continue. If you plan to be an active user on a small multiuser system in a single-user environment, look out for this. The multitasking benchmark in listing 6b will usually bring any problems to light.

Knowledgeable 4.1 BSD and 4.2 BSD users should beware of systems that claim to have Berkeley enhancements. This means that the Berkeley version of some UNIX commands have been added. For example, most so-called Berkeley-enhanced systems include the **termcap** (terminal capability) database, **more** (a utility that prints files one screen at a time), and a version of ls (a utility to list the files in a directory) that lists files across, rather than down the screen. Don't expect to find the **newtty** driver and the job-control facilities of real Berkeley UNIX systems.

If you're considering a UNIX microcomputer, remember that response doesn't always vary linearly with load (even on large UNIX systems). This is due to several factors, most notably available real memory and disk-access speed. If you plan to add a user or two later, test the prospective system now. Find out if the hardware can support additional memory and/or faster disks.

The benchmarks presented here try not to be blind to what users do at the keyboard (not all users execute programs similar to the Sieve of Eratosthenes), but they do try to evaluate operating-system features that are routinely used. By explaining how benchmarks should be developed, this article

Benchmark the specific kinds of things you will be doing as well as overall performance.

has tried to dispel the myth that all benchmarks do is see how fast a machine can crunch numbers (e.g., the Whetstone benchmark has not been mentioned).

Of course, benchmark results are not the only means to judge microcomputers. Clear and sufficient documentation, a solid customer base, and good product-support history are also important. If you do perform benchmarks on systems you are considering purchasing, try to benchmark the specific kinds of things you will be doing as well as overall performance in case your needs change. This sounds incredibly obvious, but many people have been disappointed by systems purchased yesterday that don't meet their needs today. ■

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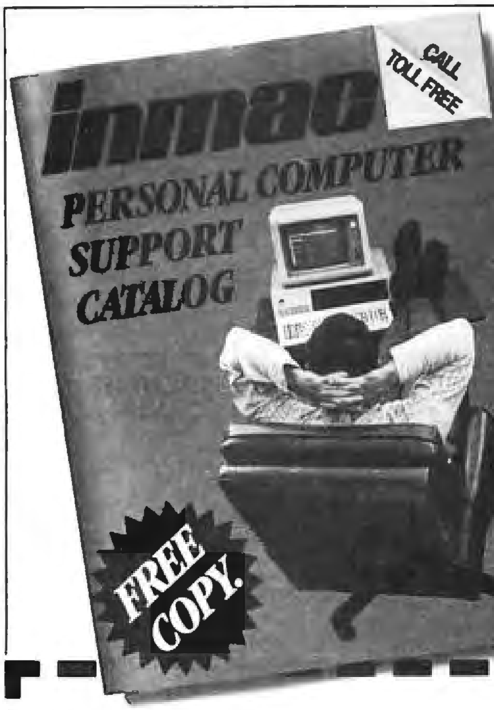

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Table 3: *FORTH-83 modifications to the required word set. (For an explanation of the abbreviations used in the stack diagrams, see table 7.) The pronunciation is in parentheses next to the FORTH word. A star (☆) indicates a new FORTH word.*

("sharp")
Stack: (*+d1 — +d2*)
Modifications: stack diagram modified; usage outside of <# ... #> is unrestricted

---

#S ("sharp-s")
Stack: (*+d — 0 0*)
Modifications: stack diagram modified; usage outside of <# ... #> is unrestricted

---

#TIB ("number-t-i-b")☆
Stack: (— *addr*)
New definition: user variable, containing the byte length of the text input buffer

---

' ("tick")
Stack: (— *addr*)
Format: ' *<name>*
New definition: leave the compilation address *addr* of *<name>*, which must be found within the current search order; note that ' is no longer an immediate word

---

(("paren")
Stack: (—)
(—) (compiling)
Format: (*ccc*)
New definition: comment characters *ccc*, up to the ")" delimiter, are not processed; the zero or more comment characters must be entirely contained within the remaining input stream

---

***/** ("times-divide")
Stack: (*n1 n2 n3 — n4*)
New definition: multiply *n1* by *n2* to form an intermediate 32-bit value, then divide by *n3*; result *n4* is the floored quotient, rounded toward negative infinity; forces an error for *n3* equal to 0 or *n4* out of range

---

***/MOD** ("times-divide-mod")
Stack: (*n1 n2 n3 — n4 n5*)
New definition: multiply *n1* by *n2* to form an intermediate 32-bit value, then divide by *n3*; result *n4* is the remainder, with the same sign as *n3* if nonzero; result *n5* is the floored quotient rounded toward negative infinity; forces an error for *n3* equal to 0 or *n5* out of range

---

+LOOP ("plus-loop")
Stack: (*n* —)
(*sys* —) (compiling)
Format: : ... **DO** ... **+LOOP** ... ;
New definition: immediate word to add *n* to the loop index; terminate the loop if the index was incremented over the (limit-1) to limit boundary (otherwise, repeat the loop); the error-check value *sys* is left by **DO** during compilation

---

, ("comma")
Stack: (*16b* —)
Modifications: stack diagram modified; definition clarified to indicate that *16b* is compiled at the top of the dictionary

---

." ("dot-quote")
Stack: (—)
(—) (compiling)
Format: : *<name>* ... ." ccc" ... ;
New definition: immediate word to output the character string *ccc*, up to the delimiting "quote" character, during execution of *<name>*

.(("dot-parens")☆
Stack: (—)
(—) (compiling)
Format: .(*ccc*)
New definition: immediate word to output the character string *ccc*, up to the delimiting ")" character

(continued from page 138)

resulting in 65,536 passes before detection of the necessary transition.

Execution of **LEAVE** in FORTH-79 sets the loop index to the limit value, causing termination at the next **LOOP** or **+LOOP**. FORTH-83's **LEAVE** jumps control to the first word beyond the next **LOOP** or **+LOOP**, without executing any words between **LEAVE** and **LOOP** or **+LOOP** during the final pass.

Relationals in the new standard use true arithmetic comparisons. Some older FORTH implementations (but not FORTH-79) use a 64K-byte number circle for comparisons as well, so that a relational test such as

```
-30000 30000 <
```

returns an incorrect result. FORTH-83's arithmetic comparisons instead must use a "number line" from the lowest to the highest permissible operand values, providing proper results in all cases.

FORTH-83 comparisons that result in a Boolean true flag leave a value of −1 (FFFF hexadecimal in 2's complement notation) rather than FORTH-79's value of 1 (01 hexadecimal). Although these definitions are shown as changed in the standard, it is the definition of "true flag" that has been revised. Many FORTH-79 applications use comparison flags arithmetically and may not operate properly with the new "true" value. Any nonzero value is still accepted as a true flag when used as an operand, though. **NOT** now leaves the 1's complement of a numeric operand and is no longer equivalent to **0=** .

Buffer Restrictions

Mass-storage buffer areas, frequently used as scratch pads between FORTH-79 disk accesses, are restricted in FORTH-83. The definition of **BLOCK** now specifies that buffer contents may not be changed unless that change can be transferred to mass storage. FORTH-79's **EMPTY-BUFFERS** has been relegated to the reference word set because FORTH-83 buffers by definition contain only data to be saved by **SAVE-BUFFERS**, **UPDATE**, or **FLUSH**. **FLUSH**, new to FORTH-83, saves all buffer contents before unassigning all buffers; this permits disks to be changed during processing without the chance of data or source code being placed on

(continued)

/ ("divide")
Stack: (*n1 n2 — n3*)
New definition: divide *n1* by *n2*, leaving the floored quotient *n3* rounded toward negative infinity; forces an error if *n2* equals 0 or *n3* is out of range

/MOD ("divide-mod")
Stack: (*n1 n2 — n3 n4*)
New definition: divide *n1* by *n2*, leaving the floored quotient *n4* rounded toward negative infinity; remainder *n3* has the same sign as *n2* if nonzero; forces an error if *n2* equals 0 or *n4* is out of range

0< ("zero-less")
Stack: (*n — flag*)
New definition: leave a true flag (−1) if *n* is less than 0

0= ("zero-equals")
Stack: (*w — flag*)
New definition: leave a true flag (−1) if *w* equals 0

0> ("zero-greater")
Stack: (*n — flag*)
New definition: leave a true flag (−1) if *n* is greater than 0

2/ ("two-divide")☆
Stack: (*n1 — n2*)
New definition: the operand is shifted 1 bit right arithmetically, including the sign bit

: ("colon")
Stack: (*— sys*)
Format: : . . . ;
Modifications: stack diagram modified; vocabulary references changed to comply with FORTH-83 search order

< ("less-than")
Stack: (*n1 n2 — flag*)
New definition: leave a true flag (−1) if *n1* is less than *n2*

= ("equals")
Stack: (*w1 w2 — flag*)
New definition: leave a true flag (−1) if *w1* equals *w2*

> ("greater-than")
Stack: (*n1 n2 — flag*)
New definition: leave a true flag (−1) if *n1* is greater than *n2*

>BODY ("to-body")☆
Stack: (*addr1 — addr2*)
New definition: leave the parameter field address *addr2* of the word whose compilation address is *addr1*

?DUP ("question-dupe")
Stack: (*16b — 16b 16b*) or (0 — 0)
Modifications: stack diagram modified and pronunciation changed

ABORT" ("abort-quote")☆
Stack: (*flag —*)
(—) (compiling)
Format: : *<name>* . . . **ABORT"** *ccc"* . . . ;
New definition: immediate word to output the character string *ccc* (up to the delimiting "quote") and initiate a system-dependent abort if flag is true when *<name>* is executed; the abort routine must at least include all functions of **ABORT**

BASE
Stack: (*— addr*)
New definition: user variable containing the current I/O radix, in the range of 2 to 72

(continued)

BLOCK
Stack: (*u* — *addr*)
New definition: assign the buffer whose first data byte is at *addr* to block *u* and transfer the data if the block is not already in a buffer; prior contents of the buffer are saved to disk if the update bit is set; if block *u* is already in a buffer, *addr* points to it and no data is transferred; buffer contents must be storable (only the data within the last buffer referenced by **BLOCK** or **BUFFER** is valid)

BUFFER
Stack: (*u* — *addr*)
New definition: similar to **BLOCK** except that block *u* might not be transferred to the buffer if not already in memory; the contents of the buffer after execution are unspecified

CMOVE> ("c-move-up")☆
Stack: (*addr1 addr2 u* —)
New definition: move *u* bytes, starting with the byte at (*addr1* + *u* – 1) to (*addr2* + *u* – 1) and proceeding toward low memory; no bytes are moved if *u* is 0

COMPILE
Stack: (—)
Format: : <*name1*> . . . **COMPILE** <*name2*> . . . ;
New definition: during execution of <*name1*> , compile the compilation address of the nonimmediate word <*name2*> into the top of the dictionary

CONSTANT
Stack: (*16b* —)
Format: **CONSTANT** <*name*>
New definition: compile the definition of <*name*> such that later execution of <*name*> leaves *16b* on the stack

D< ("d-less-than")
Stack: (*d1 d2* — *flag*)
New definition: leave a true *flag* (–1) if *d1* is less than *d2*

DEFINITIONS
Stack: (—)
New definition: make the compilation vocabulary the same as the vocabulary now first in the search order

DO
Stack: (*w1 w2* —)
(— *sys*) (compiling)
Formats: : . . . **DO** . . . **LOOP** . . . ;
: . . . **DO** . . . **+LOOP** . . . ;
New definition: immediate word to begin an indexed loop, with initial value *w2* and limit value *w1*; all **DO** loops are performed at least once; *sys* is balanced during compilation by **LOOP** or **+LOOP** ; force an error if space is not available for at least three levels of nesting

DOES>
Stack: (— *addr*)
(—) (compiling)
Format: : <*name1*> . . . <*create*> . . . **DOES>** . . . ;
New definition: immediate word to define the execution behavior of any later word <*name2*> defined using <*name1*> ; the <*create*> may be **CREATE** or any user-defined word that executes **CREATE** ; later execution of <*name2*> places <*name2*>'s parameter field address on the stack before executing the sequence of words between **DOES>** and ; in <*name1*>'s definition

EMIT
Stack: (*16b* —)
New definition: display the ASCII character defined by the lowest 7 bits of *16b* on the current output device; if additional bits are available for display in an environmentally-dependent manner, all must be displayed

EXPECT
Stack: (addr +n —)
New definition: store characters beginning at *addr* until a "return" is encountered or *+n* characters have been stored; the "return" is not stored but is displayed (along with all received characters) as a blank

FIND
Stack: (*addr — addr2 n*)
New definition: for a string with a count byte at *addr1*, search for a matching word name using the current search order; if found, *addr2* is the matching word's compilation address; *n* is 1 if the word is immediate (or −1 otherwise); if no match is found, *addr2* is the same as *addr1* and *n* equals 0

FLUSH ☆
Stack: (—)
New definition: unassign all block buffers after executing a sequence equivalent to the **SAVE-BUFFERS** operation

FORGET
Stack: (—)
Format: **FORGET** *<name>*
New definition: delete *<name>* and all later-defined words; force an error if *<name>* is not within the current search order or if the compilation vocabulary is removed

FORTH
Stack: (—)
New definition: make **FORTH** the first vocabulary in the search order; not immediate

FORTH-83 ☆
Stack: (—)
New definition: force an error condition if the operating environment is not a FORTH-83 standard system

HOLD
Stack: (*char* —)
Modification: usage outside of <# ... #> is unrestricted

KEY
Stack: (— *16b*)
New definition: receive the ASCII character defined by the lowest 7 bits of *16b* on the current input device; all ASCII codes are permitted; characters are not displayed, nor are control characters processed

LEAVE
Stack: (—)
(—) (compiling)
Formats: : *<name>* ... **DO** ... **LEAVE** ... **LOOP** ... ;
: *<name>* ... **DO** ... **LEAVE** ... **+LOOP** ... ;
New definition: immediate word, to transfer execution of *<name>* to the first word beyond **LOOP** or **+LOOP** ; **LEAVE** may appear multiple times or within other control structures

LITERAL
Stack: (— *16b*)
(*16b* —) (compiling)
Format: : *<name>* ... **LITERAL** ... ;
New definition: immediate word to compile a system-dependent operation; later execution of *<name>* leaves *16b* on the stack

LOOP ("loop")
Stack: (—)
(*sys* —) (compiling)
Format: : ... **DO** ... **LOOP** ... ;
New definition: immediate word to increment the current loop index by 1; terminate the loop if the index was incremented over the (limit-1) to limit boundary (otherwise, repeat the loop); the error check value *sys* is left by **DO** during compilation

(*continued*)

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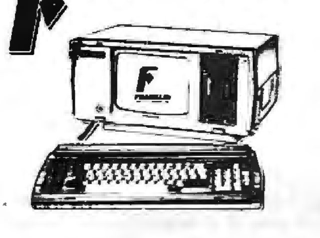

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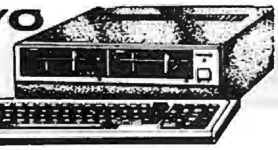

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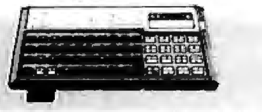

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MOD
Stack: (*n1 n2* — *n3*)
New definition: divide *n1* by *n2*; the remainder of *n3* has the same sign as *n2* if nonzero; force an error if *n2* equals 0 or *n3* is out of range

NOT
Stack: (*16b1* — *16b2*)
New definition: leave the one's complement of *16b1*

PAD
Stack: (— *addr*)
New definition: leave a pointer to the first byte of a floating scratch-pad area; the area must contain at least 84 bytes

PICK
Stack: (*+n* — *16b*)
New definition: leave a copy of the *n*th stack location, not counting the location containing the *+n* operand; the operand is zero-based, so that **DUP** is equivalent to 0 **PICK**, and **OVER** is equivalent to 1 **PICK**

ROLL
Stack: (*+n* —)
New definition: roll the *n*th (not counting the position occupied by *+n*) stack location's contents to the top of the stack, moving all intervening values down one location; the *+n* operand is zero-based, thus **ROT** is equivalent to 2 **ROLL** and 0 **ROLL** is a null operation

SIGN
Stack: (*n* —)
Modification: usage outside of < ... ... > and colon definitions is unrestricted

SPAN ☆
Stack: (— *addr*)
New definition: user variable containing the number of characters received and stored by the last execution of **EXPECT** .

STATE
Stack: (— *addr*)
Modification: contents may not be modified by a program

TIB ("t-i-b")☆
Stack: (— *addr*)
New definition: leave a pointer to the first byte of the terminal input buffer; length of the buffer must be at least 80 characters

U< ("u-less-than")
Stack: (*u1 u2* — *flag*)
New definition: leave a true flag (−1) if *u1* is less than *u2*

UM* ("u-m-times")☆
Stack: (*u1 u2* — *ud*)
New definition: leave the unsigned double-precision product of *u1* and *u2*

UM/MOD ("u-m-divide-mod")☆
Stack: (*ud u1* — *u2 u3*)
New definition: leave the remainder *u2* and floored quotient *u3* of *ud* divided by *u1*; force an error if *u1* equals 0 or *u3* is out of range

VOCABULARY
Stack: (—)
Format: **VOCABULARY** <*name*>
New definition: compile a definition for <*name*> to initiate a new vocabulary; later execution of <*name*> makes it the first vocabulary in the search order; the sequence <*name*> **DEFINITIONS** makes <*name*> the compilation vocabulary, to which new definitions are linked; <*name*> is not immediate

WORD	
Stack:	(*char* — *addr*)
New definition:	parses the next word delimited by *char* (ignoring any leading instances) or the end of the input stream and stores it with its count bytes at *addr*; a blank is appended to the character string but is not included in the count; the count equals 0 if the input stream is already exhausted; the pointer in **>IN** is updated to indicate the character after the final delimiter
['] ("bracket-tick")☆	
Stack:	(— *addr*)
	(—) (compiling)
Format:	: <*name1*> . . . ['] <*name2*> . . . ;
New definition:	immediate word to compile the compilation address *addr* of <*name2*> as a literal in the definition of <*name1*> ; later execution of <*name1*> leaves *addr* on the stack

Table 4: *FORTH-83 modifications to the double-number* (32-*bit*) *word set.* (*For an explanation of the abbreviations used in the stack diagrams, see table* 7.) *The pronunciation is in parentheses next to the FORTH word. A star* (☆) *indicates a new FORTH word.*

2CONSTANT ("two-constant")	
Stack:	(*32b* —)
Format:	**2CONSTANT** <*name*>
New definition:	create a dictionary definition for <*name*>, which executes by leaving *32b* on the stack
D.R ("d-dot-r")	
Stack:	(*d*+*n* —)
New definition:	output *d* in the current radix, right justified in a field of +*n* characters; force an error condition if the field width is insufficient
D0 = ("d-zero-equals")	
Stack:	(*wd* — *flag*)
New definition:	leave a true flag (−1) if *wd* is 0
D2/ ("d-two-divide")☆	
Stack:	(*d1* — *d2*)
New definition:	the operand *d1* is shifted one bit right arithmetically, including the sign bit
D< ("d-less-than")	
Stack:	(*d1 d2* — *flag*)
New definition:	leave a true flag (−1) if *wd1* is less than *wd2*
D= ("d-equals")	
Stack:	(*wd1 wd2* — *flag*)
New definition:	leave a true flag (−1) if *d1* is less than *d2*
DABS ("d-absolute")	
Stack:	(*d* — *ud*)
Modifications:	stack diagram modified; pronunciation changed
DU< ("d-u-less")	
Stack:	(*ud1 ud2* — *flag*)
New definition:	leave a true flag (−1) if *ud1* is less than *ud2*

the new disk by mistake.

All mass-storage buffer assignments are in an installation-dependent sequence rather than the rotation specified by FORTH-79 to assign a block to the buffer accessed least recently. In FORTH-79, **BUFFER** can be used to assign a buffer to a specific disk block without actually transferring the block from disk. The FORTH-83 version of **BUFFER** may (but needn't, depending on the installation) actually transfer the specified block from disk to buffer. As a result, buffer contents after execution of **BUFFER** are unspecified in FORTH-83.

The data (parameter) stack-manipulating words **PICK** and **ROLL** have been changed from 1-origin to 0-origin form. In other words, the FORTH-83 sequence **2 ROLL 4 PICK** is equivalent to FORTH-79's **3 ROLL 5 PICK** . Definitions for all required words with stack operands or results have been more closely defined, using the value types listed in table 7. FORTH-79 and FIG-FORTH both suffer from poorly specified stack operands; for example, earlier definitions of **DROP** specify a signed single-precision operand, yet they also work perfectly well for unsigned numerics or ASCII (American National Standard Code for Information Interchange) values. The FORTH-83 version indicates that any arbitrary 16-bit value (one stack position) can be properly used. Similar revisions throughout FORTH-83's required and extension word sets remove many ambiguities and greatly enhance the internal consistency of the language (see table 2).

I/O words have been redefined to permit coding for I/O-device selection, input-line editing, output control codes, and other "environmentally dependent" operations. To be labeled compatible with the FORTH-83 standard, however, programs must keep all environmentally dependent word definitions in an isolated set, with full documentation.

The input stream from the terminal is now directly accessible, using the buffer whose address is given by **TIB** and whose length (80 characters or more) is specified by the user variable **#TIB** . Unlike FORTH-79, FORTH-83 does not add ASCII nulls to delimit the end of an input stream. Instead, the new user-variable **SPAN** holds the count of the characters actually received and stored by the last execution of **EXPECT** .

Numeric I/O may be received and transmitted in any radix up to 72; FORTH-79 has a limit of 70. Pictured numeric output words, **#** , **#S** , **HOLD** , and **SIGN** are no longer restricted to use between **<#** and **#>** , and **SIGN** may also appear outside of colon definitions if desired. The floating scratch-pad area designated by **PAD** is now at least 84 characters rather than 64.

FORTH-79 has several immediate "state smart" words; their execution differs depending upon whether the system is compiling or executing (specified by the value of user-variable **STATE**). Some words have been made "state

(continued)

Table 5: *FORTH-83 system-extension word set. (For an explanation of the abbreviations used in the stack diagrams, see table 7.) The pronunciation is in parentheses next to the FORTH word.*

<MARK ("backward-mark")
Stack: (— *addr*)
Format: : <*name*> ... **<MARK** ... ;
Definition: leave the pointer *addr* to the destination of a backward branch; the pointer is primarily for later use by **<RESOLVE**

<RESOLVE ("backward-resolve")
Stack: (*addr* —)
Format: : <*name*> ... **<RESOLVE** ... ;
Definition: used after **?BRANCH** or **BRANCH** at the source of a backward branch to compile a branch address using the destination pointer *addr*

>MARK ("forward-mark")
Stack: (— *addr*)
Format: : <*name*> ... **>MARK** ... ;
Definition: used after **?BRANCH** or **BRANCH** at the source of a forward branch at *addr* to compile space for a pointer to the destination; the pointer is primarily for later use by **>RESOLVE**

>RESOLVE ("forward-resolve")
Stack: (— *addr*)
Format: : <*name*> ... **>RESOLVE** ... ;
Definition: used at the destination of a forward branch to compile a branch offset in the space left by **>MARK** , using the source pointer *addr*

?BRANCH ("question-branch")
Stack: (*flag* —)
Format: : <*name*> ... **COMPILE ?BRANCH** ... ;
Definition: in the specified format, compile a conditional branch operation; a branch address must immediately follow; it is usually compiled by **<RESOLVE** (backwards branch) or **>MARK** (forward branch); later execution of <*name*> ignores the branch if flag is true or executes the branch if flag is false

---

BRANCH
Stack: (—)
Format: : <*name*> ... **COMPILE BRANCH** ... ;
Definition: in the specified format, compile an unconditional branch operation; a branch address must immediately follow; it is usually compiled by **<RESOLVE** (backward branch) or **>MARK** (forward branch)

CONTEXT
Stack: (— *addr*)
Definition: user variable specifying the dictionary search order

---

CURRENT
Stack: (— *addr*)
Definition: user variable specifying the vocabulary to receive new word definitions

dumb" in FORTH-83, and programs are also prohibited from changing the value of STATE. Both ." and LITERAL may now appear only within colon definitions. FORTH-83's ' ("tick") is no longer immediate; it's supplemented by the immediate word ['] to compile a compilation address within a colon definition. The new immediate word .(displays the characters that follow up to the delimiting right parenthesis, during compilation or execution. Both compilation and run-time stack diagrams are now specified for FORTH-83's immediate words, and all references to separate run-time code have been removed.

FORTH-83 defining words have not escaped change. The definition of DOES> has been expanded to permit use not only with CREATE but also with any user-defined word that executes CREATE.

Vocabulary creation, searching, and deletion have always been problem areas for FORTH, and that tradition, unfortunately, continues in FORTH-83. FORTH-79's **CONTEXT** and **CURRENT** user variables have been moved to the new system-extension word set, along with words to mark and resolve branch operations within colon definitions. The word-name that serves as an operand following FORGET must now be found in the compilation vocabulary (called the "current" vocabulary in FORTH-79) that receives new definitions; FORTH-79 permits the specified word to be in either the current or the FORTH vocabulary.

The default search order still begins with the last executed ("context") vocabulary and ends with FORTH, but now it may be changed in a system-dependent manner. All further references to chaining have been removed from VOCABULARY and search-related words.

The vocabulary search words FIND and WORD have been significantly changed in FORTH-83. FIND now requires an address operand pointing to the first (count) byte of a dimensioned string. If a matching word is found within the currently active search order, its compilation address is left on the stack; an additional value of –1 is left on top of the stack if the matching word is nonimmediate, or 1 if immediate. If no match is found, the result matches the address operand, and the value on top of the stack is a false flag (0). FORTH-83's version of WORD parses the next delimited word from the input stream, along with a preceding count byte, but the delimiter operand may now be specified as any ASCII character, including a null. The resulting string ends with a blank (not included in the count) rather than the actual delimiter found (as in FORTH-79).

Both FORTH-79 and FORTH-83 strongly restrict the user's direct access to many areas of memory. Programs are absolutely prohibited from addressing into the data or return stacks or any definition fields other than parameter fields stored by the application. One improvement of FORTH-83 is the addition of >BODY, which converts a word's compilation (code field) address to its parameter field address.

Conclusions

Due to the numerous variations, only relatively few FORTH-79 programs will

Table 6: *FORTH-83 modifications to the assembly-language extension word set. (For an explanation of the abbreviations used in the stack diagrams, see table 7.) The pronunciation is in parentheses next to the FORTH word.*

;CODE ("semicolon-code")	
Stack:	(—)
	(*sys1* — *sys2*) (compiling)
Format:	: <*name1*> ... <*create*> ... **;CODE** ... **END-CODE**
Modifications:	format modified to permit use with any user-defined word executing **CREATE** ; stack diagram added
ASSEMBLER	
Stack:	(—)
New definition:	make **ASSEMBLER** the first vocabulary in the search order: not immediate
CODE	
Stack:	(— *sys*)
Format:	**CODE** <*name*> ... **END-CODE**
New definition:	compile a code definition for <*name*> using **ASSEMBLER** , which is made the first vocabulary in the search order; the definition of <*name*> cannot be found by a dictionary search before execution of **END-CODE** , which uses the *sys* parameter
END-CODE	
Stack:	(*sys* —)
Format:	**;CODE** ... **END-CODE**
	CODE ... **END-CODE**
Modifications:	stack diagram changed; usage formats specified

Table 7: *Stack parameter types, ranges, and abbreviations for FORTH-83.*

Parameter Type	Width (bits)	Decimal Range	Abbreviation
Address	16	0 ... 65,535	*addr*
Arbitrary			
bit	1	0 ... 1	*b*
Boolean flag	16	0 (false), nonzero (true)	*flag*
byte	8	n.a.	*8b*
2 bytes	16	n.a.	*16b*
4 bytes	32	n.a.	*32b*
Boolean			
false	16	0	*false*
true	16	−1 (result), nonzero (operand)	*true*
Character	7	0 ... 127	*char*
Double-precision			
signed	32	−2,147,483,648 ... 2,147,483,647	*d*
positive	32	0 ... 2,147,483,647	*+d*
unsigned	32	0 ... 4,294,967,295	*ud*
arbitrary	32	−2,147,483,647 ... 4,294,967,295	*wd*
Single-precision			
signed	16	−32,768 ... 32,767	*n*
positive	16	0 ... 32,767	*+n*
unsigned	16	0 ... 65,535	*u*
arbitrary	16	−32,768 ... 65,535	*w*
System compilation (generated by system; normally used for error checking; width and range constraints do not apply)			*sys*

execute properly in a FORTH-83 environment without conversion; considering FORTH's often cryptic source code, conversion of application programs may require substantial effort. Of course, existing software can still be used under a FORTH-79 system.

Compliance with the FORTH-83 standard is necessary only to indicate if a system includes the required (or optional) word set(s) in source or object form; FORTH-83 applications are to execute equivalently on each standard system. The FORTH Standards Team has explicitly acknowledged that noncompliance is sometimes both beneficial and necessary and is entirely within the user's choice; publication of the standard was not intended to prevent the implementation, marketing, purchase, or use of noncomplying systems or programs.

In a language praised for its transportability, the abundance of competing—and generally incompatible—dialects may continue to be detrimental. Is FORTH-83 the final word? That would seem about as likely as Apple Computer building abacuses, or universal acceptance of COBOL as the ultimate programming language. There is no question that FORTH-83 is several steps ahead of earlier versions, but the scope of the revisions indicates a language still very much in flux. FORTH-85, -86, or -87 may be inevitable. ■

FOR MORE ON FORTH

Copies of the FORTH-79 and FORTH-83 standards are available from the FORTH Interest Group (FIG), POB 1105, San Carlos, CA 94070, (415) 962-8653. FIG also offers back issues of its journal, *FORTH Dimensions.*

The Orange County (CA) FIG offers a public-domain version of FORTH-83 on 8-inch CP/M, Apple, or IBM PC disks for $25. Contact Wil Baden, 325 Princeton, Costa Mesa, CA 92626.)

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COMPUTER PLAYGROUND, M. J. Winter. Chatsworth, CA: Datamost, 1983; 128 pages, 27.5 by 20.3 cm, softcover, ISBN 0-88190-108-3, $9.95.

COMPUTERS AND DATA PROCESSING, 2nd Ed., H. L. Capron and Brian K. Williams. Menlo Park, CA: Benjamin/Cummings Publishing, 1984; 490 pages, 20.5 by 26 cm, hardcover, ISBN 0-8053-2214-0, $26.95.

COMPUTERS FOR PROFESSIONAL PRACTICE, E. J. Neiburger. Waukegan, IL: Andent, 1984; 282 pages, 20.3 by 26.5 cm, softcover, ISBN 0-014555-00-6, $14.95.

EASY-TO-UNDERSTAND GUIDE TO HOME COMPUTERS, the editors of *Consumer Guide*. New York: Beekman House, 1984; 96 pages, 20.5 by 27.5 cm, spiral-bound, ISBN 0-517-42584-X, $3.98.

EASY-TO-UNDERSTAND GUIDE TO WORD PROCESSING, the editors of *Consumer Guide*. New York: Beekman House, 1984; 96 pages, 20.5 by 27.5 cm, spiral-bound, ISBN 0-517-39869-9, $3.98.

EVERYONE'S GUIDE TO BASIC, the editors of *Consumer Guide*. New York: Beekman House, 1984; 80 pages, 21 by 27.5 cm, spiral-bound, ISBN 0-517-41594-1, $4.98.

GAMES ATARIS PLAY, Hal Glicksman and Kent Simon. Chatsworth, CA: Datamost, 1983; 224 pages, 22.3 by 27.8 cm, spiral-bound, 0-88190-118-0, $14.95.

GRAPHICS PROGRAMMING ON THE IBM PERSONAL COMPUTER, J. Edward Volkstorf Jr. Englewood Cliffs, NJ: Prentice-Hall, 1984; 304 pages, 17.3 by 23.3 cm, softcover, ISBN 0-13-363219-9, $39.95.

HIVELY'S CHOICE, Wells Hively. St. Louis, MO: Hively's Choice Publications, 1984; 244 pages, 21.5 by 27.8 cm, softcover, ISBN 0-8454-8100-2, $19.95.

THE IBM COBOL ENVIRONMENT, Robert T. Grauer. Englewood Cliffs, NJ: Prentice-Hall, 1984; 400 pages, 18.3 by 24.3 cm, hardcover, ISBN 0-13-448654-4, $21.95.

IBM PC BASIC PROGRAMMING, Richard Haskell and Glenn A. Jackson. Englewood Cliffs, NJ: Prentice-Hall, 1984; 192 pages, 21.5 by 27.8 cm, softcover, ISBN 0-13-448424-X, $13.95.

IBM PCJR FAVORITE PROGRAMS EXPLAINED, Donald C. Kreutner. Indianapolis, IN: Que Corp., 1984; 208 pages, 18.5 by 23.5 cm, softcover, ISBN 0-88022-102-X, $12.95.

INVESTING WITH A COMPUTER, Herb Brooks. Princeton, NJ: Petrocelli Books, 1984; 148 pages, 14.4 by 21.3 cm, hardcover, ISBN 0-89433-194-9, $19.95.

KIDS AND THE IBM-PC / PCJR, Edward H. Carlson. Chatsworth, CA: Datamost, 1983; 240 pages, 22.3 by 27.3 cm, spiral-bound, ISBN 0-88190-265-9, $19.95.

KIDS TO KIDS ON THE COMMODORE 64, Sam Edge, Billy Sanders, and Kris Houser. Chatsworth, CA: Datamost, 1983; 160 pages, 27.3 by 20.8 cm, softcover, ISBN 0-88190-320-5, $9.95.

KIP'S ARMOR, Jay Danler. Twin Cities, MN: Treasure Hunters International, 1983; 108 pages, 13.8 by 21.5 cm, softcover, ISBN 0-916167-00-3, $11.95.

A LIBRARY OF SUBROUTINES, David S. Walonick. Glenview, IL: Scott, Foresman and Co., 1984; 128 pages, 18.5 by 23.5 cm, softcover, ISBN 0-673-15965-5, $19.95.

MICOS: A MICROPROGRAMMABLE COMPUTER SIMULATOR, Lubomir Bic. Rockville, MD: Computer Science Press, 1984; 128 pages, 15.3 by 22.5 cm, softcover, ISBN 0-914894-76-5, $15.95.

MS-DOS USER'S GUIDE, Chris DeVoney. Indianapolis, IN: Que Corp., 1984; 350 pages, 18.8 by 23.5 cm, softcover, ISBN 0-88022-061-9, $12.95.

MAKING THE MOST OF YOUR TRS-80 COLOR COMPUTER, Peter Vernon. Englewood Cliffs, NJ: Prentice-Hall, 1983; 200 pages, 15 by 23 cm, softcover, ISBN 0-13-547647-X, $19.95.

THIS IS A LIST *of books recently received at* BYTE *Publications. The list is not meant to be exhaustive, its purpose is to acquaint* BYTE *readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.*

MASTERING dBASE II THE EASY WAY. Paul W. Heiser. Englewood Cliffs, NJ: Prentice-Hall, 1984; 240 pages, 21.3 by 28 cm, spiral-bound, ISBN 0-13-559626-2, $14.95.

MATHEMATICS FOR COMPUTER PROGRAMMERS. Christine Benedyk Kay. Englewood Cliffs, NJ: Prentice-Hall, 1984; 416 pages, 18.3 by 24.3 cm, hardcover, ISBN 0-13-562140-2, $24.95.

MICROCOMPUTER TOOLS FOR COMMUNICATIONS ENGINEERING. Shing Ted Li, John W. Rockway, James C. Logan, and Daniel W. S. Tam. Dedham, MA: Artech House, 1983; 278 pages, 21.3 by 28 cm, spiral-bound, ISBN 0-89006-132-7, $50.

THE MICROCOMPUTER USERS HANDBOOK 84. Dennis Longley and Michael Shain. New York: John Wiley & Sons, 1983; 336 pages, 20.8 by 29.5 cm, softcover, ISBN 0-471-80436-3, $39.95.

MICROCOMPUTERS FOR LAWYERS. J. Stewart Schneider and Charles E. Bowen. Blue Ridge Summit, PA: Tab Books, 1983; 128 pages, 18.8 by 23.5 cm, softcover, ISBN 0-8306-0614-9, $14.50.

MICROPROCESSOR OPERATING SYSTEMS, VOL. III. John Zarrella, ed. Fairfield, CA: Microcomputer Applications, 1984; 160 pages, 15.3 by 22.8 cm, softcover, ISBN 0-935230-10-6, $12.95.

MICROPROCESSORS: HARDWARE, SOFTWARE, AND DESIGN APPLICATIONS. Wunnara V. Subbarao, Ph.D. Reston, VA: Reston Publishing Co., 1984; 365 pages, 18 by 24.5 cm, hardcover, ISBN 0-8359-4394-1, $27.95.

THE MODEL 100 BOOK. Jonathan Erickson and Robert J. Sayre. Berkeley, CA: Osborne/McGraw-Hill, 1984; 336 pages, 16.3 by 23.3 cm, softcover, ISBN 0-88134-124-X, $17.95

THE MODEL 100 COMPANION. the editors of Osborne/McGraw-Hill. Berkeley, CA: Osborne/McGraw-Hill, 1984; 150 pages, 20.5 by 27.5 cm, softcover, ISBN 0-88134-122-3, $15.95.

MUSIC AND SOUND FOR THE COMMODORE 64. Bill L. Behrendt. Englewood Cliffs, NJ: Prentice-Hall, 1984; 192 pages, 15 by 22.8 cm, softcover, ISBN 0-13-607094-9, $14.95.

PARADIGMS AND PROGRAMMING WITH PASCAL. Derick Wood. Rockville, MD: Computer Science Press, 1984; 440 pages, 15.5 by 23.5 cm, hardcover, ISBN 0-914894-45-5, $25.95.

PASCAL. Geneva G. Belford and C. L. Liu. New York: McGraw-Hill, 1984; 352 pages, 18.5 by 23.5 cm, softcover, ISBN 0-07-038138-0, $19.95.

PASCAL APPLICATIONS FOR THE SCIENCES. Richard E. Crandall. New York: John Wiley & Sons, 1984; 256 pages, 17.3 by 25.3 cm, softcover, ISBN 0-471-87242-3, $14.95.

PASCAL FOR PROGRAMMERS. Olivier Lecarme and Jean-Louis Nebut. New York: McGraw-Hill, 1984; 288 pages, 16 by 23.5 cm, hardcover, 0-07-036958-5, $22.95.

PRODUCING USEFUL KNOWLEDGE FOR ORGANIZATIONS. Ralph Kilman. New York: Praeger Publishers, 1983; 750 pages, 16 by 24 cm, hardcover, ISBN 0-03-063199-8, $49.95.

PROFIT FROM THE IBM. Dan Post. Arcadia, CA: Edge Press, 1984; 192 pages, 16 by 23.8 cm, hardcover, ISBN 09-11160-89-2, $17.95.

PROTECTING YOUR MICROCOMPUTER. Harold Joseph Highland. New York: John Wiley & Sons, 1984; 274 pages, 17 by 25 cm, softcover, ISBN 0-471-89216-5, $14.95.

P-SOURCE: A GUIDE TO THE APPLE PASCAL SYSTEM. Randall Hyde. Chatsworth, CA: Datamost, 1983; 463 pages, 13.3 by 20.9 cm, softcover, ISBN 0-88190-004-4, $24.95.

REINVENTING MAN. Igor Aleksander and Piers Burnett. New York: Holt, Rinehart & Winston, 1984; 304 pages, 15.8 by 23.5 cm, hardcover, ISBN 0-03-063857, $17.95.

SCIENTIFIC PASCAL. Harley Flanders. Reston, VA: Reston Publishing, 1984; 580 pages, 17.3 by 23.5 cm, softcover, ISBN 0-8359-6931-2, $21.95.

SOFTWARE AUTHOR'S GUIDE. Mildred A. Heiney. Chatsworth, CA: Datamost, 1983; 208 pages, 21 by 27.8 cm, softcover, ISBN 0-88190-235-7, $19.95.

THE SOFTWARE GUIDE, IBM PERSONAL COMPUTER & XT. Gerald VanDiver. Prior Lake, MN: Micro Information, 1983; 1024 pages, 21 by 27.5 cm, softcover, ISBN 0-912603-00-3, $49.95.

STRUCTURED PROGRAM DESIGN WITH TRS-80 BASIC. Thomas Dwyer and Margot Critchfield. New York: McGraw-Hill, 1984; 352 pages, 21.5 by 27.8 cm, softcover, ISBN 0-07-018493-3, $17.95.

33 ADULT COMPUTER GAMES IN BASIC. David W. Chance. Blue Ridge Summit, PA: Tab Books, 1983; 504 pages, 13 by 21 cm, softcover, ISBN 0-8306-1627-6, $13.50. ■

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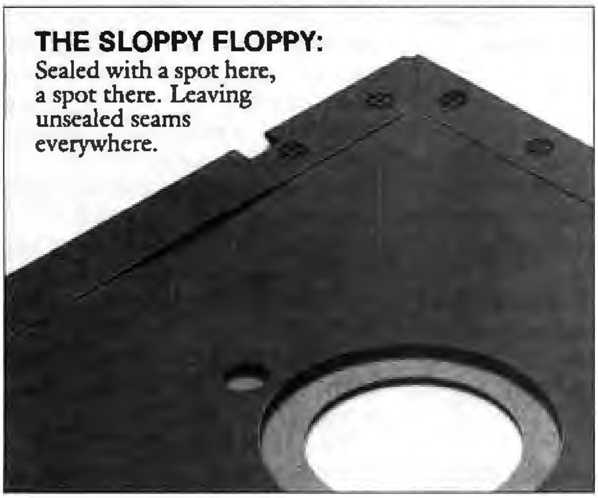

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UCSD PASCAL VS. MODULA-2

A DISSENTING VIEW

BY DAVID V. MOFFAT

A comparison between the old "extended" and the new "standard"

SEVERAL ARTICLES have shown how Modula-2 is an improvement over Standard Pascal (see references 2 and 4). Other articles describe some of Modula-2's imperfections and major trouble spots (see reference 3). In this article, I will endeavor to show how UCSD Pascal is superior to Modula-2 in many ways.

Like Modula-2, UCSD Pascal is a Pascal derivative designed for general-purpose and systems programming. The two languages are about the same size—that is, they have the same number of symbols, identifiers, and statements. Both support type-checked separate compilation, procedure libraries, concurrent programming, low-level I/O (input/output) handling, interrupt handling, and many other kinds of programming. But they have major differences as well.

SPELLING

One of the seemingly trivial, but irritating, facts about Modula-2 is that spellings are case sensitive. This means that "Number," "number," and "NUMBER" are all different words. Therefore, to read a program aloud verbatim is impossible, that is, to *talk* about a program accurately. Two examples follow:

```
WHILE SYM = While DO...
IF n < N THEN...
```

Note that WHILE is a reserved word, but While is not. Worse, there is no way to predict how the standard names or another programmer's names are capitalized.

UCSD Pascal solves this problem by making no distinctions between the uppercase and lowercase spellings of words, just like any dictionary.

TYPES

Modula-2 lacks several types that are used constantly in general-purpose programming.

First, this language has no varying-length string type as found in UCSD Pascal (and many other languages). While varying-length strings can be simulated and included in a library of routines for future use, this solution is only a half measure. The advantages of having them designed into the language are many: they are available by default, they are highly efficient, and the compiler allows them to have special behaviors. For example, the string functions in UCSD Pascal can return string values (unlike programmer-defined functions), and some string functions can accept varying numbers of parameters. Programmer-defined procedures and functions are not nearly as easy to use. Unlike Modula-2, UCSD Pascal accepts a single-character literal as either a character *or* as a single-character string.

The CHAR type in Modula-2 is restricted to the 128 standard ASCII (American National Standard Code for Information Interchange) values, thereby defining away almost all the special values used for graphics and special fonts. UCSD Pascal accepts all 256 character values.

UCSD Pascal also provides a long integer type, with up to 36-digit accuracy. Long integers are used in applications that require exact-precision arithmetic, such as financial calculations. This type, and operations upon it, can be simulated in Modula-2, but UCSD Pascal per-

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mits the use of the simpler standard operations, DIV, +, −, and *, and defines conversions between long integers and other types.

Modula-2 sets are defined to be small, but their exact size is not defined. In programming, one of the most convenient sets is a set of character values, used quite often in any kind of text processing. However, Modula-2's sets are too small for this application. UCSD Pascal's sets can contain 4088 elements, enough for a wide variety of range-checking and value-testing applications.

UCSD Pascal lets you "pack" any structured variable into as little space as necessary to contain it. These compact data structures save disk space and are useful in systems programming. Packing is not available in Modula-2.

Taken together, these characteristics make it apparent that UCSD Pascal provides a richer selection of useful types for the demands of programming in a variety of real-world applications.

Input and Output

Input and output in Modula-2 is the most tedious of any language, except perhaps assembly languages without macros. All of the convenient I/O procedures that you would normally use in almost all of your programs are missing. Whereas in UCSD Pascal the READ procedure can be used to read any number of values of any single-valued or string type, Modula-2 has the procedures Read (a character), ReadString, ReadInt, ReadReal, ReadCard, and so on. Each procedure can read only one value of the type implied by its name. Standard output (Write) is similar. In UCSD Pascal one could use

```
WRITELN('The ', N, ' cars average ',
  W:8:2, ' pounds.');
```

but Modula-2 would require

```
WriteString('The ');
WriteInt(N,1);
WriteString(' cars average ');
WriteReal(W, 8, 2);
WriteString(' pounds.');
WriteLn;
```

(and, of course, the procedures must be capitalized exactly as shown).

Most of the procedures used to do standard input and output in UCSD Pascal also apply to files of programmer-defined types (sometimes called record files in other languages). These files can therefore be handled in a similar and familiar fashion. In Modula-2, I/O procedures for such files must be custom programmed.

Interestingly, UCSD Pascal also provides the low-level I/O operations that Modula-2 provides. In all, UCSD has 26 I/O procedures, functions, and so on, which do more for the programmer than Modula-2's 46 I/O operations. UCSD Pascal also provides more support for interactive I/O and graphics.

Overall, convenient I/O took a big step backward in Modula-2. UCSD Pascal's I/O routines, joined with its greater variety of types, make it a much better general-purpose language.

Separate Compilation

Though both languages support separate compilation, UCSD Pascal does it in a simpler fashion than Modula-2. In both languages, groups of related declarations and procedures can be packaged into a module, compiled as a single unit, and saved on disk as part of a "library" of precompiled packages. Programs can then use these packages of declarations and procedures as if they were built into the language. These packages are called modules in Modula-2 and units in UCSD Pascal.

In both languages two parts compose each module or unit—an interface that shows how to use the procedures and the implementation. The major difference between the languages is in how these parts are stored. In Modula-2 the interface is stored in a source file, then compiled into an object file; the implementation is stored in another source file and compiled into another object file—a total of four files. In UCSD Pascal, the interface and implementation are in the same source file, which is compiled into a single object file. Half as many files are used. UCSD Pascal lets the operating system keep track of the various parts, the ordinary function of operating systems.

The UCSD Pascal units are also easier to understand and maintain because both parts can be edited at the same time.

Development Environment

The languages differ in many other ways, but those discussed above are the most important ones. However, other factors must be considered when comparing languages—factors that determine how the programmer gets his or her work done. One such consideration is the language's environment.

UCSD Pascal comes embedded in the UCSD p-System operating system, a complete development, production, and maintenance environment. The p-System includes compilers, an assembler, an editor, a linker, a file manager, an execution monitor, a print spooler, a large set of utilities and software tools, and a large library of precompiled units for screen handling, graphics, and other applications. The languages and system commands are integrated into a unified whole.

Modula-2 comes with a compiler, a linker, an execution monitor, and a set of standard modules (these modules support features that are built into UCSD Pascal). Modula-2 has few, if any, software tools and no utilities. Editing and file handling must be done catch-as-catch-can using the existing operating system. Therefore, the environment is not integrated at all.

The run-time environment provided by the UCSD p-System is available for many computers for as little as $50. Because UCSD Pascal programs are entirely portable with respect to this environment, programs written on one system can be run on every major microcomputer. The portability of Modula-2 programs is still very limited; they have too few implementations.

Because the UCSD operating system is such a good development environment, one version of Modula-2 (by Volition Systems) has been embedded in a UCSD system, but it is an older version, not the portable p-System.

In any case, a language cannot stand on its own: its environment is an important factor in its usability.

Documentation

Setting aside differences in language and development environments, to use a language successfully you have to learn it and understand what has already been done with it. These factors are yet two more ways in which UCSD Pascal is an "improvement" over Modula-2.

In the first place, UCSD Pascal is an extended Pascal; Modula-2 is not. If you

(continued)

A new language is not necessarily more advanced than its predecessors

already know Standard Pascal, you already know much of UCSD Pascal.

More to the point, many good texts, references, and tutorials are available for UCSD Pascal alone. In addition, more than 100 other Pascal texts and books have been written. These books exhibit algorithms and working programs for business, games, graphics, operating systems, software tools, database management, and so on. More than 90 percent of this material applies to UCSD Pascal. By contrast, there are very few books on Modula-2 and even fewer texts.

Even if all else were equal, getting down to serious work using UCSD Pascal is possible much sooner than with Modula-2.

Summary

I have presented UCSD Pascal almost as if it were a "successor" to Modula-2. In fact, Modula-2 was designed chronologically later than UCSD Pascal. My point was to show that a new language is not necessarily more advanced than its predecessors. In fact, UCSD Pascal is a positive step in the evolution of "living" Pascal (as opposed to Standard Pascal which, like Latin, is unchanging and therefore dead). Modula-2, on the other hand, is another language altogether, even if Pascal-like. (Ada, Euclid, Mesa, Edison, and many other languages are also Pascal-like.)

Between the publications of the first Pascal report and the first Modula-2 report, hundreds of papers were written on Pascal, many of which pointed out its deficiencies and offered ways to improve it. When Wirth designed Modula-2, he ignored most of that advice, even though much of it came from experienced critics and users of programming languages. He was obviously not so interested in improving Pascal as in designing another language for an entirely different application area. That was his decision. But it is not intellectually honest for persons promoting Modula-2 to claim that it is "the" successor to Pascal (it is not), or that it solves all of Pascal's problems (it does not).

At the same time, users of Modula-2 can either rejoice or be wary that Wirth and others are trying to avoid having Modula-2 suffer the same fate as Pascal—what the orthodox would call undisciplined changes and extensions to the language. In reality, such modifications are part of a process of evolution in response to real and perceived needs. To have anything in computing nailed down long enough to become comfortable with it is a luxury. But computing marches on; if we are not going forward, then we are standing still, and if we are standing still, then we are falling behind. Standard Pascal is nailed down; will Modula-2 be nailed down also?

Thus, when Modula-2 is looked at as a candidate for a long-term language commitment for systems programming on microcomputers, it is a big improvement (in many ways) over much older languages. It is not very remarkable in comparison to other modern languages. Although Modula-2 implementations and environments are likely to improve, even as the language remains unchanged, if commitment to a language is necessary, then UCSD Pascal, already a mature and well-supported product, is probably a better choice in terms of better business sense.

On the other hand, in the perspective of ongoing developments in computing, Modula-2 is just an interestingly different—and imperfect—stepping-stone along the way, frozen in time and space. We should pause to admire it, but it is not the end of the road. We must reconcile ourselves to the insecurity of constant change. That is what progress is about. ■

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NEW SYSTEMS

Portable Computer Line from Franklin

Franklin Computer Corporation recently introduced a line of portable computers. The CX Series is made up of four models, each incorporating 64K bytes of RAM, the Franklin Office Manager integrated software package, and Franklin DOS. Advanced models are available with CP/M and MS-DOS.

Franklin DOS is an Apple-compatible operating system that uses a minimal amount of ROM memory and boots the operating system, language, or utility software into RAM on an as-needed basis under operator control. When not using BASIC, Franklin DOS provides an additional 12K bytes of memory.

The Franklin Office Manager integrates word processing, spreadsheet, graphics design, and a spelling checker. It uses icon-type prompting aids and an 80-column display (70 columns for graphics).

The CX Series unit measures $15\frac{7}{10}$ by $16\frac{9}{10}$ by $6\frac{1}{2}$ inches and weighs approximately 25 pounds. It includes color capabilities and a high-resolution monitor. Its 86-key detachable keyboard has 10 programmable function keys, numeric keypad, WordStar-compatible control keys, uppercase/lowercase, and LED indicators for cap- and numeric-lock keys.

Interface ports are supplied for Centronics-parallel or RS-232C serial printers. An RS-232C, external composite-video, and miscellaneous (DB9) port are standard equipment. The 7-inch green-phosphor monitor has brightness and contrast controls, blink and reverse video, and a 192- by 280-pixel resolution.

Options include a 110/300-bps modem, a carrying case, MS-DOS memory upgrades to 256K bytes, peripheral card brackets, keyboard templates, and a technical reference manual.

The CX-1 is a single-disk-drive computer that sells for $1395. The dual-drive CX-2 is $1695. Including CP/M, WordStar, and 64K bytes of additional RAM, the CX-2C is $1995. The top-of-the-line CX-2M is $2295, which includes 128K bytes of additional memory, WordStar, and MS-DOS. Contact Franklin Computer Corp., 1070 Busch Memorial Highway, Pennsauken, NJ 08110, (609) 488-0600.

Circle 610 on inquiry card.

Computer Derived from Micro/PDP-11

The CI-Micro-11 from Chrislin Industries is derived from DEC's Micro/PDP-11 computer. It permits upward expandability and is available in a variety of configurations.

The CI-Micro-11 can use LSI-11/23+ or LSI-11/73 central processors. Winchester-disk storage capacities range from 10 to 40 megabytes, and emulation on the Winchesters is RL02, RL01, and RD51. Each CI-Micro-11 comes with dual floppy-disk backup. Floppy disks are available in RX50 (800K bytes) or RX02 (2 megabytes).

The CI-Micro-11 operates under existing software and diagnostics without modifications. Emulators permit software-transparent operation under RSTS-E, RSX11M, RSX11M+, RT11, and UNIX.

A rack-mounted CI-Micro-11 is $6850. Vertical floor mount is available. For more information, contact Chrislin Industries Inc., 31352 Via Colinas #101, Westlake Village, CA 91362, (818) 991-2254.

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Apple- and CP/M-Compatible Portable

An Apple- and CP/M-compatible portable computer, the Alex 500A is available for $2495. The Alex has dual Z80 and 6502 microprocessors, 64K bytes of RAM, four expansion slots, twin disk drives, and a speaker. It has built-in disk and printer interfaces and a single RS-232C serial, a parallel, external-monitor, and game ports. Alex's keyboard is detachable and equipped with a numeric keypad and uppercase/lowercase capabilities.

This computer weighs 18 pounds and measures 15 by 14 by 5 inches. Contact Comp-U-Save, Turtle Creek, POB 1300, Skyland Park, NC 28776, (704) 274-3003.

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Slave Boards and Module Create Multiuser PC

Alloy Computer Products' PC-Plus family of hardware and software products lets you build a multiuser system with inexpensive terminals. Alloy says that the cost of the PC-Plus scheme approaches half that of competitive offerings.

Alloy's approach is based on the assumption that you have already made your investment in a microcomputer. By plugging one of Alloy's PC-Slave boards directly into a personal computer expansion slot and adding a terminal, you have created a two-user system, complete with shared disk drives and printer.

Up to 12 users can be accommodated with Alloy's PC-XBUS expansion module, which plugs directly into the host's expansion slot and houses a mix of 8- and 16-bit processors. With three PC-XBUS modules, as many as 30 processors can share data, software, and peripherals under the tutelage of the host computer.

The PC-Plus is faster than most computers and nearly twice as fast as an IBM PC, according to Alloy. The PC-Slave/16 board includes an 8-MHz 8088 processor, 256K bytes of RAM, and two serial ports. The PC-Slave/8 has a 6-MHz Z80B, 128K bytes of RAM, and two serial ports. High-speed band switching provides bus-speed host/slave transfers of 64K bytes. The serial ports, which serve as an interface to the user's terminal, have programmable rates up to 19,200 bps.

The PC-Plus operates under Alloy's PC-RTNX executive, which deploys system resources and provides file/record locking with controls to manage file access. It emulates the functions of such black-and-white terminals as the DEC VT-100/200 series and Televideo 925. It supports PC-DOS, MS-DOS, and Concurrent CP/M for the PC-Slave/16 processors and CP/M for the PC-Slave/8. Software support includes Lotus 1-2-3, WordStar, and dBASE II.

Single-unit prices are $1195 for the PC-Slave/16 and $995 for the PC-Slave/8. The PC-XBUS is $1495. For more information, contact Alloy Computer Products Inc., 100 Pennsylvania Ave., Framingham, MA 01701, (617) 875-6100.

Circle 613 on inquiry card.

(continued)

PERIPHERALS

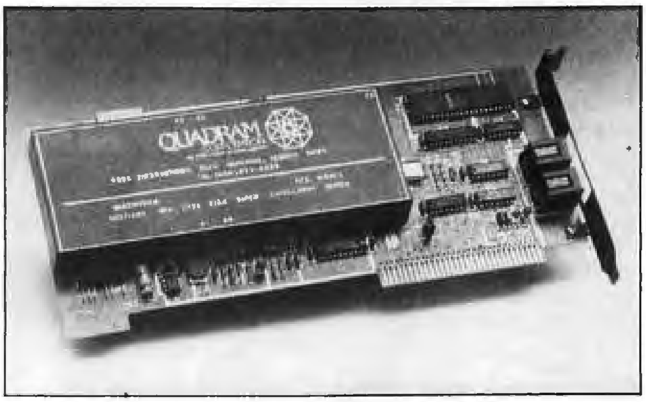
Quadram's Quadmodem Line

Quadram has introduced a line of modems for Apple, IBM PC, and other popular microcomputers. Available in both stand-alone and integral models, the intelligent Quadmodem operates at either 300 or 1200 bps. Its diagnostic capabilities tell you whether a communications problem is occurring with the modem, the transmission over telephone lines, or the remote modem.

QuadTalk, a menu-driven communications software package, provides the Quadmodem with such features as auto or manual dial, auto or manual answer, AT&T 212A/103 compatibility, electronic call progress detection (i.e., dial, busy, ring back, data-carrier tone, and human voice), auto-speed selection, and auto parity. Tone or rotary-pulse dialing can be automatically selected or command specified.

The Quadmodem is compatible with most modems. The stand-alone version is $695, and the integral card for the IBM PC is $595. Contact Quadram Corp., 4355 International Blvd., Norcross, GA 30093, (404) 923-6666.

Circle 614 on inquiry card.



Videodisc Interface

Orenda's LaserLynx 100 controls all your videodisc's functions, and it can switch the video source between your computer and videodisc player. It's compatible with Apple, Atari, and Commodore computers, and it interfaces with most videodisc players. Support software is available. The list price is $99.95. Contact Orenda Inc., 3754 Overland Ave., Los Angeles, CA 90034, (213) 202-0770.

Circle 615 on inquiry card.

Hard Disk and Hard-Disk Boot Chip

Falcon Technology has added a 30-megabyte unit to its PC eXTender line of IBM PC hard-disk drives and a ROM chip that boots PC-DOS directly from hard disk.

The 30-megabyte eXTender features a clock/calendar, a serial port, and sockets on the hard-disk controller board for up to 192K bytes of RAM. A voice-coil positioner in the drive has decreased the data-access time to 45 milliseconds; the 30-megabyte PC eXTender can read 1 megabyte of data from the disk every 3 seconds. Complete with software backup utilities and an enclosure that complements the IBM PC, the 30-megabyte PC eXTender is $3995.

The boot chip, designed for all PC eXTenders, eliminates the need to use floppy disks to load the disk operating system into the PC's main memory. It plugs into an empty socket on the IBM PC system board.

Present owners of the PC eXTender can upgrade their systems with the ROM chip for $15. The chip is included with all eXTenders shipped after June 1. Contact Falcon Technology Inc., Suite T-101, 6644 South 196th St., Kent, WA 98032, (800) 722-2510; in Washington, (206) 251-8282.

Circle 618 on inquiry card.

Image Processors for Personal Computers

The Computer Research Company's Oculus-100 and Oculus-200 are image-processor boards for the IBM PC or PC compatibles.

The Oculus-200 is a high-performance board incorporating such features as a real-time 30-frame-per-second video digitizer and 256K bytes of memory. With its on-board video output, you can display processed images on an auxiliary monitor and use graphic overlays and vectoring. It transforms images received from any standard video camera into a 512- by 512-pixel array with 128 shades of gray. The Oculus-200 lists for $1995.

The Oculus-100, suitable for applications where a real-time binary system is required, digitizes a television image into a 512- by 512-pixel black-and-white array that can be processed by your personal computer and displayed in low resolution. The $695 Oculus-100 has 32K bytes of memory.

Each board comes with menu-driven imaging software, cable, and manual. Dedicated software for a variety of applications is available. Contact The Computer Research Co., 547 St. Thomas, Longueuil, Quebec J4H 3A7, Canada, (800) 361-4997; in Canada, (514) 651-2919.

Circle 616 on inquiry card.

Modem for Osborne

The CTS OE-1 for the Osborne Executive is a full-duplex, 300-bps AT&T 103J-compatible modem. It comes with Mycroft Labs' Myterm communications package.

The OE-1 lets the Osborne emulate an intelligent terminal with text- and binary-file transfer capabilities. It has auto answer, auto dial, asynchronous operation, and a direct-connect telephone link.

The price is $129, plus $6 shipping. Contact Modem Sales, CTS Datacomm Products, POB 320, Sandwich, IL 60548, (815) 786-8411.

Circle 617 on inquiry card.

ADD-INS

Auto-Dial Modems for IBM PC

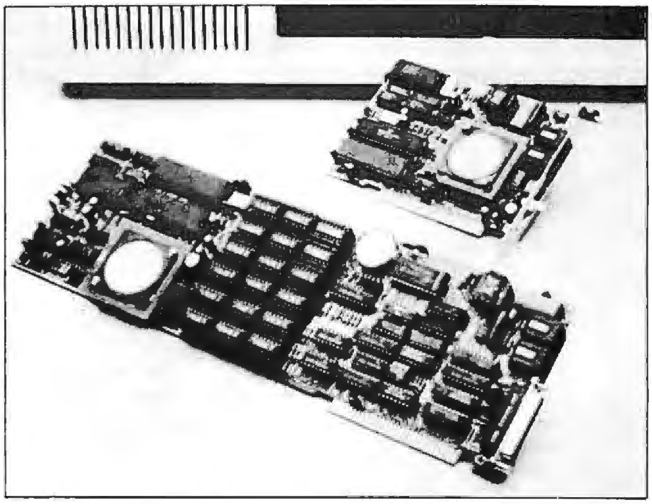
The Personal Communicator line of integral modems from U.S. Robotics is designed for the IBM PC, PC XT, and IBM PC compatibles. Available in three configurations, each Personal Communicator modem provides data-transmission capabilities of 300 and 1200 bps. Two of the modems have usable RAM, a battery-backed real-time clock, and a parallel interface. The Personal Communicator, which is AT&T 103/212A-compatible, slides into any available PC expansion slot.

The basic Personal Communicator is an auto-dial, auto-answer asynchronous modem featuring automatic speed-detect, audio telephone-line monitor, volume control, programmable commands, two RJ11C telephone jacks, telephone cord, a manual, and the Telpac communications software package.

Telpac lets you use the Personal Communicator to automatically or manually call another computer, and it allows a remote computer to enter your system. It provides password protection and the ability to create graphics to be viewed by the receiver. An unlimited number of telephone numbers can be stored and automatically dialed. Each phone number can be assigned such options as data rate, parity, full- or half-duplex, a log-on sequence, and tone- or rotary-pulse dialing. Telpac also automatically redials busy numbers and has four types of protocols, including "MODEM" and user-defined protocols. Other features are automatic error detection and two types of block checks.

The enhanced Personal Communicators come with 64K or 256K bytes of RAM and a parallel port. They are priced at $699 and $999, respectively. The basic model is $499. For more information, contact U.S. Robotics Inc., 1123 West Washington Blvd., Chicago, IL 60607, (312) 733-0497.

Circle 619 on inquiry card.



Speech Synthesizers Use SC-02 Chip

The Voice Box 3 line of speech synthesizers from the Alien Group comes in versions for the Apple II and any computer with an RS-232C serial port. Each unit features an SC-02 (i.e., SSI 263) speech chip, software, and an external speaker. All have unlimited vocabularies and can speak with male or female voices with variable speed and loudness in response to commands added to the text.

The software produces speech directly from English text, adding inflection either automatically or under user direction. Voice Box 3 uses punctuation, word length, and other clues, such as word endings, to assign stress. In an alternate mode, you can control intonation by inserting numbers that represent pitch changes into the text. It is not necessary to mark syllable boundaries or resort to phoneme spelling when adding intonation.

The Voice Box 3m plugs into any Apple slot and works with BASIC or assembly-language programs. The speaking program, which occupies less than 5K bytes of memory, comes on disk and is loaded into memory. It produces a high-resolution face, which moves its mouth in synchronization with the spoken word.

Voice Box 3i, also for the Apple, is configured as an intelligent peripheral. You can use the Voice Box 3i with word processors and report generators. The card contains the text-to-speech program in ROM, a 1.5K-byte buffer, and a microprocessor that allows it to speak while the Apple works on another task.

The Voice Box 3s connects to any computer through a standard RS-232C interface. It's configured as a bus, which lets it share a single port with other devices. The host computer sends English text to the 3s, which accumulates the text until it is instructed to speak.

The Voice Box 3m is $129, and the 3i lists for $219. Both prices include software and an external speaker. With an integral speaker, the 3s is $269. For more information, contact The Alien Group, 27 West 23rd St., New York, NY 10010, (212) 741-1770.

Circle 620 on inquiry card.

Integrated Text/ Graphics System

The Concept 100 is a multipurpose VDI (virtual device interface) graphics controller for the IBM PC and PC XT. It gives you the means to create high-resolution, interactive text and graphics that can be reproduced on a printer or other output device. It offers the ability to lay out pages in different formats and concurrent operation of the computer and output devices.

The Concept 100 is made up of an Intel 80186-based intelligent graphics subsystem, software incorporating a graphics editor and data-driven charting capabilities, a Wang look-alike word processor, a mouse, and documentation The graphics subsystem replaces and emulates both IBM color and monochrome display adapters. The display resolution is 720 by 352, with two levels of intensity for alphanumerics and graphics. The display is 50 Hz, noninterlaced, and supports 25 rows by 80 columns of characters.

The Graphics Software Systems implementation of the proposed ANSI VDI standard is used. The graphics editor has many of the capabilities of a CAD package, and it lets you create charts, flow diagrams, lines, boxes, circles, maps, and text with diagrams.

A basic font set and sizes are provided. File translators for commonly used programs, dictionaries, and a spelling checker are standard. Epson FX-80/ MX-100, C. Itoh Prowriter, and Okidata printers are supported. Centronics-type parallel and RS-232C serial ports are offered.

Options are an extended font set, Tektronix 4010 terminal emulation, the ability to accept graphics formats from CAD/CAM systems, and equation setting. The list price is $2195. For further details, contact Concept Technologies Inc., 6950 Southwest Hampton, Tigard, OR 97208, (503) 684-3314.

Circle 621 on inquiry card.

(continued)

SOFTWARE • CP/M / MS-DOS

New MS-DOS Versions of Pascal, FORTRAN, and C

Microsoft has released new versions of Pascal, FORTRAN, and C Compiler languages for use with its MS-DOS operating systems.

Two new mathematics libraries have been added to Pascal, supplementing the existing 8087 coprocessor and 8087 emulation support, and its name has been changed to Pascal 3.2. The first library offers high-speed performance without an 8087. It supports both single- and double-precision numbers, which makes it faster than emulation software but slightly less accurate. The second mathematics package offers BCD floating-point arithmetic for more accurate dollars-and-cents calculations.

Pascal 3.2's 14-digit decimal format eliminates many of the problems associated with rounding off binary mathematics. Other features include MS-DOS 2.0 run-time support, the ability to access files by means of the path-name directory structure, linker extensions that support overlays so that program modules can be loaded when required, and the ability to call overlays from the root program or from another overlay.

FORTRAN 3.2 can now handle nearly unlimited data arrays. The 64K-byte segment restrictions for arrays and common blocks have been overcome, which allows manipulation of large matrices. In conjunction with module linking, a single program can use up to 1 megabyte of 8086 memory.

FORTRAN 3.2 supports complex number calculations in addition to specific and generic conversion intrinsics conforming to the ANSI 77 standard. Double-precision Complex data types have also been added. Some of its other features are a Parameter statement, Block Data programs, an Inquire statement, and an I/OStat read/write clause for checking the status of I/O operations.

Microsoft's C Compiler 2.0 supports the use of path names to take advantage of the DOS directory structure as well as I/O redirection. It has expanded memory capabilities that let programs compiled with C employ the full memory capacity of their system. Small, medium, compact, and large memory models are programmer-selectable.

Pascal 3.2 is $300, while FORTRAN 3.2 and C 2.0 are priced at $350 and $500, respectively. Previous owners can purchase updates at reduced rates. Contact Microsoft Corp., 10700 Northup Way, Bellevue, WA 98004, (206) 828-8080.

Circle 622 on inquiry card.

MegaBASIC Addresses Up to 1 Megabyte

MegaBASIC can directly address 1 megabyte of memory by accessing packages from memory in much the same way as FORTH provides its extensions. This procedure lets you load libraries of programs, subroutines, and functions into memory that can be executed from the running program with a single statement as if it were an integral part of MegaBASIC itself. The packages are user-written in MegaBASIC, which provides each user with the ability to tailor the language to individual needs.

With direct addressing of 1 megabyte of memory for program and data, MegaBASIC gives MS-DOS, MP/M-86, CP/M-86, and TurboDOS users flexible use of the 16-bit processing power of such machines as the IBM PC. All memory allocation is fully dynamic and transparent. Up to 64 separate programs can coexist in memory simultaneously. Its memory management can support more than 6000 variables at the same time; each string variable contains up to 65,535 characters, and bit strings can be 524,288 characters long. Nesting of WHILE and FOR loops, functions, GOSUBS, and procedures is allowed to any depth.

MegaBASIC is said to execute programs faster than any existing BASIC by a factor of 2 to 15 times. Large-scale file applications under MegaBASIC reportedly run faster than under compiled software. Other features include execution control and debugging, structured programming, segmentation and overlays, unlimited numeric and string array dimensions, and a variety of data-manipulation functions.

The standard version of MegaBASIC contains 28 commands, 65 statements, 64 functions, 37 operators, and a variety of specialized control keys. Its editor has such capabilities as global search, list, and edit, and the ability to rearrange, move, or copy all program lines, including a fully global, defined regional, or line-specific renumbering command. One feature provides a quick display of statistics about the program and its execution state, while a separate cross-reference generator defines all variables, functions, and so on.

MegaBASIC immediately executes programs written in North Star BASIC. A translator is available for converting Microsoft BASIC programs to MegaBASIC. This language will work with any machine based on the 8086 or 8088 microprocessor. The list price is $400, including extensive documentation. For complete details, contact American Planning Corp., Suite 425, 4600 Duke St., Alexandria, VA 22304, (800) 368-2248; in Virginia, (703) 751-2574.

Circle 623 on inquiry card.

Telecommunications Program

ReachOut 2.001 is a telecommunications program for any 8-bit micro running CP/M and any 16-bit IBM PC or PC compatible using CP/M or MS-DOS. A key feature of ReachOut is its auto-answer facility, which permits unattended file transfers to or from another computer that has ReachOut. A reporting system informs operators of the unattended computer what activity occurred during their absence.

This menu-driven program offers a Help system, keyboard and directory dialing, automatic redialing, and the execution of scripts for the automatic control of log-on, data capture, and disconnect. Files can be transferred either with or without error checking. Pretyped electronic mail can be sent.

Transfers to another system include an estimate of the transfer time and file-by-file updates on both computers. Batches can be defined either ambiguously or by a list of filenames. When problems are encountered during batch transfers, the resultant files contain filenames that can be used to control later transfer attempts. The free space on the target disk is determined before each file is sent.

ReachOut automatically renames incoming files when they duplicate names of existing files. All operating system transients are contained within the program. A nonmodem installation option is provided for downloading applications. ReachOut uses a 16-bit CRC transfer protocol and is compatible with the file-transfer error correction/detection protocols of many public-domain programs, including Modem7.

ReachOut comes with utilities and a menu-driven installation program. It costs $199, which includes a pair of updates. Contact Applied Computer Techniques, 104 Knight Dr., San Rafael, CA 94901, (415) 459-3212.

Circle 624 on inquiry card.

SOFTWARE • IBM PC

Text Editing, Page Makeups with PagePlanner

PagePlanner from Westminster Software is a text editing/design tool that lets you enter, hyphenate, justify, and design text into full-page makeups with an IBM Personal Computer. When your page is complete, PagePlanner's drivers let you run the text through Mergenthaler 202, Compugraphics, AM, Autologic, and Itek typesetting equipment.

For text entry and editing, PagePlanner lets you merge raw text with typesetting codes. Status fields can be filled with information both by the operator and the system. Editing functions include character, word, line, and block delete, block move, and copy. An intermediate save function lets you store chunks of text.

Hyphenation and justification of text is performed at more than 1000 lines per minute. Hyphenation is determined by a user-selectable 5000-rule prefix/suffix logic table. Justification is done by accessing the correct character width and using a 500 typeface kerning table. A document can be hyphenated and justified up to 99 times. A logical hyphenation capability backs up the kerning tables.

PagePlanner lets you continually review and revise any part of your project. Major revisions to a job are merely a matter of changing the job specifications on screen.

Its page-makeup mode lets you display solid blocks of type, rule lines, and protected areas and modify them to meet your design criteria. Multicolumn designs and odd-size areas can be laid out. All page designs remain "soft" until they're output to hard copy.

Minimum system requirements are 128K bytes of RAM, two 320K-byte floppy-disk drives, IBM Color Graphics card, color monitor, and a parallel printer port. Software requirements are CP/M-86 with GSX86 and MS- or PC-DOS 2.0 with the Graphics Program. It will also work with IBM or Hercules graphics card and monochrome monitors and the Compaq. (Other PC compatibles are being evaluated.) A custom cable for interfacing with the typesetting equipment is available.

PagePlanner costs $1995. Contact Westminster Software Inc., Suite 2, 660 Hansen Way, Palo Alto, CA 94304, (415) 424-8300.

Circle 625 on inquiry card.

Multilingual Word Processor

The Multilingual Worldmaster word-processing program from Emcon Marketing lets you type two languages within the same document. Worldmaster, which runs on the IBM PC and PC compatibles, allows you to mix eight character sets in a single document. It has a menu-based structure, and the mixing of languages is performed using simple function keys. Keyboard templates and stickers are provided so that you can identify the characters for each key.

Worldmaster is available in four versions: English to Romance languages, to Arabic, to Hebrew, and to Russian. The Arabic and Hebrew versions let you type from right to left in both the insert and regular edit modes.

This program is configured to work with Epson's FX series printers and with such letter-quality printers as the Diablo and Juki. (Foreign print wheels are required for the daisy-wheel printers.) A minimum of 128K bytes of memory and a color-graphics card for the Arabic, Hewbrew, and Russian versions are required. The suggested retail price is $495. Contact Emcon Marketing Group Inc., 366 Fifth Ave., New York, NY 10001, (212) 563-0443.

Circle 626 on inquiry card.

Color Print Utility

ColorScreenPrint from Application Techniques is a software utility that lets you obtain full-color graphics from your IBM Personal Computer Color Printer. In addition, it can print any graph that can be displayed on the PC's color display at any size up to 13 inches anywhere on paper.

When used with Lotus 1-2-3, ColorScreenPrint eliminates the need to swap disks to print graphs. By pressing the PrtSc key, you gain control over the graph's colors, size, and positioning.

Colors can be selected from a palette of 16 or from virtually unlimited user-defined colors. The width and height of the printout is set in tenths of inches, and auto centering is supported. A portion of the screen can be cut out for printing anywhere on the paper, and a quarter-turn rotation is supported.

A program that generates samples of more than 50 color textures and shows you how to produce different colors comes with ColorScreenPrint. A demonstration program is supplied.

ColorScreenPrint is $79.95. For more information, contact Application Techniques Inc., 80 Townsend St., Pepperell, MA 01463, (617) 433-5201.

Circle 627 on inquiry card.

More Than 110 Scientific Subroutines

A FORTRAN 77 Scientific Subroutine Library for IBM PC-DOS users can be purchased from Peerless Engineering Service. Each of the more than 110 subroutines is written and tested in Microsoft FORTRAN 3.13 and is provided in disk form, both as a linkable library and in source format. Each subroutine has an accompanying test program on disk. The 450-page manual provides hard copy of each subroutine, its test program, the results of the test, and the mathematical method used in the subroutine.

This scientific library has subroutines for statistical and numeric analysis, solutions for third-order differential equations, solutions to *M* equations in *N* unknowns, and approximations by a variety of different methods. It is $149.95, plus $2.50 shipping. Contact Peerless Engineering Service, POB 71, Soquel, CA 95073, (800) 824-7888, operator 419; in California, (408) 462-0330.

Circle 628 on inquiry card.

LISP Interpreter

Levien Instruments bills its BYSO LISP interpreter as a "very healthy" subset of McCarthy's LISP 1.5, which implements every feature described in Laurent Siklossy's *Let's Talk LISP*.

BYSO LISP includes integers, map functions, functional arguments, input/output functions, a variety of list operators, functions, lambda operators, an editor, and tracing functions. It comes with an error system that explains each error with a message and the context in which it appeared.

BYSO LISP is written in assembly language. It requires an IBM PC, PC XT, or PCjr and 128K bytes of RAM. The list price is $195. Contact Levien Instrument Co., POB 31, McDowell, VA 24458, (703) 396-3345.

Circle 629 on inquiry card.

(continued)

SOFTWARE • IBM PCjr

Business Productivity Tools

Rags to Riches is a financial-management series for the IBM PCjr. comprising ledger, receivables, sales, and payable modules. All the modules are one-disk programs requiring about 32K bytes of memory. They load into RAM, which makes response time fast. The modules are consistent in design, and they work with each other.

The modules come with software templates so that they can be customized for a variety of business, retail, or personal applications. The users manual provides workbook-style introductions and tutorials.

The receivables module shows the status of customer accounts, audits accounts, produces reports, and automatically updates accounts. It has a wild-card provision. The payable module tracks payments required by vendors, including their terms, discounts, and outstanding balances. Miscellaneous payments or adjustments can be added at any time. Totals are accumulated as invoices or payments are recorded.

The sales module features automatic calculation of tax and change. You can preset the keyboard to record the sale of specific items or type of payments and use formulas for data-entry calculations, such as partial refunds. Its itemized journal provides an audit trail, and product classifications can be grouped for reporting.

The general-ledger program constantly displays income, expenses, assets, liabilities, estimated profits, and net worth. Updates are made with each entry. Transactions are documented by individual submenus. It provides such reports as audit trails and charts of accounts.

Individual Rags to Riches modules are $99.95. Support booklets with tips on computerized accounting are $9.95 Contact Chang Labs Inc., Suite 200, 5300 Stevens Creek Blvd., San Jose, CA 95129, (408) 246-8020.
Circle 630 on inquiry card.

Program Locks Up Files

The Lock-It-Up copy-protection system for the Apple II series and the Macintosh lets you impose several levels of security that render disks uncopyable. This package includes a software-duplication system that enables you to duplicate the protected disk.

Lock-It-Up uses an encrypted signature track written to a random location on the disk. The code to verify the accuracy and existence of the signature track is automatically encrypted into the protected program. Protected files can be backed up by the user, although they will operate only if they reside on the original disk.

Protection is not based on a physical fingerprint. Lock-It-Up is said to make information completely write-protected. The protection scheme does not interfere with normal operations.

Lock-It-Up is also available in an IBM PC version. Licensing begins at $495. Contact DoubleGold, Suite 29, 3900 Moorpark Ave., San Jose, CA 95117, (408) 554-9133.
Circle 631 on inquiry card.

Low-Cost Modula Compiler

Modula Corporation is releasing a $90 Modula-2 compiler for the Macintosh this month. The compiler runs under the Macintosh's operating system, and it allows you to use the Macintosh's built-in graphics and mouse toolkit.

This compiler generates an extended version of M-code, which is a compact code designed especially for Modula. It interprets M-code programs at run time without disrupting the Mac's user interface. M-code benchmark programs that make heavy use of procedure calls and toolkit graphics are said to run 75 percent as fast as programs compiled to 68000 native code on the Lisa and downloaded to the Mac.

The Modula-2 compiler is supplied with the basic I/O modules described in the book *Programming in Modula-2* by Niklaus Wirth. You can write assembly-language routines and link them to Modula-2 programs.

The Modula-2 compiler comes with I/O library and documentation. For further information, call or write Modula Corporation, 950 North University Ave., Provo, UT 84604, (800) 545-4842; in Utah, (801) 375-7400.
Circle 632 on inquiry card.

DBM for IIc

Precision Software's Superbase database-management and information-retrieval system for the Apple IIc portable computer uses B+ direct-tree indexing for record access. This program offers menu-driven operation, direct commands to the database, or use of a user-programmable interface to create custom applications packages within the Superbase environment.

Apple IIc Superbase costs $169. Contact Precision Software (USA) Inc., Suite 1100, 820 Second Ave., New York, NY 10017, (212) 490-1825.
Circle 634 on inquiry card.

Detailed Multiyear Real Estate Analysis

Real Estate Investor II for the Apple computer performs a detailed multiyear analysis of before- and after-tax cash flows and rates of return from any type of improved real estate. It offers nine different loan types and includes variable parameters and eight depreciation methods. It computes return on investment, return on equity, internal rate of return, and financial management rate of return.

Real Estate Investor II will also provide a detailed sale analysis, including sensitivity analysis, and produce a formatted multipage report. It's written in AppleSoft BASIC. The list price is $295. C language versions for the IBM PC, the Tandy 2000, Wang Professional, and CP/M-based systems are available. Contact REMS Software, 526 Northwest Second St., Corvallis, OR 97330, (503) 757-8887.
Circle 633 on inquiry card.

SOFTWARE • OTHER COMPUTERS

Moses

Moses (Modula-2 Support Environment System) is the first product in TDI's Liberator line of Modula-2-based software. It is a portable operating system written in Modula-2 that requires only a conventional character-oriented video display, 128K bytes of memory, and a floppy-disk drive.

The Moses package includes a Modula-2 compiler, a screen editor, a symbolic debugger, a modifiable menu-driven user interface with windows, and a library of routines and utilities The compiler and editor are linked so that compiler errors return the user to the editor with up to 128 errors flagged for ease of correction.

The system is available for the Sage II and IV computers with versions for other 68000- and 16032-based computers available soon. The price was not available at press date but was estimated to be between $250 and $500; source code for the system will be available at additional cost. For more information, contact TDI Ltd., 29 Alma Vale Rd., Bristol BS8 4NI, England, tel: (0272) 742796.

Circle **635** on inquiry card.

Word Processor Runs on TI Professional

R Word, a word-processing package first introduced for MC68000 and 990 series computers, is available for the TI Professional Computer and the IBM PC. Made up of a group of integrated programs, R Word offers such features as mail merge, table mathematics, spelling check, and database capabilities.

R Word combines eight different color choices for creating backgrounds, reverse video, and underlined or highlighted text. A three-level file structure used for document organization contains 9 directories with 32 categories in each directory and 32 documents in each category.

Complicated documents employing headers, footers, tables, and footnotes can be produced with R Word. Its six text-editing modes are text, word, sentence, line, paragraph, and page. Miscellaneous features include automatic page numbering, table of contents, document assembly, on-screen formatting, automatic text alignment, global search and replace, screen prompts, and Help screens.

R Word requires 256K bytes of memory and single or dual floppy-disk drives. The suggested retail price is $395. Contact R Systems Inc., 11450 Pagemill Rd., Dallas, TX 75243, (214) 343-9188.

Circle **636** on inquiry card.

BASIC Compiler Works Under FLEX/OS-9

K-BASIC, a BASIC-language compiler that converts BASIC programs to machine code, is now available for systems running FLEX, OS-9, or Color OS-9. Because compiled programs have less overhead than interpretive BASIC programs, according to the manufacturer, Lloyd I/O, you can expect greater speed and larger programs and data files.

K-BASIC has three general data types, REAL, STRING, and INTEGER, and four INTEGER sizes, 8, 16, 32, and 64 bit. Its real numbers are 15-digit precision, with an exponent of ±99. Each type can be dimensioned and defined to absolute addresses. K-BASIC has a variety of directives, statements, and functions not normally found in BASIC interpreters. Line numbers or labels are not required on every line. Variable names are significant to 12 characters, and labels are significant to 16 characters. K-BASIC includes debugging features and error processing.

K-BASIC is $199. The manual alone is $15. Contact Lloyd I/O, 19535 Northeast Glisan, Portland, OR 97230, (503) 666-1097.

Circle **637** on inquiry card.

CAD Package Aids Mechanical Engineers

Sumicom's CAD 10 for its System 830 is suitable for architects, interior designers, mechanical engineers, and other professionals using diagrams and schematics.

CAD 10 uses all of the System 830's hardware, including its soft function keys, function keys F1 through F10, high-resolution capabilities, pixel-addressable graphics, and internal printer. The program addresses the 830's color graphics chip directly and expands the pixels from 250,000 to 800,000. It permits easy transposition of floor plans and schematics, and diagrams or two-dimensional drawings can be displayed in as many as eight colors.

You can draw symbols and transcribe them into scaled drawings. CAD 10 allows you to edit, update, and reorganize drawings. Its Delete function key lets you cancel the last element drawn, and the Next function key lets you search through your drawing and cancel or add to the design without starting from the beginning

An alignment grid with submenu lets you design or copy any symbol at 10 times the actual size, which improves accuracy. A drawing board with 800 by 1000 raster points on the screen lets you assemble symbols into an actual drawing. Fifty symbols, with an average of 20 elements each, can be transferred from the symbol file to a drawing. CAD 10 parameter functions permit a choice of eight colors, the selection of four sizes of lines for pen-plotter printing, and rotation of symbols from 0 to 270 degrees. A zoom feature is provided.

Utilities include a program that permits the assembly of individual symbols stored in various data files into a new symbol set of a new data file. CAD 10 is $595. Contact Sumicom Inc., 17862 East 17th St., Tustin, CA 92680, (714) 730-6061.

Circle **638** on inquiry card.

(continued)

SDLC-Like Protocols for Wangs

Relay Version 2.2 for the Wang PC is a communications software system incorporating first-, second-, and third-generation SDLC-like asynchronous communications protocols. It comes with an editor and provisions for remote and unattended operations. The suggested list price is $149.

Relay supports simultaneous unattended bidirectional file transfers (including binary files) and can automatically invoke the functions of such intelligent modems as the Hayes Smartmodem, the Racal-Vadic VA212, and the Rixon PC212A. It combines menu- and function-key driven operation, and to facilitate use, offers Help screens.

One key feature is its directory of computers, which contains complete values for every communications parameter for each computer entered, any of which can be called or answered with a single keystroke. Individual entries include the name of the system, its telephone number, data rate, type of system, and configuration specifications for communications. Configuration options stipulate such characteristics as data rate, parity, full- or half-duplex, port selection, and yes/no toggles for XON/XOFF protocols, automatic line feed, local echo, and APL mode. A turnaround character and a delay after each line can be specified. Control codes can be displayed.

In conjunction with an intelligent modem, Relay will provide auto dialing. It has the ability to enact entire log-on repertoires, including multilevel passwords, remote system sequences, and sign-off. It has a WAIT.COM command, which halts all DOS activity for specified periods (up to one year). You can perform DOS commands from within Relay, even during a connection.

Relay's built-in editor lets you build or modify ASCII files, and its command tables include 19 function-key and 11 Alt-key commands. It provides two levels of password protection.

A Wang PC with 64K bytes of RAM, one disk drive, MS-DOS version 1.0 or later, an asynchronous communications adapter, and a modem with RS-232C cable are required. Contact VM Personal Computing Inc., 60 East 42nd St., New York, NY 10165, (800) 847-3529; in New York, (212) 697-4747.
Circle 639 on inquiry card.

Two for QX-10

MicroPlot and PlotPak for the Epson QX-10 are available directly from MicroNova.

MicroPlot, a graphics package, consists of a searchable library of more than 100 graphics routines, any of which can be incorporated into a Pascal/MT+ program during link time. MicroPlot can draw lines, rectangles, circles, and characters of any size or angle, and it can scale, translate, and rotate graphic objects. It features virtual windows with automatic line clipping and multiple and split screens.

MicroPlot requiresPascal/MT+. It comes on two disks with documentation and a 10-minute graphics demonstration. The price is $60 (U.S.).

A collection of graphics utilities, PlotPak provides programs for such common applications as bar and line graphs, pie charts, bell curves, trend lines, and log and semilog plots. Data for the utilities can be entered either interactively or from a disk file. All PlotPak utilities are stand-alone programs that do not require a programming language. The suggested price is $60 (U.S.), which includes on-line documentation. For more information, contact MicroNova, RR 5, Canning, Nova Scotia B0P 1H0, Canada, (902) 582-7016.
Circle 640 on inquiry card.

Sourcebook for Software Writers

More than 500 companies soliciting software from the general public have supplied information to *The Software Writer's Marketplace*, by Dennis Joyce and John Earl Pickering. Step-by-step instructions on researching the market, structuring salable programs, and writing acceptable documentation are included in this 228-page paperback.

Once your program is written, *The Software Writer's Marketplace* guides you through the chores associated with selling your work to a publisher, beginning with an initial letter of inquiry and ending with the contract signing. A section on copyright information is provided.

The Software Writer's Marketplace is $9.95. Contact Running Press, 125 South Twenty-second St., Philadelphia, PA 19103, (215) 567-5080.
Circle 641 on inquiry card.

Computer Cables

Candy Cables Corporation distributes more than 500 computer interfaces. A catalog of these interfaces has been compiled.

Standard interfaces listed include RS-232 serial cables with PVC jacket or ribbon (nine feet long), monitor cables, parallel printer cables with PVC jackets or ribbon (eight feet long), 50-foot extended data cables, 50-foot low-cap twisted-pair shield cables with metal hoods, and disk-drive cables. Special cables for serial plotters and modems are also listed, as are switch boxes and computer and printer coveralls. Smart cables can be obtained.

The catalog lists dealer costs and suggested retail prices. No minimum order required. Contact Candy Cable Corp., 920 San Marcos Blvd., San Marcos, CA 92069, (619) 744-2291.
Circle 642 on inquiry card.

Magazine on Languages Had July Debut

Computer Language, a technical magazine dedicated solely to programming languages, debuted in July. It covers assembly language, C, Pascal, BASIC, FORTH, and applications and systems programming, and reports on major developments in the software-design field.

Among the topics discussed are algorithmic applications to problem solving, language portability features, useful utilities, artificial intelligence, editors, language selection criteria, and telecommunications. It offers tips on marketing your own software, as well as software and hardware reviews, regular columns, and reader forums.

Regular monthly publication will begin in October. Annual subscriptions are $25. The cover price is $2.95. Contact *Computer Language*, CL Publications Inc., 131 Townsend St., San Francisco, CA 94115, (415) 957-9353.

Circle 643 on inquiry card.

WHERE DO NEW PRODUCT ITEMS COME FROM?
The new products listed in this section of BYTE are culled from the thousands of press releases, letters, and telephone calls we receive each month from manufacturers and distributors. The basic criteria for selection for publication are a) does a product match our readers' interests, and b) is it new or simply a "reintroduction" of an old item. If you want your product to be considered for publication (at no charge), send full information about it, including its price and an address and telephone number where a reader can get more information. Send this to the New Products Editor, BYTE, POB 372, Hancock, NH 03449.

IBM PC 128K	**IBM PC 128K**	**IBM PC Portable**
(1) 360k DSDD Drive	**(1) 360k DSDD Drive**	**(1) 360k DSDD Drive**
Diskette Adaptor Card	**Diskette Adaptor Card**	**Diskette Adaptor Card**
Color Graphic Card	**IBM Monochrome Card**	**Amber Display**
10 Mb Hard Disk System	**IBM Monochrome Monitor**	**256K Ram**
$2995.00	**$2195.00**	**$2450.00**

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- LazerColor $199
- Hercules Card 349
- QuadColor I 239
- PC Peacock 295

EXPANSION BOARDS
- AST 6-pac 64K 225
- Quadram EXII 64K 245
- 10Mb Hard Disk 899
- Baby Blue II 599

MONITORS
- Roland DG121 (comp) $129
- Roland DG122 (mono) 149
- PGS HX12 RGB 495
- Max 12 Amber (mono) 195
- Sakata 12" green 129
- Sakata Color (comp) 295
- Sakata Color (RGB) 495

EXPANSION ACCESSORIES
- 64K Upgrade (9/IC's) 50

MODEMS
- Hayes 1200 Int $429
- Hayes 1200 Ext 489
- Qubie Int 289
- Anchor 1200 289

PRINTERS
- Epson FX80 475
- Epson Fx100 725
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- Brother HR-25 750

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- ☐ Computer Cabinet $99.00
- ☐ 83 Key full-funtion Keyboard $120.00
- ☐ 100 WATT Power Supply $130.00
- ☐ Monochrome Graphic Card w/Printer Port $350.00
- ☐ Color Graphic Card (Display 16 colors) $199.00
- ☐ FDD Controller Card w/Cable $149.00
- ☐ Parallel Printer Card $75.00
- ☐ Dual ASYNC & RS232 Port $99.00
- ☐ 320KB DS/DD Slimline Disk Drive $189.00
- ☐ SAM WOO IBM Style Amber or Green Monitor (Composite Video) $99.00
- ☐ IBM Parallel Cable 10' $29.95
- ☐ IBM Prototype Board (SUN-208) $19.50
- ☐ MICROLOG Z-80B Co-Processor, Multi-funtion (Run CP/M80 Software) $499.00
- ☐ Apparat EPROM Blaster $129.00
- ☐ IBM Up-Grade Kit (4164) .... $44.00/per kit

Apple Compatible Products

- SUN Z80 Card (w/o Software) $55.00
- SUN 80 Column Card (w/Soft switch) . $97.00
- Power Supply (5 Amp) $59.95
- Cooling Fan $42.00
- Apple Compatible Disk Drive (slimline) $175.00
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- EPROM Programmer (2716, 2732, 2764) $75.00
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- Apple Prototype Board (SUN-722) $5.95

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- 64K Static Memory Board (6116) w/RAM A & T $339.00
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- SBC-880 Single Board Computer (Z80A) A & T $149.00
- UFDC-1 5¼ and 8 Floppy Disk Controller (BIOS available) A & T $245.00
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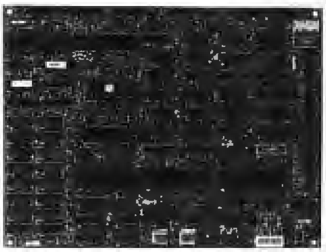

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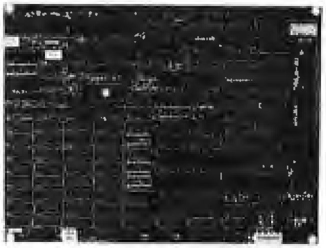

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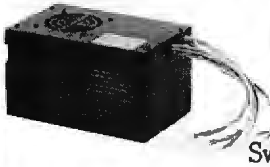

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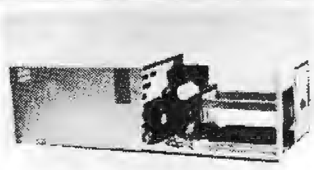

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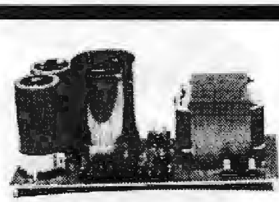
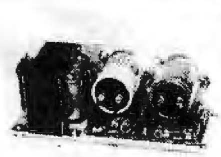


Kit 1, 2 & 3 for S-100



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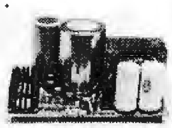
S_4	6 SLOT & 2 FLOPPY	4A	1A	4-5A PEAK	8A	3A	8⅜" x 5" x 4¾"	95.95



S_3, S_4 for S-100 & 2 Drives

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R_1	2 x 8" or 2 x 5¼" DISK	4A	1A	3A - 5A Peak	2A		8" x 4" x 3¾"	56.95
R_2	3 x 8" (or 5¼") FLOPPY	6A	1A	6A - 8A Peak			10" x 4⅞" x 3¾"	71.95
R_3	or 1x Floppy & 1x Hard	6A	1A	6A - 8A Peak		1A	9" x 6¼" x 4⅜"	98.95

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ITEM	(IDEAL FOR)	+8V	−8V	+16V	−16V	+28V	SIZE: WxDxH	PRICE
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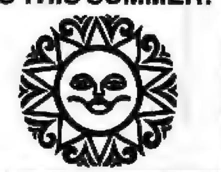

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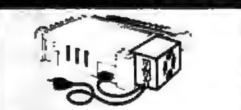

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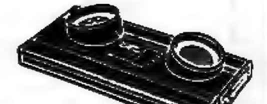

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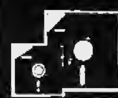

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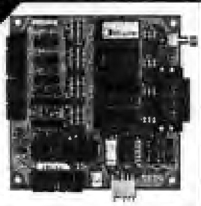

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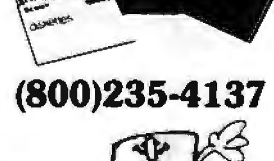

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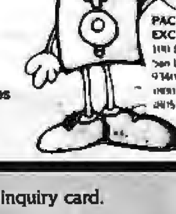

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Tava PC-XT #1: 10 MByte Hard, Graphics Video ... $2795
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Hayes Smartmodem 1200........ $ 479
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Hayes 1200-b with Software........ $ 445
Hayes Micromodem II-e .... $ 295
Novation Access 1-2-3 .... $ 445
Rixon PC212a "IBM Internal" .... $ 395

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R:Base 4000 .... $ 305
Lotus 1-2-3........ $ 325
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HR-25 Tractor........ $ 120
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Epson FX-100 .... $ 730
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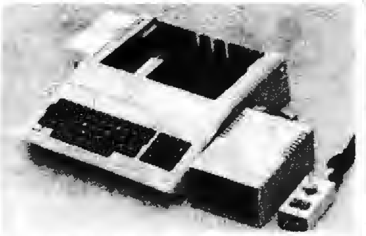

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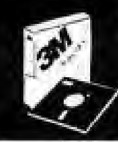

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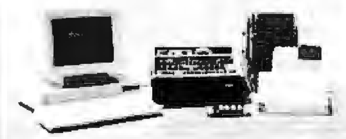

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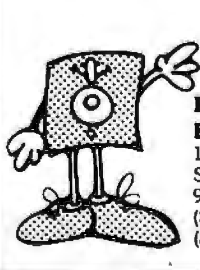

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7 POSITION .... .94
8 POSITION .... .94

IC SOCKETS
(1 to 99)

8 pin ST	.12	8 pin WW	.58
14 pin ST	.14	14 pin WW	.66
16 pin ST	.16	16 pin WW	.68
18 pin ST	.19	18 pin WW	.98
20 pin ST	.28	20 pin WW	1.04
22 pin ST	.29	22 pin WW	1.34
24 pin ST	.29	24 pin WW	1.44
28 pin ST	.39	28 pin WW	1.64
40 pin ST	.48	40 pin WW	1.94

ST = Soldertail WW = Wirewrap

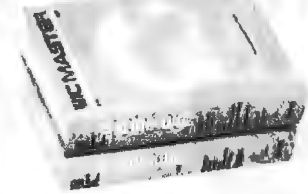
ZIF SOCKETS

16 pin ZIF 5.90
24 pin ZIF 7.90
28 pin ZIF 8.90
ZIF = TEXTOOL (Zero Insertion Force)

1984
– THE IC MASTER –

Your ticket to fast and easy IC selections

$ 89.95



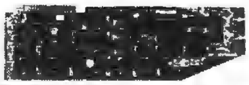
IBM Expansion KIT Upgrade Chips

4164 200ns 9 @ 5.45 ea.

micromax

VIEWMAX-80 149.95

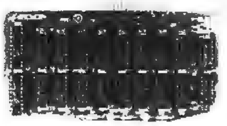
- 80 Column card for Apple II+
- Video Soft Switch
- Inverse Video
- 2 Year Warranty



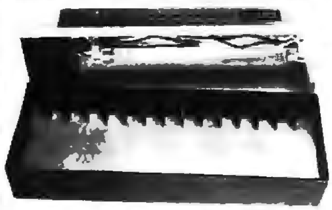
VIEWMAX-80e 129.95

- 80 Column card for Apple IIE
- 64K RAM expandable to 128K

64K RAM Upgrade 43.60



QUV-T8/1
EPROM Eraser



QUV-T8/1 Economy Model:
Low cost EPROM eraser in plastic enclosure. The UV element is in the lid and you place the EPROMS in the bottom half. No timer or switch option.

- Erases up to 8 EPROMS in 15 - 20 minutes.
- 12,000 uWatts at 1" distance.
- 90-Day Warranty **49.95**

The FLIP SORT™

The new Flip Sort™ has all the fine qualities of the original with some added benefits: a new design and 50% greater capacity. Holds 75 diskettes and the price is now lower than ever— **$16.95**

ATHANA BULK 5¼" DISKETTES (NO LABEL)

SS/SD	15.90		
SS/DD	16.90	SS/DD	10/14.90
DS/DD	22.90	100 up	— CALL

APPLE ACCESSORIES

80 Column Apple II+ ... 149.95
80 Column Apple IIE ... 129.95
Z80 Apple II+ 89.00
Z80 Apple IIE 89.00
16K Card 39.95
Cooling Fan 38.95
Power Supply 74.95
Joystick 29.95
RF Modulator 13.95
Disk Drive 199.00
Controller Card 59.95

APPLE COMPATIBLE
DISK DRIVE

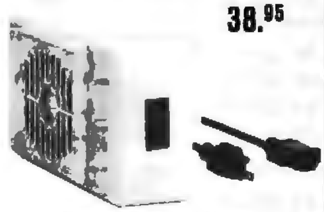
199.00

- Shugart mechanism, made in U.S.A.
- Directly replaces Apple Disk II
- Fully compatible with Apple Controller or other Apple compatible controllers.
- One Year Warranty

CONTROLLER CARD... 59.95

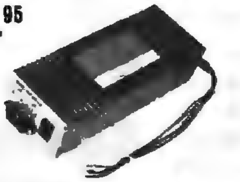
COOLING FAN

38.95



APPLE COMPATIBLE
POWER SUPPLY

74.95



- Powers Apple type systems
- +5V @ 5A +12V @ 3A
  −5V @ .5A −12V @ .5A
- Includes instructions

The Flip Sort PLUS™

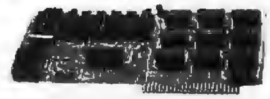
The new Flip Sort PLUS™ adds new dimensions to storage. Its smoked acrylic elegance holds over 100 diskettes with all the features you expect from the Flip Sort Family— **$24.95**

APPLE COMPATIBLE
JOYSTICK

29.95

16K RAM Card – Apple II+

- 2-Year Warranty



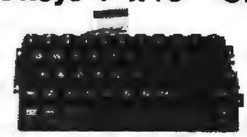
Assembled & Tested 39.95

For the APPLE HOBBIEST
DoKay KITS:

16K RAM card 24.95
80 Column Card II+ ... 89.95
Z80 Card 69.95
Printer Card 24.95
80 Column Card IIE ... 89.95

KEYBOARD (99/4)

48 keys 4" x 10" 6.95



Reg. Power Supply
Model 4A/PS (99/4)
3 DC Outputs:

12V @ .4A, +5V @ 1.1A
−5V @ .2A Highly Filtered

6.95

TERMS: Minimum order $10.00. For shipping and handling, include $2.50 for UPS ground or $3.50 for UPS Blue (air). For each additional air pound, add $1 for UPS Blue shipping and handling. California residents must include 6% sales tax; Bay area and LA residents include 6½% sales tax. Prices are subject to change without notice. We are not responsible for typographical errors. We reserve the right to limit quantities and to substitute manufacturers. All merchandise subject to prior sale.

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Telex: 756440

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California Digital

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FREE

Plastic library case supplied with all diskettes purchased from California Digital.

DISKETTES AS LOW AS $16.50

FIVE INCH SINGLE SIDED DOUBLE DENSITY

	Soft Sector / Ten Sector / Sixteen	Each box	10 Boxes	100 Boxes
CAL DIGITAL	CAL-501 / CAL-510 / CAL-516	18.95	17.50	16.50
SCOTCH	MMM-744/0 / MMM-744/10 / MMM-744/16	24.95	22.75	21.75
VERBATIM	VRB-525/01 / VRB-525/10 / VRB-525/16	24.95	22.75	21.75
MEMOREX	MRX-3481 / MRX-3483 / MRX-3485	24.95	21.75	17.75
MAXELL	MXL-MD1 / MXL-MH1/10 / MXL-MH1/16	24.95	22.75	21.25
DYSAN	DYS-104/1D / DYS-107/1D / DYS-105/1D	35.00	33.00	30.50

FIVE INCH DOUBLE SIDED DOUBLE DENSITY

CAL DIGITAL	CAL-551 / CAL-561 / N/A	24.95	22.75	20.50
SCOTCH	MMM-745/0 / MMM-745/10 / MMM-745/16	37.95	35.95	31.25
VERBATIM	VRB-550/01 / VRB-550/10 / VRB-550/16	37.95	35.95	32.75
MEMOREX	MRX-3491 / MRX-3493 / MRX-3495	32.95	31.25	26.25
MAXELL	MXL-MD2 / MXL-MD2/10 / MXL-MD2/16	37.95	35.95	33.75
MAXELL / 96	MXL-MD2/96 / N/A / N/A	45.00	43.00	41.25
DYSAN	DYS-104/2D / DYS-107/2D / DYS-105/2D	42.50	40.50	35.50
DYSAN / 96	DYS-204/2D / N/A / N/A	49.95	47.95	45.75

EIGHT INCH SINGLE SIDED SINGLE DENSITY

SCOTCH	MMM-740/0	28.50	27.50	23.80
MEMOREX	MRX-3062	27.75	26.60	22.25
VERBATIM	VRB-34/9000	31.50	29.50	25.60
DYSAN	DYS-3740/1	35.75	32.75	29.75

EIGHT INCH SINGLE SIDED DOUBLE DENSITY

SCOTCH	MMM-741/0	33.95	31.75	29.15
MEMOREX	MRX-3090	31.95	27.75	26.15
VERBATIM	VRB-34/8000	35.25	33.25	28.75
DYSAN	DYS-3740/1D	40.75	38.75	32.25
MAXELL	MXL-FD1	45.50	39.75	35.15

EIGHT INCH DOUBLE SIDED DOUBLE DENSITY

SCOTCH	MMM-743/0	45.95	43.25	37.50
MEMOREX	MRX-3102	37.95	36.75	31.50
VERBATIM	VRB-34/4001	41.75	37.50	32.25
DYSAN	DYS-3740/2D	54.65	49.75	40.50
MAXELL	MXL-FD2	52.50	48.75	40.45

MODEMS

$319

The CTS212AH Modem is 300/1200 Auto Answer/Auto Dial, Hayes Compatible. Mycroft Labs Companion communications software $35.00 additional

Signalman Mark 12, 1200 baud, Hayes compatible.	SGL-MK12	259.00
Signalman Mark 1, direct connect with terminal cable.	SGL-MK1	75.00
CTS 212AH 1200 baud, auto dial, Hayes compatible.	CTS-212AH	319.00
Hayes Smart Modem 1200 baud, auto answer, auto dial	HYS-212AD	479.00
Hayes 1200B for use with the IBM/PC, 1200 baud.	HYS-1200B	429.00
Hayes Smartmodem, 300 baud only, auto answer, auto dial	HYS-103AD	229.00
Hayes Micromodem II, 103 Apple direct connect	HYS-MM2	279.00
Universal Data 103LP, line power, answer & originate	UDS-103LP	169.00
Universal Data 212LP, full 1200 baud duplex, line power	UDS-212LP	359.00
Novation 'J' Cat, direct connect, auto answer	NOV-JCAT	115.00

MITSUBISHI 96 TPI • 4853 $179

California Digital has purchased over one thousand **factory new** Mitsubishi M4853 5¼" disk drives from the Eagle Computer Company. The drives are half height double sided 96 track per inch. The M4853 interfaces the same as the Shugart SA465.
We are currently offering these drives at only $179.00. This is far below distributor cost. Offer is subject to remaining inventory on hand at time of order. MIT-4853

MEMORY

16K DYNAMIC	2732 EPROM
1.95	4.95
4116 150ns.	450ns.
2764 EPROM	**16K STATIC**
6.95	4.95
350ns.	6116 200ns.

4164 DYNAMIC MEMORY 150ns $5.95

DYNAMIC MEMORY

		1-31	32 +	100 +
4027 4K dynamic 250ns.	ICM-4027250	1.90	1.85	1.75
4116 150ns. 16K	ICM-4116150	1.75	1.65	1.45
4116 200ns. 16K	ICM-4116200	1.75	1.65	1.45
4164 150ns. 64K 128 refresh	ICM-4164150	5.95	5.85	5.55
41256 150ns. 256K	ICM-41256150	Available		
DP8409 dynamic controller	ICT-8409	39.00	35.00	29.00

EPROMS

2708 450ns. 1K x 8	ICE-2708	4.95	4.75	4.55
2716 450ns. 2K x 8	ICE-2716	4.50	4.25	3.97
2716TMS 450ns. Tri-voltage	ICE-2716TMS	7.95	7.65	7.25
2732 450ns. 4K x 8	ICE-2732	4.50	3.75	3.55
2732 350ns. 4K x 8	ICE-2732350	8.50	8.00	7.60
2532 450ns. 4K x 8	ICE-2532	10.50	9.90	9.50
2764 350ns. 8K x 8	ICE-2764	6.95	6.95	6.95
27128 350ns. 16K x 8	ICE-27128	18.95		

STATIC MEMORY

21L02 200ns. 1K static	ICM-21L02200	1.49	1.29	1.15
21L02 450ns. 1K static	ICM-21L02450	1.29	1.15	.99
2112 450ns. 2K static	ICM-2112450	2.99	2.85	2.75
2114 300ns. 1K x 4	ICM-2114300	1.95	1.85	1.75
4044TMS 450ns. 4K x 1	ICM-4044450	3.49	3.25	2.99
5257 300ns. 4K x 1	ICM-5257300	2.50	2.25	1.99
6116 P4 200ns. 2K x 8	ICM-6116200	4.85	4.65	4.50
6116 P3 150ns. 2K x 8	ICM-6116150	5.25		
6167/2167 100ns. 16K x 1 (20 pin)	ICM-6167100	8.95		

CONNECTORS

S-100 Gold

DB25P

GOLD S-100 EDGE CARD CONNECTORS

	catalog	each	10-99	100+
Imsai s/t .250	CNE-IMS	2.95	2.50	2.19
Sullins Hi/Rel	CNE-H100	4.10	3.85	3.47
S-100 Wire W.	CNE-W10	3.95	3.50	3.19
Altair 140 s/t	CNE-100A	4.95	4.50	4.19

.156" CENTER EDGE CARD CONNECTORS

22/44 Eyelet	CNE-44E	2.50	2.15	1.95
43/72 Moto. s/t	CNE-72S	6.60	6.15	5.75
36/72 D/G s/t	CNE-72S	5.95	5.50	5.19

Other connectors available upon request

RIBBON CONNECTORS

DB25P male	CND-r25P	5.65	5.25	4.15
DB25S female	CND-r25S	5.95	5.50	4.50
57-30360 male	CNC-r36P	7.95	6.75	5.90
57-30360f male	CNC-r36S	7.95	6.75	5.90
20 pin edge	CNI-DE20	4.35	3.30	2.50
20 pin socket	CNI-DS20	2.75	1.85	1.60
26 pin edge	CNI-DE26	4.95	3.50	2.70
26 pin socket	CNI-DS26	3.50	2.40	2.15
34 pin edge	CNI-DE34	4.95	4.50	3.80
34 pin socket	CNI-DS34	4.50	3.95	3.15
50 pin edge	CNI-DE50	5.95	5.60	4.90
50 pin socket	CNI-DS50	4.95	4.60	3.80

"D" TYPE	catalog	each	10-99	100+
DE9P male	CND-9P	1.60	1.40	1.30
DE9S female	CND-9S	2.25	2.00	1.30
DE hood	CND-9H	1.50	1.35	1.20
DA15P male	CND-15P	2.35	2.10	1.80
DA15S female	CND-15S	3.25	3.10	2.90
DA15 hood	CND-15H	1.60	1.35	1.30
DB25P male	CND-25P	1.95	1.75	1.35
DB25S female	CND-25S	2.85	2.55	1.85
DB25 hood	CND25H	1.35	1.15	.77
DC37P male	CND-37P	4.20	3.95	3.65
DC37S female	CND-37S	5.95	5.75	5.50
DC37 hood	CND-37H	2.25	1.95	1.65
DD50P male	CND-50P	5.50	5.10	4.75
DD50 hood	CND-50H	2.60	2.40	2.10
Hardware 2/set	CND-2HS	.89	.69	.42

AMPHENOL / CENTRONICS TYPE

57-30360 36/P	CNC-36P	7.95	6.35	3.97
IEEE488. C dor	CND-24P	7.95	6.35	5.35

DISK DRIVE POWER CONNECTORS

8 6 pin D C	CNP-6DC	1.95	1.29	.89
8 3 AC Sol/S	CNP-3SS	1.69	1.09	.89
8 3 AC DG/S	CNP-3DS	1.69	1.09	.89
5¼ 4 pin D C	CNP-4DC	1.79	1.19	.99
3 pin DIN recpt	CNP-D3P	2.59	1.99	1.59

BLOWOUT SALE $129

California Digital has recently participated in the purchase of several thousand Siemens FDD 100-8 floppy disk drives. These units are electronically and physically similiar to that of the Shugart 801R. All units are new and shipped in factory sealed boxes. Manual and power connectors supplied free upon request. Your choice 115 Volt. 60 Hz. or 230 Volt. 50Hz.

NOTE! European customers, we have a large quantity of 230 volt 50 Hz. units warehoused in Frankfort Germany. Arrangements can be made to will call these drives in quantities of 50 or more in Frankfort reducing import duty and freight charges.

REMEX DOUBLE SIDED $219

California Digital has just purchased a large quantity of Remex RFD-4000 **Eight inch double sided** disk drives. Remex is the only double sided disk drive that has an double gimbal mounted head assembly that guaranties lower head tracking. This drive is mechanically solid. Remex has always been known for producing premiere products for the floppy disk market. The Remex company is a subsidiary of the Ex-cell-o Corporation, a Fortune 500 Company.

Five Inch Single Sided Drives

TEAC FD-54A half height	129	123	119
SHUGART SA400L	189	179	175
SHUGART SA200 ⅔ Height	159	149	139
TANDON TM100-1 full height	169	165	179

Five Inch Double Sided Drives

TEAC FD55B half height	139	135	129
CONTROL DATA 9409 IBM/PC	229	219	215
CONTROL DATA 9428 half ht.	229	219	215
SHUGART SA455 Half Height	259	249	239
PANASONIC JA551/2N (SA455)	169	159	155
SHUGART SA465 Half Ht. 96TPI	289	279	269
TANDON 100-2 full height	197	193	185
TANDON 101-4 96TPI 80 Track	369	355	351
MITSUBISHI 4851 Half Height	259	249	245
MITSUBISHI 4853 ½ Ht. 96TPI	179	175	169
MITSUBISHI 4854 ½ Ht., 8" elec.	465	449	439
QUME 142 Half Height	239	229	219

Eight Inch Single Sided Drives

	One	Two	Ten
SHUGART 801R	385	375	365
SIEMENS FDD 100-8	129	125	119
TANDON 848E-1 Half Height	369	359	349

Eight Inch Double Sided Drives

SHUGART SA851R	495	485	475
QUME 842 "QUME TRACK 8"	459	459	449
TANDON 848E-2 Half Height	459	447	435
REMEX RFD-4000	219	219	209
MITSUBISHI M2894-63	447	439	433
MITSUBISHI M2896-63 Half Ht.	459	449	409

Three Inch Disk Drives

SHUGART SA300 with diskette	229	219	209

Five Inch Winchester Hard Disk Drives

FUJITSU M2235AS	27 M/Bytes	999	959	889
RODINE RO-208	53 M/Byte	1589	1493	1427
MAXTOR XT1065	65 M/Byte	1995	1965	1939
SHUGART 712	13 M/Byte, ½ Ht	795	765	725
TANDON 503	19 M/Byte	795	775	755

Upon request, all drives are supplied with power connectors and manual

ENCLOSURES

California Digital manufactures an asortment of stock and custom disk drive enclosures. If the volume is justified we will custom design an enclosure for your application. The following stock disk drive enclosures are available. All include power supplies the 8" enclosures are supplied with exhaust fans.

Horizontal mount two 8" full height drives. $279.00
Vertical mount two full height 8" disk drives. $299.00

Horizontal mount one full height or two half height 8" disk drives $239.00
Vertical mount two full height 5¼" disk drives $139.00

Telex 753607

VISA · master charge

Shipping: First five pounds $3.00, each additional pound $.50.
Foreign orders: 10% shipping, excess will be refunded.
California residents add 6½% sales tax. ● COD's discouraged.
Open accounts extended to state supported educational institutions and companies with a strong "Dun & Bradstreet" rating.
Retail location: 17700 Figueroa Street, Carson CA. 90248.

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TECHNICAL & CALIFORNIA
(213) 217-0500

California Digital

17700 Figueroa Street ● Carson, California 90248

EAGLE $895

In conjunction with the California Digital has agreed to assist in the liquidation of approximately 1000 Eagle IIE/2 Computers.
These units features a 12" non-glare green phosphor CRT, typewriter style keyboard with separate numeric cluster. This unit provides two 5 1/4" drives for a combined storage capacity of 780 K/Byte. The Eagle II contains a 4Mhz Z-80A, DMA disk interface, two RS-232C serial ports, Centronics style printer interface, along with an auxillary parallel port.
Software included consists of ULTRACALC electronic spread sheet, SPELLBINDER word processor, CBASIC2, CP/M 2.2, and an exclusive Eagle menu driven utility package.
These units are all "factory new" and are being offered far below their suggested price of $1995. This is your opportunity to purchase a complete CP/M system for only $895. EAG-2E2

Epson Comrex PLOTTER $189

The Comrex Comscriber I is the ideal solution to make short work of translating financial and other numeric data into a graphic presentation. Complete with menu driven software for use with either IBM/PC or Apple II. Along with this are included mulicolor plotter pens, demonstration software and interface/cable.
The Comscriber I was originally priced to sell at $795. This is your opportunity to purchase a high value graphic plotter at only $189. IBM/PC COM-C1PC: Apple COM-C1A2

PRINTERS

MATRIX PRINTERS

Star Gemini-10X 120 char/sec	STR-G10X	279 00
Star Gemini-15X, 100 char/sec 15" paper	STR-G15X	389 00
Star Gemini Delta 10, 160 Char/sec	STR D10	399 00
Star Coax 80FT friction & tractor	VST-C80FT	195 00
Toshiba P1350, 192 char/sec. letter quality	TOS-1350	1495 00
Okidata 92A serial & parallel 9½" paper	OKI-82A	347 00
Okidata 92A parallel interface, 160 char/sec	OKI-92A	427 00
Okidata 83A & parallel 15" paper	OKI-83A	567 00
Okidata 84A & parallel 15" paper	OKI-84A	897 00
Okidata 2350 (new) 350 char/sec	OKI-2350	1995.00
Epson RX-8010 120 Char/sec	EPS-RX80	317 00
Epson FX80, 10" 160 char/sec with graphtrax	EPS-FX80	529 00
Epson FX 100 15" 160 char/sec with graphtrax	EPS-FX100	719 00
Epson MX100 with graphtrax 15" paper	EPS-MX100	589 00
NEC8023A parallel 9½" paper, graphics	NEC-8023A	389 00
Anadex 9501B high speed with graphics	ADX-9501B	1029 00
Anadex 9620B 200 char/sec par'l & serial	ADX-9620B	1129 00
Quantex 7030 correspondence quality 180 char/sec	QTX-7000	1539 00
Prowriter 8510 parallel 9½" paper	PRO-8510P	359 00
Prowriter II, parallel 15" paper, graphics	PRO-2P	689 00
Dataproducts B-600-3 band printer 600 LPM	DPS-B600	6985 00
Printronix P300 high speed printer 300 lines per minute	PTX-P300	4250 00
Printronix P600 ultra high speed 600 lines per minute	PTX-P600	5795 00

WORD PROCESSING PRINTERS

NEC7710 55 char/second, serial interface	NEC-7710	1979 00
NEC7730 55 char/sec par'l interface	NEC-7730	1979 00
NEC3550 popular printer designed for the IBM/PC	NEC-3550	1799 00
NEC2050 designed for IBM/PC 20 char/sec par'l	NEC-2050	995 00
Silver Reed EXP500 14 char/sec par'l interface	SRD-EXP500	459 00
Silver Reed EXP550 17 Char/sec par'l interface	SRD-EXP550	659 00
Diablo 630 40 char/sec serial	DBL-630	1785 00
Diablo 620, proportional spacing horz & vert tab 20 cps.	DBL-620	879 00
Juki 6100, 18 char/sec graphic mode	JUK-6100	495 00
Brother HR1A daisy wheel, parallel interface	BTH-HR1P	695 00
Brother HR1A serial interface	BTH-HR1S	695 00
Starwriter F10 serial, 40 char/sec	PRO-F10S	1125 00
Starwriter F10 parallel, 40 char/sec	PRO-F10P	1125 00
Comrex CR1 word processing printer, serial intr	CRX-CR1S	729 00
Comrex CR2, 5k buffer, proportional spacing, par'l	CRX-CR2P	495 00

TERMINALS

Freedom 100 split screen, detatchable keyboard	LIB-100	495 00
Qume 102 green phosphor terminal	QUM 102	539 00
Visual 50 Green screen	VSL-50G	650 00
Ampex Dialogue 125 green screen	APX-D125G	675 00
Ampex Dialouge 175 amber screen two page func. keys	APX-D125A	719 00
Wyse 50 14" green phosphor	WYS-50	595 00
Wyse 100 horz & vert split screen metal enclosure	WYS-100	795 00
Wyse 300 Eight color display split screen	WYS-300	1159 00
Zenith 29 terminal VT52 compatible detatchable keyboard	ZTH-Z29	765 00
Televideo 910 Plus, block mode	TVI-910P	575 00
Televideo 925 detatchable keyboard 22 function keys	TVI-925	789 00
Televideo 950 graphic char. split screen 22 func.	TVI-950	950 00
Televideo 970 14" green 132 column European	TVI-970	1095 00

NEC RGB COLOR MONITOR $259

The NEC JC-1401D is a 13" medium/high resolution RGB monitor suitable for use with the Sanyo MBC-550/555 or the IBM/PC. The monitor features a resolution of 400 dots by 240 lines. Colors available are Red, Green, Blue, Yellow, Cyan, Magenta, Black and White.
These monitors are currently being used in applications far more critical than microcomputers.
The NEC monitor carries the Litton-Monroe label and was originally scheduled for use in their "Office of the Future" equipment. A change in Monroe's marketing strategy has made these units excess inventory which were sold to California Digital. We are offering these prime "new" RGB monitors at a fraction of their original cost. Sanyo compatible NEC-1401/S. IBM/P/C Computer compatible NEC-1401/PC

MONITORS

BMC 12A green phosphor 15 MHz composit video	BMC-12A	78 95
BMC 12" high resolution 20MHz	BMC 12EN	119 00
Amdek 300G 12" green phosphor	AMK 300G	128 95
Amdek 300A 12" amber phos. hi-resolution	AMK-300A	138 95
Amdek 310A designed for IBM/PC amber	AMK-310A	158 95
Zenith ZVM122 Amber Phosphor 12" 40/80 column switch	ZTH 122	94 95
Zenith ZVM123 green phosphor 12" 40/80 column switch	ZTH Z123	94 95
NEC JB1201 green phosphor 18 MHz composit video	NEC-JB1201	159 00
NEC JB1260 commercial grade composit	NEC-JB1260	119 00
Motorola 23" open frame blk/white composit video	MOT BW23	159 00
Motorola 12" open frame requires horz sync and power	MOT-BW12	69 00
Conrac 9" open frame requires horz sync & 12v supply	CON-BW9	50 00
COLOR		
NEC JC1401D Medium High 13" RGB	NEC 1401/X	259 00
BMC AU9191U Color composit video with sound	BMC-9191	238 95
BMC 9191M RGB designed for use with the IBM computer	BMC-9191M	379 00
NEC JC1203DM RGB color monitor	NEC-1200	699 00
NEC JC1201 color composit	NEC-JC1201	339 00
Zenith ZVM135 RGB & composite suitable for IBM PC	ZTH Z135	475.00
Amdek Color I 13" composit video	AMK-100	299 00
Amdek Color II + 13" RGB hi resolution	AMK 200	419 95
Amdek Color III + 13" RGB medium resolution	AMK 300	359 95
Princeton HX 12 RGB IBM/PC compatible	PRN-HX12	478 95

ASCII KEYBOARD $49

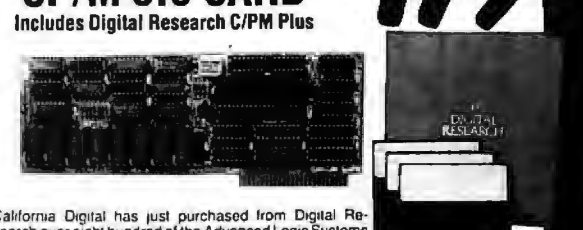
California Digital has purchased over 3000 of these Microswitch keyboards from the General Dynamics Corporation. 93 ASCII encoded Hall effect switches includes 8 function keys and 14 key numeric cluster make this keyboard an excellect value at only $49. MIC-93GD 5 lbs
We also have available a matching General Dynamics steel trim panel $10

Non-encoded Hytek 58 key metal contact keyboard HIK-58 $24 95. Matching 15 key numeric cluster $9 95 HIK 15. Both for only $29 95. HIK-5815

Not pictured 49 key eight bit modified Hollerith coded Microswitch Hall effect keyboard REMOVED from punch card equipment $14 95. DIT KB49 ASCII encoder available

Advanced Logic Systems CP/M 3.0 CARD $179

Includes Digital Research C/PM Plus



California Digital has just purchased from Digital Research over eight hundred of the Advanced Logic Systems CP/M 3.0 cards. This unique product offers performance upto 300% faster than existing Apple CP/M cards. Featuring a 6 MHz. Z80B micro-processor, 64K/Byte of on board memory, with CP/M 3.0 along with GSX 80 graphics and CBasic. The ALS card supports larger programs with enhanced CP/M editing features. Manufacturers suggested price on the CP/M board is $399. while supplies last California Digital is offering this card at only $179. ALS-Z80

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16 BIT MICROPROCESSORS

Octagon dual CPU 8088/Z80 & controller	OCT-88Z80	795 00
Godbout 8086/8087 microcomp 16 bit	GBT-8687	495 00
Godbout dual processor 8085/8088 8/16	GBT-8588	359 00

SINGLE BOARD COMPUTERS

Insight EO-4 128K 4 serial not S-100	INS-EO4	595 00
Advanced Digital Floppy & 64K	AMD Z80	750 00
Teletek System master 765 floppy 64K	TEL-SM1	895 00
Teletek FDC-1 single board no memory	TEL-FDC1	675 00

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California Computer Z80 microprocessor	CCS-2810	275 00
Tarbell Z80 with two RS232 ports	TAR-Z80	339 00

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Godbout Disk 1 double density	GBT-DSK1	395 00
California Computer 2422A with CPM	CCS-2422	339 00
Morrow Disk Jockey II with CPM 2 2	MDS-DJ2	350 00
Morrow Disk Jockey I with CPM sgl Den	MDS-DJ1	225 00
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Tarbell Electronics single density	TAR-SDC	279 00
Fulcrum DMA OmniDisk I/O to hard disk	FCM-OD1	389 00

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Digital Research CP/M 3 0 8" sgl den	DRC-CpM30	249 00
Godbout CPM 2 2 for Disk I	GBT-CpM22	159 00
Godbout CPM86 for 8088 and 8086	GBT-CpM86	265 00
Tarbell Electronics CPM 2 2	TAR-CpM22	159 00

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Godbout Disk 2 8" & 14" hard disk	GBT-DSK2	569 00
Godbout Disk 3 for 5¼" Winchesters	GBT-DSK3	
Morrow Designs controller for 5¼" Win	MDS-W506	495 00
Western Digital new WD-1001 (not S 100)	WDI 1001	495 00

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Digital Research PROM board 32K	DGR-P32	119 00

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Godbout Ram 21 128K byte 8/16 transfer	GBT R21	859 00
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California Comp 2066 64K bank select	CCS-2066	295 00

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Godbout Interfacer II 1 serial 3 par'l ports	GBT-150A	269 00
Godbout Interfacer III with 5 serial ports	GBT-135A	495 00
Godbout Interfacer III, with 8 serial ports	GBT-138A	585 00
Godbut Interfacer IV 3 serial 2 parallel	GBT 187A	329 00
California Computer 2710 4 serial ports	CCS-2710	279 00
California Computer 2719 2 serial 2 par'l	CCS-2719	295 00
California Computer 2720 4 port par'l	CCS-2720	219 00
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Quadboard 256K Four Function	QUD-4/256	429 00
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Hercules Graphics Card	HCS-G100	337 95
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STB Super RIO 256K	STB-RI256	750 00
STB Super RIO Piggyback 64K	STB-P864	299 00
STB Super RIO Piggyback 256K	STB-P8256	795 00
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Quickcom 300/1200 internal modem	WAD-3/12	495 00
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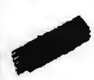

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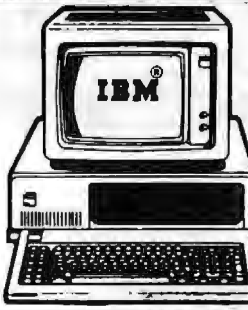

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LP = Lower Power Qstat = Quasi-Static

DYNAMIC RAMS

TMS4027	4096 x 1	(250ns)	1.99
2107	4096 x 1	(200ns)	1.95
MM5280	4096 x 1	(300ns)	1.95
TMS4060	4096 x 1	(300ns)	1.95
UPD411	4096 x 1	(300ns)	1.95
TMS4050	4096 x 1	(300ns)	1.95
MK4108	8192 x 1	(200ns)	1.95
MM5298	8192 x 1	(250ns)	1.85
4116-300	16384 x 1	(300ns)	8/11.75
4116-250	16384 x 1	(250ns)	8/7.95
4116-200	16384 x 1	(200ns)	8/12.95
4116-150	16384 x 1	(150ns)	8/14.95
4116-120	16384 x 1	(120ns)	8/29.95
2118	16384 x 1	(150ns) (5v)	4.95
MK4332	32768 x 1	(200ns)	9.95
4164-200	65536 x 1	(200ns) (5v)	5.44
4164-150	65536 x 1	(150ns) (5v)	5.44
4164-120	65536 x 1	(120ns) (5v)	8.95
MCM6665	65536 x 1	(200ns) (5v)	8.95
TMS4164	65536 x 1	(150ns) (5v)	8.95
TMS4416	16384 x 4	(150ns) (5v)	9.95
41256-150	262144 x 1	(150ns) (5v)	54.95
41256-200	262144 x 1	(200ns) (5v)	49.95

5v = Single 5 volt supply

EPROMS

1702	256 x 8	(1us)	4.50
2708	1024 x 8	(450ns)	3.95
2758	1024 x 8	(450ns) (5v)	5.95
2716-6	2048 x 8	(650ns)	2.95
2716	2048 x 8	(450ns) (5v)	3.95
2716-1	2048 x 8	(350ns) (5v)	5.95
TMS2516	2048 x 8	(450ns) (5v)	5.50
TMS2716	2048 x 8	(450ns)	7.95
TMS2532	4096 x 8	(450ns) (5v)	5.95
2732	4096 x 8	(450ns) (5v)	4.95
2732-250	4096 x 8	(250ns) (5v)	8.95
2732-200	4096 x 8	(200ns) (5v)	11.95
2732A-4	4096 x 8	(450ns) (5v) (21vPGM)	6.95
2732A	4096 x 8	(250ns) (5v) (21vPGM)	9.95
2732A-2	4096 x 8	(200ns) (5v) (21vPGM)	13.95
2764	8192 x 8	(450ns) (5v)	6.95
2764-250	8192 x 8	(250ns) (5v)	7.95
2764-200	8192 x 8	(200ns) (5v)	19.95
TMS2564	8192 x 8	(450ns) (5v)	14.95
MCM68764	8192 x 8	(450ns) (5v) (24pin)	39.95
MCM68766	8192 x 8	(350ns) (5v) (24pin)	42.95
27128-30	16384 x 8	(300ns) (5v)	29.95
27128	16384 x 8	(250ns) (5v)	34.95

5v Single 5 Volt Supply 21vPGM Program at 21 Volts

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- ★ **Fast service – most orders processed within 24 hours!**

CRYSTALS

32.768 khz	1.95
1.0 mhz	3.95
1.8432	3.95
2.0	2.95
2.097152	2.95
2.4576	2.95
3.2768	2.95
3.579545	2.95
4.0	2.95
5.0	2.95
5.0688	2.95
5.185	2.95
5.7143	2.95
6.0	2.95
6.144	2.95
6.5536	2.95
8.0	2.95
10.0	2.95
10.738635	2.95
14.31818	2.95
15.0	2.95
16.0	2.95
17.430	2.95
18.0	2.95
18.432	2.95
20.0	2.95
22.1184	2.95
32.0	2.95

UARTS

AY5-1013	3.95
AY3-1015	6.95
PT1472	9.95
TR1602	3.95
2350	9.95
2651	8.95
IM6402	7.95
IM6403	8.95
INS8250	10.95

GENERATORS

BIT-RATE

MC14411	11.95
BR1941	11.95
4702	12.95
COM5016	16.95
COM8116	10.95
MM5307	10.95

FUNCTION

MC4024	3.95
LM566	1.49
XR2206	3.75
8038	3.95

CMOS

4000	.29	4528	1.19
4001	.25	4531	.95
4002	.25	4532	1.95
4006	.89	4538	1.95
4007	.29	4539	1.95
4008	.95	4541	2.64
4009	.39	4543	1.19
4010	.45	4553	5.79
4011	.25	4555	.95
4012	.25	4556	.95
4013	.38	4581	1.95
4014	.79	4582	1.95
4015	.39	4584	.75
4016	.39	4585	.75
4017	.69	4702	12.95
4018	.79	74C00	.35
4019	.39	74C02	.35
4020	.75	74C04	.35
4021	.79	74C08	.35
4022	.79	74C10	.35
4023	.29	74C14	.59
4024	.65	74C20	.35
4025	.29	74C30	.35
4026	1.65	74C32	.39
4027	.45	74C42	1.29
4028	.69	74C48	1.99
4029	.79	74C73	.65
4030	.39	74C74	.65
4034	1.95	74C76	.80
4035	.85	74C83	1.95
4040	.75	74C85	1.95
4041	.75	74C86	.39
4042	.69	74C89	4.50
4043	.85	74C90	1.19
4044	.79	74C93	1.75
4046	.85	74C95	.99
4047	.95	74C107	.89
4049	.35	74C150	5.75
4050	.35	74C151	2.25
4051	.79	74C154	3.25
4053	.79	74C157	1.75
4060	.89	74C160	1.19
4066	.39	74C161	1.19
4068	.39	74C162	1.19
4069	.29	74C163	1.19
4070	.35	74C164	1.39
4071	.29	74C165	2.00
4072	.29	74C173	.79
4073	.29	74C174	1.19
4075	.29	74C175	1.19
4076	.79	74C192	1.49
4078	.29	74C193	1.49
4081	.29	74C195	1.39
4082	.29	74C200	5.75
4085	.95	74C221	1.75
4086	.95	74C244	2.25
4093	.49	74C373	2.45
4098	2.49	74C374	2.45
4099	1.95	74C901	.39
14409	12.95	74C902	.85
14410	12.95	74C903	.85
14411	11.95	74C905	10.95
14412	12.95	74C906	.95
14419	7.95	74C907	1.00
14433	14.95	74C908	2.00
4502	.95	74C909	2.75
4503	.65	74C910	9.95
4508	1.95	74C911	8.95
4510	.85	74C912	8.95
4511	.85	74C914	1.95
4512	.85	74C915	1.19
4514	1.25	74C918	2.75
4515	1.79	74C920	17.95
4516	1.55	74C921	15.95
4518	.89	74C922	4.49
4519	.39	74C923	4.95
4520	.79	74C925	5.95
4522	1.25	74C926	7.95
4526	1.25	74C928	7.95
4527	1.95	74C929	19.95

6800

68000	49.95
6800	2.95
6802	7.95
6803	19.95
6808	13.90
6809E	14.95
6809	11.95
6810	2.95
6820	4.35
6821	2.95
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	14.95
6847	11.95
6850	3.25
6852	5.75
6860	7.95
6875	6.95
6880	2.25
6883	22.95
68047	24.95
68488	19.95
6800 1MHZ	
68B00	10.95
68B02	22.25
68B09E	29.95
68B09	29.95
68B10	6.95
68B21	6.95
68B40	19.95
68B45	19.95
68B50	5.95
68B00 2 MHZ	

6500

1 MHZ	
6502	4.95
6504	6.95
6505	8.95
6507	9.95
6520	4.35
6522	6.95
6532	9.95
6545	22.50
6551	11.85
2 MHZ	
6502A	6.95
6522A	9.95
6532A	11.95
6545A	27.95
6551A	11.95
3 MHZ	
6502B	9.95

DISC CONTROLLERS

1771	16.95
1791	24.95
1793	26.95
1795	29.95
1797	49.95
2791	54.95
2793	54.95
2795	59.95
2797	59.95
6843	34.95
8272	39.95
UPD765	39.95
MB8876	29.95
MB8877	34.95
1691	17.95
2143	18.95

8000

8035	5.95
8039	5.95
INS-8060	17.95
INS-8073	49.95
8080	3.95
8085	4.95
8085A-2	11.95
8086	24.95
8087	199.95
8088	29.95
8089	89.95
8155	6.95
8155-2	7.95
8156	6.95
8185	29.95
8185-2	39.95
8741	29.95
8748	24.95
8755	24.95

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6845	14.95
68B45	19.95
HD46505SP	15.95
6847	11.95
MC1372	6.95
68047	24.95
8275	29.95
7220	99.95
CRT5027	19.95
CRT5037	24.95
TMS9918A	39.95
DP8350	49.95

8200

8202	24.95
8203	39.95
8205	3.50
8212	1.80
8214	3.85
8216	1.75
8224	2.25
8226	1.80
8228	3.49
8237	19.95
8237-5	21.95
8238	4.49
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8257	7.95
8257-5	8.95
8259	6.90
8259-5	7.50
8271	79.95
8272	39.95
8275	29.95
8279	8.95
8279-5	10.00
8282	6.50
8283	6.50
8284	5.50
8286	6.50
8287	6.50
8288	25.00
8289	49.95
8292	14.95

Z-80

2.5 Mhz	
Z80-CPU	3.95
Z80-CTC	3.95
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Z80-DMA	14.95
Z80-PIO	3.95
Z80-SIO/0	11.95
Z80-SIO/1	11.95
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Z80-SIO/9	11.95
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Z80A-CPU	4.49
Z80A-CTC	4.95
Z80A-DART	9.95
Z80A-DMA	12.95
Z80A-PIO	4.49
Z80A-SIO/0	12.95
Z80A-SIO/1	12.95
Z80A-SIO/2	12.95
Z80A-SIO/9	12.95
6.0 Mhz	
Z80B-CPU	9.95
Z80B-CTC	12.95
Z80B-PIO	12.95
Z80B-DART	19.95
Z80B-SIO/2	39.95
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Z6132	34.95
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2513-002 LOW	9.95

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MM5369-EST	4.25
MM5375	4.95
MM58167	12.95
MM58174	11.95
MSM5832	3.95

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AY5-3600	11.95
AY5-3600 PRO	11.95

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4164 64K D RAMS 150ns or 200ns 9 / $49⁰⁰

74LS00

74LS00	.24	74LS173	.69
74LS01	.25	74LS174	.55
74LS02	.25	74LS175	.55
74LS03	.25	74LS181	2.15
74LS04	.24	74LS189	8.95
74LS05	.25	74LS190	.89
74LS08	.28	74LS191	.89
74LS09	.29	74LS192	.79
74LS10	.25	74LS193	.79
74LS11	.35	74LS194	.69
74LS12	.35	74LS195	.69
74LS13	.45	74LS196	.79
74LS14	.59	74LS197	.79
74LS15	.35	74LS221	.89
74LS20	.25	74LS240	.95
74LS21	.29	74LS241	.99
74LS22	.25	74LS242	.99
74LS26	.29	74LS243	.99
74LS27	.29	74LS244	1.29
74LS28	.35	74LS245	1.49
74LS30	.25	74LS247	.75
74LS32	.29	74LS248	.99
74LS33	.55	74LS249	.99
74LS37	.35	74LS251	.59
74LS38	.35	74LS253	.59
74LS40	.25	74LS257	.59
74LS42	.49	74LS258	.59
74LS47	.75	74LS259	2.75
74LS48	.75	74LS260	.59
74LS49	.75	74LS266	.55
74LS51	.25	74LS273	1.49
74LS54	.29	74LS275	3.35
74LS55	.29	74LS279	.49
74LS63	1.25	74LS280	1.98
74LS73	.39	74LS283	.69
74LS74	.35	74LS290	.89
74LS75	.39	74LS293	.89
74LS76	.39	74LS295	.99
74LS78	.49	74LS298	.89
74LS83	.60	74LS299	1.75
74LS85	.69	74LS323	3.50
74LS86	.39	74LS324	1.75
74LS90	.55	74LS352	1.29
74LS91	.89	74LS353	1.29
74LS92	.55	74LS363	1.35
74LS93	.55	74LS364	1.95
74LS95	.75	74LS365	.49
74LS96	.89	74LS366	.49
74LS107	.39	74LS367	.45
74LS109	.39	74LS368	.45
74LS112	.39	74LS373	1.39
74LS113	.39	74LS374	1.39
74LS114	.39	74LS375	.95
74LS122	.45	74LS377	1.39
74LS123	.79	74LS378	1.18
74LS124	2.90	74LS379	1.35
74LS125	.49	74LS385	3.90
74LS126	.49	74LS386	.45
74LS132	.59	74LS390	1.19
74LS133	.59	74LS393	1.19
74LS136	.39	74LS395	1.19
74LS137	.99	74LS399	1.49
74LS138	.55	74LS424	2.95
74LS139	.55	74LS447	.95
74LS145	1.20	74LS490	1.95
74LS147	2.49	74LS624	3.99
74LS148	1.35	74LS640	2.20
74LS151	.55	74LS645	2.20
74LS153	.55	74LS668	1.69
74LS154	1.90	74LS669	1.89
74LS155	.69	74LS670	1.49
74LS156	.69	74LS674	14.95
74LS157	.65	74LS682	3.20
74LS158	.59	74LS683	3.20
74LS160	.69	74LS684	3.20
74LS161	.65	74LS685	3.20
74LS162	.69	74LS688	2.40
74LS163	.65	74LS689	3.20
74LS164	.69	81LS95	1.49
74LS165	.95	81LS96	1.49
74LS166	1.95	81LS97	1.49
74LS168	1.75	81LS98	1.49
74LS169	1.75	25LS2521	2.80
74LS170	1.49	25LS2569	4.25

74S00

74S00	.32	74S124	2.75	74S197	1.49
74S02	.35	74S132	1.24	74S201	6.95
74S03	.35	74S133	.45	74S225	7.95
74S04	.35	74S134	.50	74S240	2.20
74S05	.35	74S135	.89	74S241	2.20
74S08	.35	74S138	.85	74S244	2.20
74S09	.40	74S139	.85	74S251	.95
74S10	.35	74S140	.55	74S253	.85
74S11	.35	74S151	.95	74S257	.95
74S15	.35	74S153	.95	74S258	.95
74S20	.35	74S157	.95	74S260	.79
74S22	.35	74S158	.95	74S273	2.45
74S30	.35	74S161	1.95	74S280	1.95
74S32	.40	74S162	1.95	74S287	1.90
74S37	.88	74S163	1.95	74S288	1.90
74S38	.85	74S168	3.95	74S289	6.89
74S40	.35	74S169	3.95	74S301	6.95
74S51	.35	74S174	.95	74S373	2.45
74S64	.40	74S175	.95	74S374	2.45
74S65	.40	74S181	3.95	74S387	1.95
74S74	.50	74S182	2.95	74S412	2.98
74S85	1.99	74S188	1.95	74S471	4.95
74S86	.50	74S189	6.95	74S472	4.95
74S112	.50	74S194	1.49	74S474	4.95
74S113	.50	74S195	1.49	74S570	2.95
74S114	.55	74S196	1.49	74S571	2.95

VOLTAGE REGULATORS

7805T	.75	7905T	.85
78M05C	.35	7908T	.85
7808T	.75	7912T	.85
7812T	.75	7915T	.85
7815T	.75	7924T	.85
7824T	.75	7905K	1.49
7805K	1.39	7912K	1.49
7812K	1.39	7915K	1.49
7815K	1.39	7924K	1.49
7824K	1.39	79L05	.79
78L05	.69	79L12	.79
78L12	.69	79L15	.79
78L15	.69	LM323K	4.95
78H05K	9.95	UA78S40	1.95
78H12K	9.95		

C, T = TO-220 K = TO-3
L = TO-92

7400

7400	.19	74123	.49
7401	.19	74125	.45
7402	.19	74126	.45
7403	.19	74132	.45
7404	.19	74136	.50
7405	.25	74143	4.95
7406	.29	74145	.60
7407	.29	74147	1.75
7408	.24	74148	1.20
7409	.19	74150	1.35
7410	.19	74151	.55
7411	.25	74153	.55
7413	.35	74154	1.25
7414	.49	74155	.75
7416	.25	74157	.55
7417	.25	74159	1.65
7420	.19	74160	.85
7421	.35	74161	.69
7425	.29	74163	.69
7427	.29	74164	.85
7430	.19	74165	.85
7432	.29	74166	1.00
7437	.29	74167	2.95
7438	.29	74170	1.65
7442	.49	74173	.75
7445	.69	74174	.89
7446	.69	74175	.89
7447	.69	74177	.75
7448	.69	74181	2.25
7451	.23	74184	2.00
7473	.34	74185	2.00
7474	.33	74191	1.15
7475	.45	74192	.79
7476	.35	74193	.79
7482	.95	74194	.85
7483	.50	74195	.85
7485	.59	74197	.75
7486	.35	74198	1.35
7489	2.15	74221	1.35
7490	.35	74246	1.35
7492	.50	74247	1.25
7493	.35	74259	2.25
7495	.55	74273	1.95
7497	2.75	74276	1.25
74100	1.75	74279	.75
74107	.30	74366	.65
74109	.45	74367	.65
74116	1.55	74368	.65
74121	.29	74393	1.35
74122	.45		

SOUND CHIPS

76477	3.95	AY3-8910	12.95
76488	5.95	AY3-8912	12.95
76489	8.95	MC3340	1.49
SSI-263	39.95		

BYPASS CAPS

.01 UF DISC	100/6.00
.01 UF MONOLITHIC	100/12.00
.1 UF DISC	100/8.00
.1 UF MONOLITHIC	100/15.00

EPROM ERASERS

SPECTRONICS CORPORATION

	Timer	Capacity Chip	Intensity (uW/Cm²)	
PE-14		9	8,000	83.00
PE-14T	X	9	8,000	119.00
PE-24T	X	12	9,600	175.00
PL-265T	X	30	9,600	255.00
PR-125T	X	25	17,000	349.00
PR-320T	X	42	17,000	595.00

INTERFACE

8T28	1.59
8T28	1.89
8T95	.89
8T96	.89
8T97	.89
8T98	.89
DM8131	2.95
DP8304	2.29
DS8833	2.25
DS8835	1.99
DS8836	.99
DS8837	1.65
DS8838	1.30

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DATA ACQUISITION

ADC0800	15.55	DAC0800	4.95
ADC0804	3.49	DAC0808	2.95
DAC0806	1.95	DAC1020	8.25
ADC0809	4.49	DAC1022	5.95
ADC0816	14.95	MC1408L6	1.95
ADC0817	9.95	MC1408L8	2.95

CONNECTORS

RS232 Male	2.50
RS232 Female	3.25
RS232 Hood	1.25
S-100 ST	3.95

EXAR

XR 2206	3.75
XR 2207	3.75
XR 2208	3.75
XR 2211	5.25
XR 2240	3.25

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ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	3.95
ICM7207A	5.59
ICM7208	15.95

9000

9316	1.00
9334	2.50
9368	3.95
9401	9.95
9601	.75
9602	1.50
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LM301H	.79	LM350K	4.95	NE570	3.95	LM1830	3.50
LM307	.45	LM350T	4.60	NE571	2.95	LM1871	5.49
LM308	.69	LM358	.69	NE590	2.50	LM1872	5.49
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LM309K	1.25	LM377	1.95	LM710	.75	LM1896	1.75
LM310	1.75	LM378	2.50	LM711	.79	ULN2003	2.49
LM311	.64	LM379	4.50	LM723	.49	LM2877	2.05
LM311H	.89	LM380	.89	LM723H	.55	LM2878	2.25
LM312H	1.75	LM380N-8	1.10	LM733	.98	LM2900	.85
LM317K	3.95	LM381	1.60	LM741	.35	LM2901	1.00
LM317T	1.19	LM382	1.60	LM741N-14	.35	LM2917	2.95
LM318	1.49	LM383	1.95	LM741H	.40	LM3900	.59
LM318H	1.59	LM384	1.95	LM747	.69	LM3905	1.25
LM319H	1.90	LM386	.89	LM748	.59	LM3909	.98
LM319	1.25	LM387	1.40	LM1014	1.19	LM3911	2.25
LM320 (see 7900)		LM389	1.35	LM1303	1.95	LM3914	3.95
LM322	1.65	LM390	1.95	LM1310	1.49	LM3915	3.95
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LM324	.59	LM393	1.29	MC1349	1.89	MC4024	3.95
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LM331	3.95	LM399H	5.00	MC1358	1.69	RC4136	1.25
LM334	1.19	NE531	2.95	MC1372	6.95	RC4151	3.95
LM335	1.40	NE555	.34	LM1414	1.59	LM4250	1.75
LM336	1.75	NE556	.65	LM1458	.59	LM4500	3.25
LM337K	3.95	NE558	1.50	LM1488	.69	RC4558	.69
LM337T	1.95	NE561	24.95	LM1489	.69	LM13080	1.29
LM338K	6.95	NE564	2.95	LM1496	.85	LM13600	1.49
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H TO-5 CAN T = TO-220 K = TO-3

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CA 3046	1.25	CA 3086	.80
CA 3059	2.90	CA 3089	2.99
CA 3060	2.90	CA 3096	3.49
CA 3065	1.75	CA 3130	1.30
CA 3080	1.10	CA 3140	1.15
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CA 3160	1.19		

TI

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TL496	1.65	75450	.59
TL497	3.25	75451	.39
75107	1.49	75452	.39
75110	1.95	75453	.39
75150	1.95	75454	.39
75154	1.95	75491	.79
75188	1.25	75492	.79
75189	1.25	75493	.89
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TL072	1.19	LF347	2.19
TL074	2.19	LF351	.60
TL081	.79	LF353	1.00
TL082	1.19	LF355	1.10
TL083	1.19	LF356	1.10
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SPECIALS END 9-30-84

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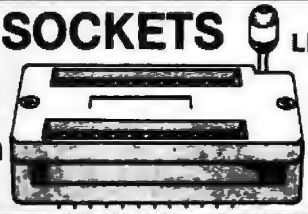
ZIF = Zero Insertion Force



LEADS	UNIT PRICE
14	5.95
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4N27	1.10	MCA-255	1.75
4N28	.69	IL-1	1.25
4N33	1.75	ILA-30	1.25
4N35	1.25	ILQ-74	2.75
4N37	1.25	H11C5	1.25
MCT-2	1.00	TIL-111	1.00
MCT-6	1.50	TIL-113	1.75

CAPACITORS

TANTALUM

	6V	10V	15V	20V	25V	35V
.22uf						.40
.27						.40
.33						.40
.47				.35		.50
.68						.45
1.0			.40	.40	.45	.45
1.5				.45		.50
1.8						.75
2.2		.35	.40	.45		.65
2.7		.40	.45			.90
3.3		.45	.50	.65	.80	.85
3.9			.45			
4.7	.45	.55		.80	.85	.85
6.8			.70		.75	
10	.55	.65	.80	.85	.90	1.00
12	.65		.85	.90		
15	.75	.85	.90			
18			1.25			
22		1.00	1.35			
27			2.25			
39		1.50				
47	1.35					
56	1.75					
100		3.25				
270	3.75					

DISC

10pf	50V	.05	470	50V	.05
22	50V	.05	560	50V	.05
25	50V	.05	680	50V	.05
27	50V	.05	820	50V	.05
33	50V	.05	.001uf	50V	.05
47	50V	.05	.0015	50V	.05
56	50V	.05	.0022	50V	.05
68	50V	.05	.005	50V	.05
82	50V	.05	.01	50V	.07
100	50V	.05	.02	50V	.07
220	50V	.05	.05	50V	.07
330	50V	.05	.1	12V	.10
			.1	50V	.12

MONOLITHIC

.1uf-mono	50V	.18	.47uf-mono	50V	.25
.047uf-mono	50V	.15	.01uf-mono	50V	.14

ELECTROLYTIC

RADIAL			AXIAL		
.47uf	50V	.14	1uf	50V	.14
1	25V	.14	4.7	16V	.14
2.2	35V	.15	10	16V	.14
4.7	50V	.15	10	50V	.16
10	50V	.15	22	16V	.14
47	35V	.16	47	50V	.20
100	16V	.18	100	15V	.20
220	35V	.20	100	35V	.25
470	25V	.30	150	25V	.25
2200	16V	.80	220	25V	.30
			330	16V	.40
			500	16V	.42
			1000	16V	.60
			1500	16V	.70
			6000	16V	.85

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.01 UF MONOLITHIC	100/12.00
.1 UF DISC	100/8.00
.1 UF MONOLITHIC	100/15.00

TRANSISTORS

2N918	.50	MPS3706	.15
MPS918	.25	2N3772	1.85
2N2102	.75	2N3903	.25
2N2218	.50	2N3904	.10
2N2218A	.50	2N3906	.10
2N2219	.50	2N4122	.25
2N2219A	.50	2N4123	.25
2N2222	.25	2N4249	.25
PN2222	.10	2N4304	.75
MPS2369	.25	2N4401	.25
2N2484	.25	2N4402	.25
2N2905	.50	2N4403	.25
2N2907	.25	2N4857	1.00
PN2907	.125	PN4916	.25
2N3055	.79	2N5086	.25
3055T	.69	PN5129	.25
2N3393	.30	PN5139	.25
2N3414	.25	2N5209	.25
2N3563	.40	2N6028	.35
2N3565	.40	2N6043	1.75
PN3565	.25	2N6045	1.75
MPS3638	.25	MPS-A05	.25
MPS3640	.25	MPS-A06	.25
PN3643	.25	MPS-A55	.25
PN3644	.25	TIP29	.65
MPS3704	.15	TIP31	.75
		TIP32	.79

IC SOCKETS

	1-99	100
8 pin ST	.13	.11
14 pin ST	.15	.12
16 pin ST	.17	.13
18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39
64 pin ST	4.25	call

ST = SOLDERTAIL

8 pin WW	.59	.49
14 pin WW	.69	.52
16 pin WW	.69	.58
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
24 pin WW	1.49	1.35
28 pin WW	1.69	1.49
40 pin WW	1.99	1.80

WW = WIREWRAP

DIODES

1N751	5.1 volt zener	.25
1N759	12.0 volt zener	.25
1N4148	(1N914) switching	25/1.00
1N4004	400PIV rectifier	10/1.00
KBP02	200PIV 1.5amp bridge	.45
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JUMBO YELLOW	.18	.15
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MAN 72	.3"	CA	.99
MAN 74	.3"	CC	.99
FND-357 (359)	.375"	CC	1.25
FND-500 (503)	.5"	CC	1.49
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- ★ Fits standard 5¼" drives, inc. Shugart
- ★ Includes mounting hardware and feet

CABINET #2 $79.00
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SS/DD — 10/$149 EA. $169.00
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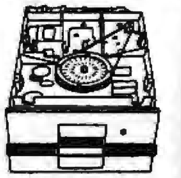
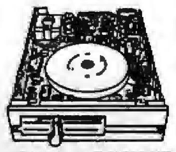

TANDON 5¼"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44 pin WW	4.95

DIP CONNECTORS

DESCRIPTION	ORDER BY	8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxx-ST	.99	.99	.99	1.69	1.89	1.89	1.99	2.49	2.99
COMPONENT CARRIERS (DIP HEADERS)	ICCxx	.65	.75	.65	1.00	1.25	1.25	1.35	1.50	2.10
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	—	1.45	1.65	—	—	—	2.50	—	4.15

(CONTACTS: 8–40)

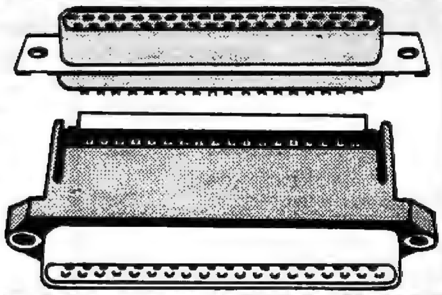
For order instructions see "IDC Connectors" below.

D-SUBMINIATURE

DESCRIPTION		ORDER BY	9	15	25	37	50
SOLDER CUP	MALE	DPxxP	2.08	2.69	2.50	4.80	6.06
	FEMALE	DBxxS	2.66	3.63	3.25	7.11	9.24
RT. ANGLE PC HOLDER	MALE	DBxxPR	1.65	2.20	3.00	4.83	—
	FEMALE	DBxxSR	2.18	3.03	4.42	6.19	—
IDC RIBBON CABLE	MALE	IDBxxP	3.37	4.70	6.23	9.22	—
	FEMALE	IDBxxS	3.69	5.13	6.84	10.08	—
HOODS	BLACK	HOOD-B	—	—	1.25	—	—
	GREY	HOOD	1.60	1.60	1.25	2.95	3.50

(CONTACTS: 9–50)

MOUNTING HARDWARE - $1.00 For order instructions see "IDC Connectors" below.

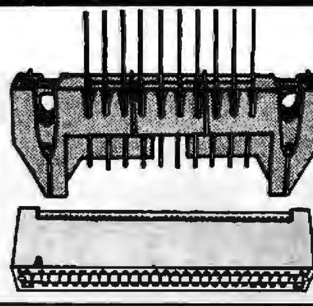


IDC CONNECTORS

DESCRIPTION	ORDER BY	10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RT. ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RT. ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	1.15	1.86	2.43	3.15	3.73	4.65
RIBBON HEADER	IDMxx	—	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	2.25	2.36	2.65	3.25	3.80	4.74

(CONTACTS: 10–50)

ORDERING INSTRUCTIONS: Insert the number of contacts in the position marked "xx" of the "order by" part number listed. **Example:** A 10 pin right angle holder style header would be IDH10SR.



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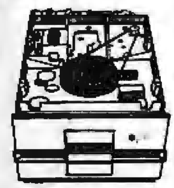

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- ★ INCLUDES INSTRUCTIONS

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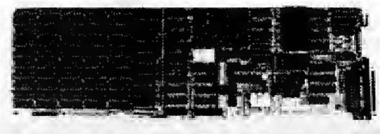

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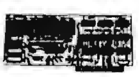

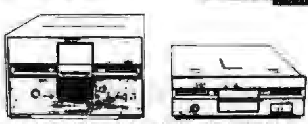

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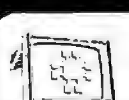

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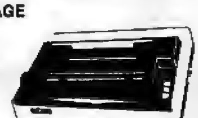

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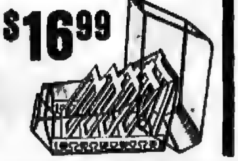

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BYTE is concerned about software piracy. Unclassified ads proposing exchanges of software must specify that the software was written by the individual or is in the public domain. BYTE reserves the right to reject any unclassified ad that does not meet this criterion.

NEEDED: Khmer, Lao, and Vietnamese word-processing and dictionary-generating programs. Also, desire interaction with others with similar interests. Maurice Bauhahn, c/o World Vision Foundation of Thailand, POB 1717, Bangkok 10500, Thailand.

NEEDED: Hewlett-Packard 85 or 86 or Apple II or equivalent sought by native geophysicist working on underground-water research to interpret electrical sounding curves. Your donation will help alleviate the drought conditions for the nomads in the Sahara desert. Will pay shipment. N. Mellal, POB 185, Tamanrasset, Algeria.

WANTED: Native American nonprofit educational organization seeks donations of peripherals for a Wang word-processing system with one or more workstations, a letter-quality printer, a cut-sheet feeder, and a telecommunications module. Also seeking donations of Wang and other manufacturer's computer equipment and business software. Shawnodese, Bear Tribe Medicine Society, 1025 North Cannon, Spokane, WA 99201, (503) 326-6561.

NEEDED: Non profit community mental-health center seeks tax-deductible donation of a personal computer with disk drives for Help Line telephone-crisis counseling and suicide-prevention program. Computer to be used for storage and retrieval of community resources referrals and other information used in handling crisis calls. Kathleen Vail, Help Line, c/o Lakeview Center, 1221 West Lakeview Ave., Pensacola, FL 32501.

WANTED: Tax-deductible donations of computers and peripherals (Apple II, IBM PC, VIC-20) to teach computer technology and programming to economically disadvantaged students. Also need printer, monitors, disk drives, and memory expansion. Fairbreak Electronics Club, Suite 102, 1100 Kermit Dr., Nashville, TN 37217, (615) 361-1652.

NEEDED: Evergreen School District's special-education department seeks donations of a personal robot or robotic arm for educational purposes to adapt environments for physically disabled students. Specialized inputs are needed: touch-sensitive screens, light pens, voice-activated computer systems, and speech synthesizers to provide these individuals with access to computer technology. Cynthia L. Campbell, Special Services, 7000 Northeast 117th Ave., Vancouver, WA 98662, (206) 256-6022.

WANTED: Tax-deductible donation of Commodore VIC-20, COM-64, Datasette, disk drive, monitor, or printer to be used by elementary school students to learn programming. Frank Church, Principal, Valley Institute, RFD 3, Bristol, VA 24201, (703) 669-3073.

WANTED: Small Catholic grade school seeks tax-deductible donation of Apple II Plus and/or IIe to introduce children to computers. Dick Stringham, St. Mary's School, 195th St., Mokena, IL 60448, (312) 479-2526.

WANTED: Computer equipment, especially components and peripherals for nonprofit student aerospace group to be used in the simulation, design, and construction of student projects. Have members, will build and debug. Software would be welcome too. American Institute of Aeronautics and Astronautics, Milwaukee Student Branch, 3200 North Cramer St., Milwaukee, WI 53211 or call John Conrad at (414) 964-9058 or Dr. Arthur Sorensen at (414) 963-6076.

WANTED: Tax-deductible donations of microcomputers (TRS-80 Model III or Apple II), disk drives, monitors, and printers for our engineering-department students' usage, especially for the Computer Aided HVAC and CAD courses. Professor M. C. Akisoglu, Engineering Department, CCAC, Allegheny Campus, 808 Ridge Ave., Pittsburgh, PA 15212, (412) 237-2690.

WANTED: Information about a nutritional-analysis program that computes diabetic exchanges on recipes sought for IBM PC, DEC Pro 350, mainframe, or equivalent. Jeanne Rogers, Kilo Foundation, Suite 321E, 777 South New Ballas Rd., St. Louis, MO 63141, (314) 567-5525.

FOR TRADE: Keypunch unit. We will swap for evidence that you are educational, charitable, and are willing to pick it up. Peter Sohn, c/o Abel/Noser, 23rd floor, 90 Broad St., New York, NY 10004.

FOR SALE: Plotter Houston Instruments Hiplot DMP-29, like new, used only for self-test patterns: $1550 cash or certified check. You pay UPS. Owner moving overseas. John M. Case, 585 Big Sky Court, Colorado Springs, CO 80919, (303) 599-0744.

WANTED: Used Kaypro or similar business computer with printer under $1000. Carol D'Agostino, 37 Jedwood Place, Valley Stream, NY 11581.

WANTED: Working computer science major would greatly appreciate donation of computer and/or peripheral equipment to allow hands-on experience. R. Day, Apt. 21, 555 Walnut, Long Beach, CA 90802.

FOR SALE: SS-30 F & D 5-inch disk controller: $75. SS-30 5- and 8-inch disk controller, single/double density and sided: $175. Heathkit H-9 terminal: $80. 12-inch video monitor: $45. ASCII keyboard with TVT board in nice enclosure: $20. Phil Moore, POB 2312, Florrissant, MO 63032.

FOR SALE: CompuPro 8086/8087 CPU board with 8086 only. This is an 8-MHz board in almost brand-new condition: $400 or best offer. Michael E. Nunamaker, 604 East Clark #5, Champaign, IL 61820, (217) 351-8215.

FOR SALE: Heath H-11 processor with 32K bytes of memory, H-27 dual floppy-disk drive, two serial-interface ports, H-19 monitor. Includes all documentation. Best offer. T. A. Homan, 7741 Stanley Mill Dr., Centerville, OH 45459, (513) 434-3896.

FOR SALE: TRS-80 Model I, 16K with monitor, keyboard, power pack, and four books: $250. Sean Brown, 400 Second Ave., New York, NY 10010, (212) 725-0379.

FOR SALE: Hewlett-Packard Model 86A personal computer, 64K, with HP 82913A 12-inch monitor, HP 9130A 5¼-inch single, flexible disk drive. Also, HP 82905B impact printer and an HP 82950A modem. Paid $4170, will sell for $3000 or best offer. Debbie Parsons, 516 Bank St., Wallace, ID 83873, (208) 752-1116 days.

FOR SALE: Netronics Cosmic Elf computer and case with 4K RAM, monitor board, ASCII keyboard, external power supply, and documentation. $425 value for $175 or best offer. Eugene Hochhalter, 4110 Dixie, Idaho Falls, ID 83401, (208) 524-3513.

FOR SALE: Timex/Sinclair ZX81, Sinclair 16K RAM, 2040 printer, Memopak 16K RAM, keyboard, Z80 assembler, *Programming the Z80*, *8080/Z80 Assembly Language*, *Explorer's Guide To the ZX-81*, *Zilog Z-80 Assembly Language Programming Manual*. Make an offer. James E. O'Donnell, 25 Main St., Newcomb, NY 12852, (518) 582-4511.

WANTED: Computer science freshman would appreciate your donation of discarded, unused, or repairable computers, printers, parts, or accessories for college work. Jehan Martinez, 11501 Pyreneese Dr., Austin, TX 78759.

FOR SALE: Okidata BMC 80/20 computer, monitor, keyboard, disk drives, printer, graphics. Never used: $1799. Also, Sanyo MBC 550 16-bit computer, 128K RAM, keyboard, 160K disk drive, monitor, parallel-printer port, and color graphics. Never used: $895. Paul Konitzer, 3856 Clark St., Seaford, NY 11783, (516) 783-7274.

WANTED: Engineering student needs a computer and a disk drive. Any other computer equipment will be appreciated too. J. C. Munoz, Casilla 1035, Concepcion, Chile.

FOR SALE: Three unused Shugart 8-inch SA1002 5.33-megabyte hard-disk drives: $269 each. Also, have Western Digital's controllers for the drives: $331 each. Easy to interface to Heath, Apple, IBM, and TRS-80. Herb Merrill, 20 Randy Dr., Taylors, SC 29687, (803) 877-9444.

WANTED: Back issues of BYTE (December 1977, January 1978, March 1979, April 79, December 1981, November 1982, and December 1982). Will give $10 plus postage for all or $1 each for single copies. Ken Hamel, Rt. 5 Box 162, Watertown, WI 53094.

WANTED: High school student seeking donations of hardware and manuals. Anything is appreciated. Will pay shipping costs. James F. McGovern Jr., 38 Ledyard Ave., Bloomfield, CT 06002.

NEEDED: High school student seeks software-product brochures. Also, seeks donations of computer hardware for DEC Rainbow and 16-bit TRS-80 and system manuals for the DEC PDP11. Junior Stephens, 356 Wolcott Ave., Windsor, CT 06095.

FOR SALE: Two disk drives, Tandon TM100-1, 5¼-inch (for North Star Horizon), SS/DD drive, no power supply or case: $170 each. Jim Lovewell, 1490 East Juana, San Leandro, CA 94577, (415) 351-6207.

FOR SALE: CompuPro boards: Interfacer-1: $175. RAM-17: $275. CPU-Z 6 MHz: $175. Disk 1 and CP/M: $400. System Support with 4MHz-9511: $375. All for $1200. Brent Dowd, 5289 South Manitou Rd., Littleton, CO 80123, (303) 797-7512.

WANTED: High school student would like donated Apple computer, cards, peripherals, or any unwanted equipment. Will pay all postage. Kenneth Minklei, 3427 Stony Point Rd., Grand Island, NY 14072, (716) 773-2478.

FOR SALE: Ithaca Intersystems DPS-1 front-panel computer with 4-MHz Z80 CPU, 64K RAM, SIO-1 serial/parallel board, FDC-II disk-drive controller. Two DS/DD 8-inch Shugart drives with case and power supply. Cost over $8000, sell for $5750. Many S-100 boards. Exidy Sorcerer (32K) with cassette deck, monitor, and sound plug: $200. More. Larry Robinette, 823 Byron Rd., Columbia, SC 29209, (803) 776-4000, ext. 251 between 8:30 a.m. and 5:30 p.m.

WANTED: A printer that is compatible with the TRS-80 Model I Level II BASIC Computer. Will pay postage. James B. Burchell, 7320-A Lobaugh St., Ft. Meade, MD 20755, (301) 674-5387.

WANTED: Printed material on the development of the microcomputer industry from 1974 through 1980, such as newspapers from computer shows and early issues of BYTE, *Infoworld*, *Interface Age*, *SCCS Interface*, *Computerworld*, *Personal Computing*, and club newsletters. John McCray, Incarnate Word College, 4301 Broadway, San Antonio, TX 78209.

FOR SALE: NorthStar Horizon, 64K, two DDDS drives with disks. Excellent condition: $1500. Smart Terminal, ActV, good condition: $150. Televideo Terminal 970 with extra ROM so can also be used as 970/950. Used 15 hours: $850. Howard Davis, 600 Oakwood St., Rome, NY 13440, (315) 337-5714.

FOR SALE: Back issues of BYTE, Vol. 2 No. 3 (March 1977) to current issue, less October 1978 and December 1979. Best offer or equipment trade. Postage free anywhere in continental USA. Rich Clemens, WVWC-18, Buckhannon, WV 26201.

WANTED: A graduate student seeks donation of an Apple Macintosh, IIe, or IBM PC for research in business-writing strategies to investigate if the interactive composing process of writers is altered by using a computer. Melba Leach, English Department, Indiana University, Ballantine Hall 447, Bloomington, IN 47401.

FOR SALE: Voicebox II for Atari. Used only a few times: $90. Ike Hudson, 519 Linden, East Lansing, MI 48823.

UNCLASSIFIED POLICY: *Readers who have computer equipment to buy, sell, or trade or who are requesting or giving advice may send a notice to BYTE for inclusion in the Unclassified Ads section. To be considered for publication, an advertisement must be noncommercial and nonprofit (individuals or bona fide computer clubs), typed double-spaced, contain 60 words or less, and include name and address. This is a free service; notices are printed as space permits. Your confirmation of placement is appearance in an issue of BYTE as we engage in no correspondence. Please allow at least four months for your ad to appear. Send your notices to BYTE, Unclassified Ads, POB 372, Hancock, NH 03449.*

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MAY'S SPEEDY RETURNS

Steve Ciarcia's column won first place in the May BYTE. Thus "Trump Card, Part 1: Hardware," describing how to speed up the IBM PC, clinches Steve the $100 jackpot. The User's Column by Jerry Pournelle on "Chaos Manor's Hard-Disk System" took second place, providing Jerry with the $50 bonus. In third place is a feature written by BYTE's senior technical editor on the West Coast, John Markoff, on "The Apple IIc Personal Computer." The two authors of "Maximizing Hard-Disk Performance," Roy Chaney and Brian Johnson, won fourth place in a feature about how to increase transfer rates. And fifth mention goes to Steve McMahon for his review of "The Kaypro 10," a hard-disk CP/M portable computer. BYTE's readership is responsible for the congratulations due these authors.

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3. □□□ [#] [#]
4. □□□ [#] [#]
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5 27 49 71 93	115 137 159 181 203	225 247 269 291 313	335 357 379 401 423	445 467 489 511 533	555 577 599 621 643	665 687 709 731 753	775 797
6 28 50 72 94	116 138 160 182 204	226 248 270 292 314	336 358 380 402 424	446 468 490 512 534	556 578 600 622 644	666 688 710 732 754	776 798
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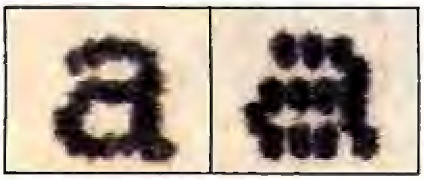

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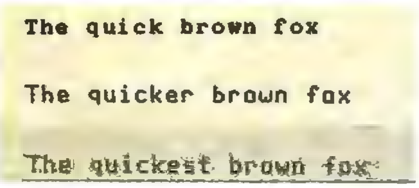

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