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BYTE

THE SMALL SYSTEMS JOURNAL

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SIMULATING SOCIETY

No matter what you're in

Candidate Search Update

FILE: *Resumes*
SEARCH DATE: *5/20/85*
CLIENT: *Splendora Gourmet Baby Foods*

FIND

EXPERIENCE = *Marketing Manager*
FIELD = *Foods/Infant*
SIZE = *500+ Employees*
SALARY REQ.= *$40-$50,000 Per Annum*
LOCATION REQ.= *Detroit*
-or-
RELOCATABLE = *Yes*

Name	Experience	Salary	Education	Age
Antosz, Hank	1978—Present Pinz-Pinz Baby Food 1976—1978 Heath Baby Products	$45,000	Harvard MBA/Mktg.	33
Brown, Bob	1984—Present Liz for Kids 1982—1984 Bonnie Babe, Inc.	$48,000	CSUN/Marketing BA	26
Hayden, Steve	1979—Present Heath Baby Products 1975—1979 Nummy Tummies	$43,000	UCLA/Sociology BA Harvard MBA	35
Morrison, John	1977—Present Camille Grocers, Ltd. 1974—1977 Georgie Porgie of London	$40,000	Oxford/Marketing	32
West, Nick	1961—Present Bonnie Babe, Inc.	$47,000	UCLA MBA/Mktg.	42

Recruit-A-Suit
100 Aldous Avenue
Suite 7-1
Detroit, Michigan

May 20, 1985

Mr. Greg Heim
Vice President, Marketing
Splendora Gourmet Baby Foods
2200 Michigan Place East
Winnetka, Illinois

Dear Mr. Heim:

As a busy executive you know that accomplishing your many professional objectives is a full-time job.

And the last thing you need is to take time out of your hectic schedule to search for a new team player. That's where Recruit-A-Suit can help!

We're a full-service recruitment firm with our finger on *more than 5,000,* meticulously selected, aggressive, ambitious, highly-qualified professionals not unlike yourself.

Our selective screening processes help us locate candidates who not only meet your specified work experience and salary requirements, but who are well suited to the corporate culture of your company.

One more reason we enjoy the highest success rate in the industry! Though our fees remain among the most competitive in the industry.

Enclosed, please find more information on our client references, case histories and terms of business for your reading pleasure.

And next time you find yourself faced with an empty swivel chair, don't hesitate to call Recruit-A-Suit.

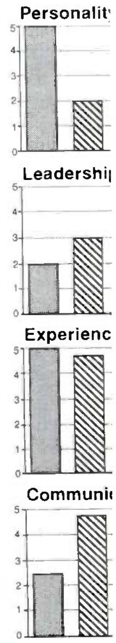
Sincerely,

Cynthia Shern

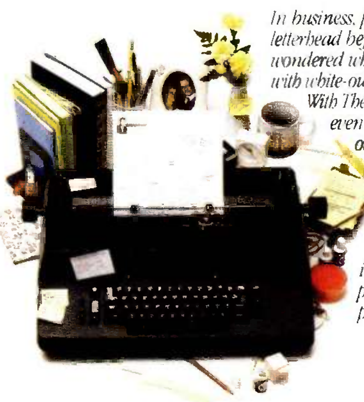
Cynthia Shern
Senior Associate

CS:dh

enc.



Using database management programs you can store, retrieve and sort information in an almost unlimited number of combinations. As opposed to the way you're probably doing it now. Above, we've located eligible candidates by salary and work experience. But database management is also handy for things like generating master mailing lists. Creating invoices. Sorting by zip code. Checking inventory. No files to lose. No cross-referencing your Rolodex.® No paperclips.



In business, people often meet your letterhead before they meet you. Ever wondered what a typewritten page stiff with white-out says about your business? With The Macintosh Office you can even design and print your own letterhead, plus combine publication quality text and graphics for a lasting first impression. More important, you can send personalized letters to as many prospects as you have paper.

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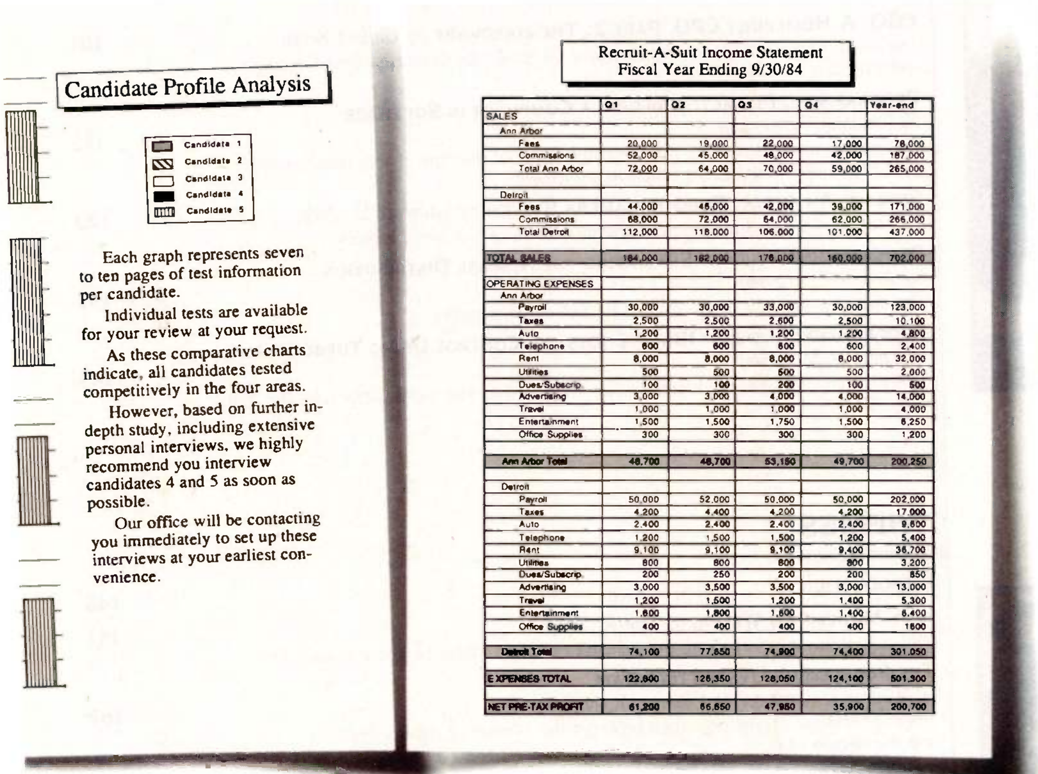
usiness you're in, business.



Candidate Profile Analysis

Candidate 1
Candidate 2
Candidate 3
Candidate 4
Candidate 5

Each graph represents seven to ten pages of test information per candidate.

Individual tests are available for your review at your request.

As these comparative charts indicate, all candidates tested competitively in the four areas.

However, based on further in-depth study, including extensive personal interviews, we highly recommend you interview candidates 4 and 5 as soon as possible.

Our office will be contacting you immediately to set up these interviews at your earliest convenience.

Recruit-A-Suit Income Statement
Fiscal Year Ending 9/30/84

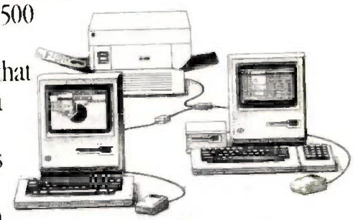
	Q1	Q2	Q3	Q4	Year-end
SALES					
Ann Arbor					
Fees	20,000	19,000	22,000	17,000	78,000
Commissions	52,000	45,000	48,000	42,000	187,000
Total Ann Arbor	72,000	64,000	70,000	59,000	265,000
Detroit					
Fees	44,000	46,000	42,000	39,000	171,000
Commissions	68,000	72,000	64,000	62,000	266,000
Total Detroit	112,000	118,000	106,000	101,000	437,000
TOTAL SALES	184,000	182,000	176,000	160,000	702,000
OPERATING EXPENSES					
Ann Arbor					
Payroll	30,000	30,000	33,000	30,000	123,000
Taxes	2,500	2,500	2,600	2,500	10,100
Auto	1,200	1,200	1,200	1,200	4,800
Telephone	600	600	600	600	2,400
Rent	8,000	8,000	8,000	8,000	32,000
Utilities	500	500	500	500	2,000
Dues/Subscrip	100	100	200	100	500
Advertising	3,000	3,000	4,000	4,000	14,000
Travel	1,000	1,000	1,000	1,000	4,000
Entertainment	1,500	1,500	1,750	1,500	6,250
Office Supplies	300	300	300	300	1,200
Ann Arbor Total	48,700	48,700	53,150	49,700	200,250
Detroit					
Payroll	50,000	52,000	50,000	50,000	202,000
Taxes	4,200	4,400	4,200	4,200	17,000
Auto	2,400	2,400	2,400	2,400	9,600
Telephone	1,200	1,500	1,500	1,200	5,400
Rent	9,100	9,100	9,100	9,400	36,700
Utilities	800	800	800	800	3,200
Dues/Subscrip	200	250	200	200	850
Advertising	3,000	3,500	3,500	3,000	13,000
Travel	1,200	1,500	1,200	1,400	5,300
Entertainment	1,600	1,800	1,600	1,400	6,400
Office Supplies	400	400	400	400	1600
Detroit Total	74,100	77,650	74,900	74,400	301,050
EXPENSES TOTAL	122,800	126,350	128,050	124,100	501,300
NET PRE-TAX PROFIT	61,200	55,650	47,950	35,900	200,700

Whether you're Nabisco® or Ms. Priss' Cookie Company you worry about the bottom line. Write letters. Keep track of inventory. Keep your overhead under control. Pay taxes. Retrieve files. Schedule projects.

Which is why you can dramatically increase your business' productivity with The Macintosh™ Office.

The cornerstone of The Macintosh Office is our Macintosh 512K computer. All you need to know about its powerful, 32-bit, mouse-driven technology is that it reduces the time it takes to become productive with a computer from well over a work week to just under a lunch hour.

But more important, Macintosh runs more than 500 software programs that can solve a multitude of business problems.



When you team up Macintosh with the second hardest worker in The Macintosh Office, our LaserWriter™ printer, you can bring a new level of professionalism to your paperwork.

It produces publication-quality text and graphics in letters, internal documents, presentations, even business forms. There's no telling what it can save you in outside printing costs alone. And the LaserWriter can be shared with as many as 31 Macintosh computers. So it becomes more cost efficient with every Macintosh you connect to it.

Butcher, baker, candlestick-maker... or Nabisco, for more information about The Macintosh Office call 800-446-3000.

No job too big.
Or too small.

If a picture is worth a thousand words, business graphics like these could cut meetings and presentations in half. We've taken information on five candidates stored in one software program, copied it into another program, where it was used to create these comparative bar graphs. Once your data is entered, this particular software program gives you your choice of 42 different graph configurations. You can preview your material (whether it's candidates, costs or cookies) in each configuration to decide which chart or graph most persuasively makes your point.

*As you well know, business involves innumerable number-related tasks, not the least of which is generating income and expense statements like this one. Should you want to change any of the entered items — to take a look at the effects of opening a new office or decreasing your staff — a spreadsheet program like Multiplan** will automatically recalculate the entire document. (Here, we've copied it into MacDraw™ and enhanced it for presentation purposes.) It not only saves hours of entering, double-checking and erasing, but when teamed up with our LaserWriter printer, it produces a printout impressive enough to show a bank president. Fast enough for this afternoon's meeting.*

The Macintosh Office.

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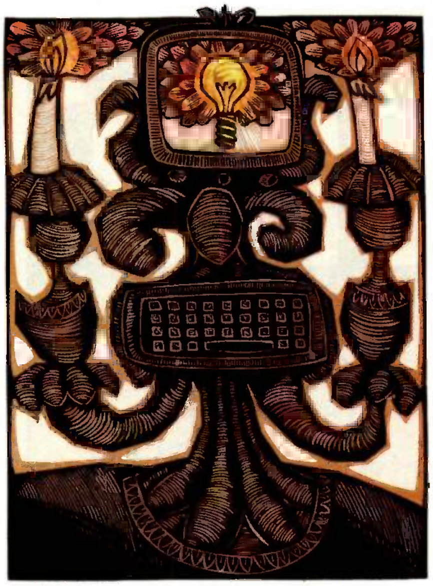

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SECTION ART BY DAVID FRAMPTON

BYTE

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E·D·I·T·O·R·I·A·L

BUILDING BIX WITH MICROS

It will come as no surprise to BYTE readers that we're building the BYTE Information Exchange (BIX) with microcomputers. Since research conducted among a sample of subscribers shows we may need to support more than 1000 simultaneous users within a year, BIX represents an exciting challenge to microcomputer and networking technology. We thought you might like to know how a group of outstanding technical people is helping us face this challenge.

The first and most important step was to select the microcomputers and the operating system. Many powerful microcomputers are available. Clearly our application will place tremendous demands on the I/O system of whatever machines we use. Three members of McGraw-Hill's top technical unit, Jon Osser, Bill Coleman, and Mike Shareck, with a big assist from McGraw-Hill's chief scientist, corporate vice president Bill Raduchel, surveyed the marketplace and chose the Areté 1200, which was designed for I/O-intensive operations and runs ARIX, Areté's version of UNIX System V.

Areté's chief designer, Ernie Rael, has created a remarkable I/O engine. The Areté 1200 has up to 4 "tightly coupled" 12.5-MHz 68000s acting as CPUs. These 68000s have a common multiported main memory shared through the 32-bit processor memory bus and can process up to 2.8 million instructions per second. Each CPU has its own 4K-byte cache and no wait states when in cache. Main memory expands as high as 16 megabytes. In addition to the 68000s serving as CPUs, the system can accommodate up to 12 more 68000s, each on an I/O card that has eight serial ports. The I/O processor cards each have dual-port RAM that is memory-mapped in the master CPU's address space for communication with the CPU. The Areté 1200 has four separate 32-bit buses: the interprocessor communication bus, the processor memory bus, the utility-transfer bus, and the data-transfer bus. The data-transfer bus is 32 bits wide and moves data at 33.3 megabytes per second. The system can support four ESMD (extended storage module device) peripherals simultaneously reading and/or writing main memory. When fully loaded, the Areté 1200 can support as many as 88 simultaneous users. Mass storage can be expanded to 9 gigabytes.

Phase one of BIX starts in Boston and will use an Areté 1200 to support 88 simultaneous users. The performance goal is to have any BIX member's communication (conference comment or private mail message) available to appropriate parties within a few seconds. Phase two, probably underway by the time you read this, will link three Areté 1200s to support 250 simultaneous users. The Aretés are linked by devoting one I/O slot in each machine to Areté's Multibus adapter and Excelan's EXOS201 Ethernet card for Multibus. The EXOS201 has a local processor, an Ethernet controller, local memory, and an implementation of levels 1, 2, and 3 of the ISO network standard. In this phase, each of the three Aretés will maintain fully redundant database copies. Updates will be broadcast to all three machines. A process running on each machine will carry out the updates.

Phase three is where things get really interesting. As Ernie Rael says, "The project is state of the art, so we'll have to learn the optimal solution." In this phase, the network will become transparent. Areté will provide an operating-system interface that allows BIX to access files on any machine in the network as if all files were in one system. The transparent network will be based on the Sun Network File System (NFS), a virtual file system that allows files to reside on any system in the net. Areté is altering the kernel to ARIX to support the transparent file access of NFS. If Areté succeeds in networking 12 to 15 machines in a way that provides access to files on any machine within a few seconds, the time-sharing scene will be altered forever, and BYTE will have succeeded in building BIX while remaining true to its microcomputer heritage.

Phase four will build the system above 1000 simultaneous users. In this phase, the BIX conferencing software (the University of Guelph's CoSy) will understand more about its environment. CoSy author Al Mayer, a key figure throughout the growth of BIX, will get to explore his ideas for distributed conferencing. Plans for phase four must remain fluid until we've learned all we can from the previous phases.

Can microcomputer technology succeed in linking the microcomputers of BYTE's readers throughout the United States and Canada, and then Europe and Japan? We hope and believe it can. We will fall back on mainframe technology if we must, but we thought you'd want us to try to build BIX this way first. Trying to build such a large-scale communications system with supermicrocomputers is a venturesome and innovative project. We are sure to encounter some roadblocks. But the history of microcomputers is full of roadblocks with big signs reading "Not Possible with Microcomputers." We find this challenge irresistible. If you want to monitor our progress day by day, join BIX and have a look. If not, we'll keep you posted in the pages of BYTE.

—*Phil Lemmons, Editor in Chief*

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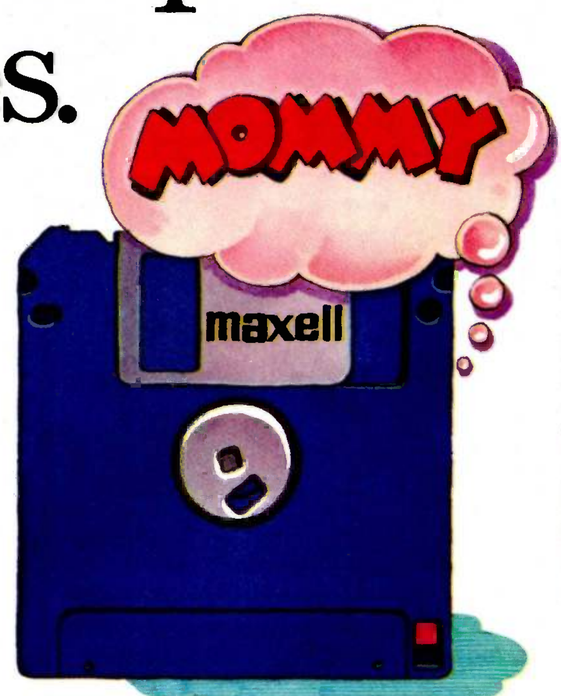

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Inquiry 209

M·I·C·R·O·B·Y·T·E·S

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

AI Influences Database-Management Program

Symantec, headquartered in Cupertino, CA, has developed a program called Q&A that combines word processing and file management with a natural-language interface referred to as the Intelligent Assistant. Using the same screen format and menu structure as Software Publishing's pfs:File, Q&A manipulates a single flat file and includes programmable forms, macros, and mass updating. The file can be sorted on up to 40 fields and indexed on 125 fields.

Q&A's word processor, which is always in RAM, can handle files of up to 100 text pages. In addition to most standard word-processing capabilities, Q&A supports macros, mail-merge, automatic reformatting, box drawing, and context-sensitive help; optionally, it can use many WordStar command keys. Columnar commands and footnotes are not supported.

The package can directly import text or database files from Writing Assistant/pfs:Write, Filing Assistant/pfs:File, Lotus 1-2-3, and DIF files, in addition to ASCII text or database files.

Q&A's database functions are accessible via menus or by typing conversational English commands to the Intelligent Assistant, which analyzes the query in light of the fields in the current file, asks you to clarify words it doesn't know, and then suggests a report format. Because the Intelligent Assistant keeps tables of the words you commonly use and the synonyms you employ, you can teach it to understand your particular style of questioning.

Symantec is making plans to extend the natural-language Intelligent Assistant to other areas of PC use, such as DOS functions.

Q&A runs on an IBM PC, XT, AT, or compatible with at least 512K bytes of RAM and two disk drives. The suggested retail price is $295, or $349 packaged with a 256K-byte RAM board. Symantec will also provide a $100 trade-in for other database programs.

Sony, Toshiba Prepare High-Density 3½-inch Disks

Sony announced in Tokyo that it has developed a 2-megabyte 3½-inch floppy disk, storing 1.6 megabytes (formatted) by doubling the number of sectors per track. The 2-megabyte medium uses a 1-micron magnetic layer (half the thickness of current 1-megabyte disks) and requires a higher coercivity (700 rather than 600–620 oersteds).

While the 2-megabyte versions use the same magnetic technology as earlier 3½-inch disks and drives, the magnetic heads of the drives require higher tolerances. An additional disk cartridge hole allows drives to distinguish between 1- and 2-megabyte disks.

Although it has already licensed 38 companies to produce 2-megabyte disks, Sony says it is waiting for formal standards to be set before marketing the disks and drives, which should be available to OEMs next year, probably at prices about 20 percent higher than 1-megabyte versions.

An even denser 3½-inch drive from Toshiba uses perpendicular recording technology to squeeze 4 megabytes of data onto a single-sided disk coated with barium ferrite. Toshiba plans to release evaluation units early next year, with full production slated for 1987.

Color-Graphics Output Approaches Photographic Quality

At the SIGGRAPH computer graphics show in San Francisco, several companies brought out high-resolution color-graphics printers.

Hitachi's CGP-400 prints up to 4096 colors at a resolution of about 400 dots per inch, but it costs about $10,000 in OEM quantities. Panasonic showed a similar printer.

Fuji Photo Film's Fujix Jategraphy 3000 printer, distributed by Mitsui, prints poster-size (up to 28 by 23 inches) images in 15 minutes; the images are printed at a resolution of 152 dots per inch in as many as 262,000 colors. While the printer's $100,000 price tag makes it an unlikely buy for most personal computer owners, it may appear in specialty stores offering instant posters or in print shops for last-minute proofing.

(continued)

Laptop Computers Linked to Two Airline Incidents

According to incident reports provided to the SC-156 committee of the Radio Technical Commission for Aeronautics, Tandy Model 100 notebook computers were linked to two separate airplane instrument malfunctions. In one incident, VOR (location) signals were affected; in the other, four instruments malfunctioned. On both flights, turning off the computer solved the problem. The SC-156 committee is investigating possible hazards that portable computers might pose in airplanes.

Novix Ships NC4000P Beta-Board

Novix Corp. of Cupertino, CA, which began sampling its 16-bit NC4000P Forth Microprocessor chip earlier this year, has begun shipping the Novix Beta-Board. This complete single-board computer—designed for evaluation of the NC4000P—includes a 6-MHz NC4000P, 28K words of 35-ns CMOS static RAM, a 4K-word CMOS PROM (which holds the software kernel), two RS-232C serial ports, and a self-incrementing counter (for performance measurement). Special on-board hardware divides the stack memory region into eight segments, thus allowing execution of up to eight concurrent tasks.

The $3550 board attaches to the RS-232C serial port of an IBM PC or compatible, which acts as a keyboard, terminal, and disk server using the software provided. Novix is developing a stand-alone version that will include the Beta-Board, floppy and hard disks, and a streaming-tape drive; the firm also plans to release VME bus and IBM PC bus versions of the board.

The Beta-Board includes the polyFORTH operating system/development environment, containing a multitasker (which switches tasks in less than 5 microseconds), a FORTH interpreter, an optimizing FORTH compiler, an advanced math package, a background-task printer driver, an editor, and all system source code. Development work on other languages, including Neon, is underway.

The NC4000P was custom-designed by Charles Moore, FORTH inventor, and Bob Murphy of Torric Corp. It directly executes FORTH code at speeds up to 8 million instructions per second, according to Novix.

Two sets of additional connectors on the Beta-Board allow direct access to the 16-bit processor data bus, the 16-bit processor address bus, the 16-bit processor B port, the 5-bit processor X-port, the 16-bit low-speed peripheral bus, and all system clock and enable lines. Novix offers blank expansion boards that attach directly to either pair of connectors and stack vertically above the Beta-Board. The company will initially use the board to develop a floating-point accelerator device.

Nanobytes

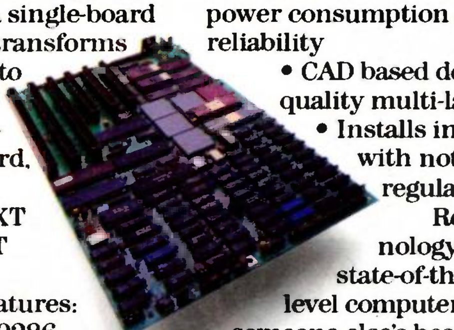
An agreement to buy most of **Sinclair Research** was canceled because prospective buyer **Hollis Brothers** found Sinclair's finances unacceptable, partly because Sinclair's unsold inventory was reportedly worth almost $50 million. Sir Clive Sinclair said that a $14 million contract with an electronics retail chain would keep the company afloat . . . . **Acorn Computers** announced the Acorn RISC Machine (ARM), a 32-bit reduced-instruction-set computer chip. Acorn claims ARM is faster at some operations than a VAX-11/780 . . . . **Pacific Bell** said it will test its 7-in-1 telephone-line technology in Danville, CA. Up to 200 customers will be able to access up to five data and two voice channels simultaneously over a single phone line. Four of the data lines operate at 1200 bps, one at 9600 bps. The "Project Victoria" test will measure equipment performance, transmission quality, and error rates . . . . **Microfield Graphics Inc.**, Beaverton, OR, released the T4 microcode-programmable color-graphics controller for IBM's PC AT. The T4 fully emulates the IBM Color Graphics Adapter and provides a 1024- by 800-pixel display mode. Designed for OEMs, the $3200 card uses four 2901 bit-slice processors . . . . **AT&T** and **Unisoft** have announced a kanji (Japanese alphabet) interface for UNIX on AT&T's 3B computers . . . . **Stanford University** students have developed a mechanical hand that can "speak" sign language to persons who are both deaf and blind. The hand responds to ASCII text input from a terminal or computer . . . . The **Internal Revenue Service** said it will test electronic filing of tax returns by commercial tax-preparation firms in three cities next year . . . . **MicroRIM** now offers a run-time module for its R:base 5000 database program. Unlike Ashton-Tate, which licenses its dBASE III run-time program to approved vendors only, MicroRIM will offer a $450 package of five run-time products through distributors . . . . **GTE Telenet** announced PC Pursuit, a telecommunications service allowing unlimited nighttime 300- or 1200-bps data calls between major cities for $25 per month. Each call cannot exceed an hour.

The IBM® upgrade path.

It's still a great system—in perfect condition. But now you're ready to make a deal on your IBM PC or XT.

Maybe your business needs have grown, or your new application package runs too slow.

Don't dump your present IBM system. Red River Technology has a better offer—ATlas—a single-board plug-in package that transforms your IBM PC or XT into a super-AT.



ATlas isn't a semi-compatible plug-in card, but completely transforms your PC or PC XT into a 100% IBM PC AT compatible system.

Consider these features:

- 8 or 10 Mhz 80286 CPU. 50-100% more performance than IBM's PC AT (switch selectable—6, 8, or 10 Mhz)
- IEEE 802.3 standard LAN option on the base board (your choice, StarLAN or Ethernet)
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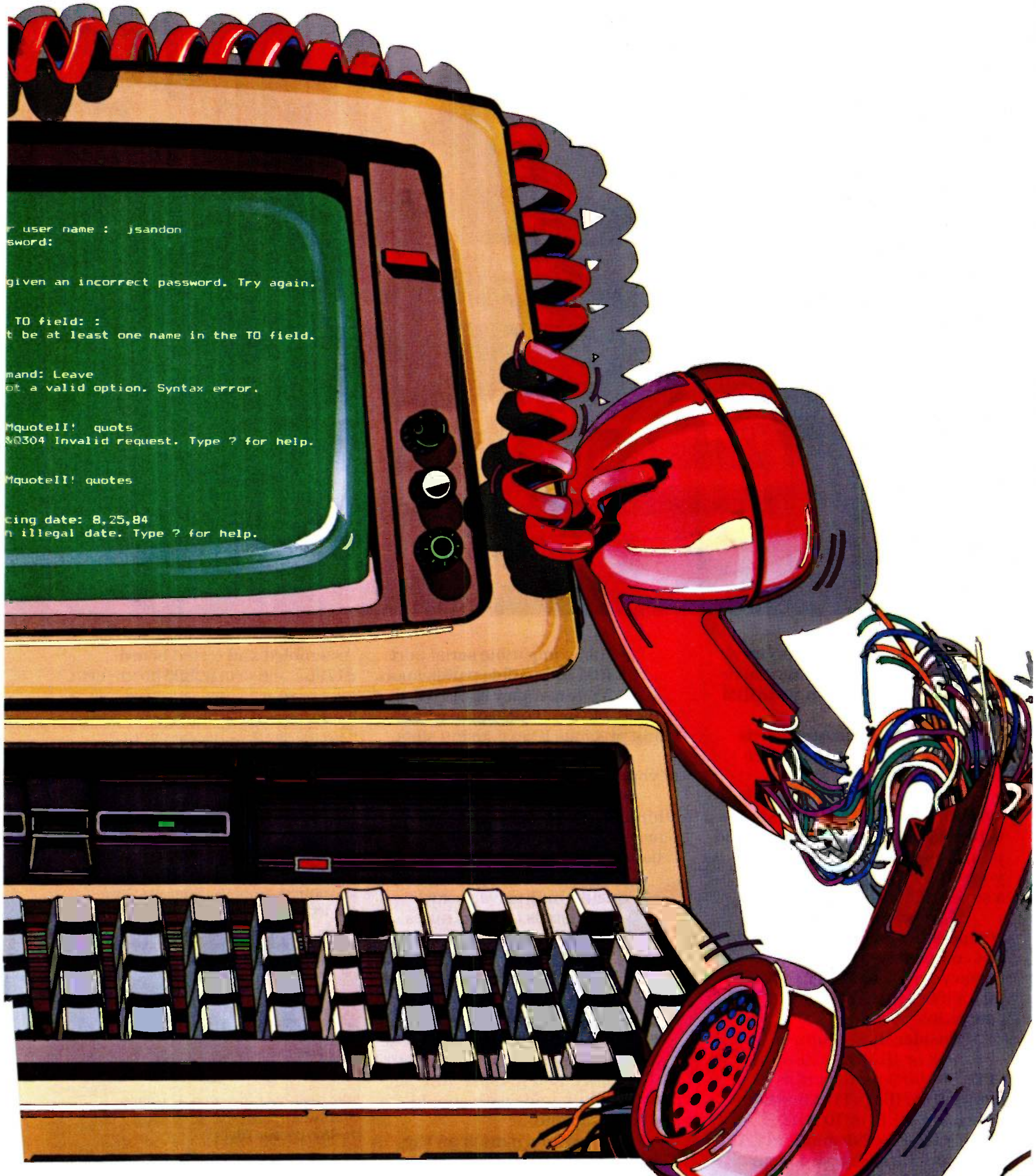
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REMOTE DIAGNOSTICS

In response to your editorial "Service and Support" (February, page 6), remote diagnostics is an idea that the industry has been enamored with for some time. Many companies have field-service organizations whose eyes sparkle when they cite the scenario that you describe in your editorial. There are very serious problems, however, with implementing such a scheme, much as the basic notion of it is appealing.

One of the most annoying aspects of remote diagnostic schemes is that if the system works well enough to implement remote diagnostics, then it probably doesn't need diagnostics at all!

To test a system remotely, there must be interaction between the testing system and the system under test. There must be a modem driver and code to download the diagnostic software and transfer control to it (or to activate it if the diagnostic software is resident in EPROM). There must be code to communicate results to the testing system, etc. This implies that the system under test has brains enough to perform these functions. It must have a working CPU, ROM or RAM, serial chips, data paths, etc.

In other words, a large percentage of the hardware must be fault-free to run remote diagnostics. Failure in any of the critical hardware will most likely also lead to failure of the remote-diagnostic system. Clearly, this means that the proportion of hardware that can be reliably tested with present remote-diagnostic schemes is necessarily small. It also explains why the successes of remote-diagnostic schemes to this point have been limited.

Programmers tend to cultivate an undying faith in the ability of the machine. They tend to consider remote diagnostics as just another function to program. After all, the power of a programmable device is that it can do anything we choose to program. Unfortunately, remote diagnostics is not just another function. There are entanglements involved in that the testing program must execute on the very hardware that you wish to test!

When programmers think of all the functions a system can do, the system they think of is an intact system. Broken systems, however, are not intact and don't behave as such. They can't be depended on. In fact, the worst thing about broken systems is that they can lie to you. You just can't trust 'em! A stuck bit here, a bad memory cell there, an incorrect address, can send the program off to an improper branch, perhaps to the routine that reports the memory addressing subsystem is fine. Isn't the very reason you need diagnostics because the system is acting strangely? Do you think the anomalies selectively appear only when the application programs are run and not during execution of the diagnostics? What guarantee do you have that the diagnostics will be executed reliably, especially when the diagnostics rely on a large portion of the system for their operation?

One of the basic guiding principles of diagnostic engineering is that of hierarchical structure. You never use a circuit for testing unless the circuit has itself been tested. Thus, a diagnostic should start testing with the smallest, most basic set of circuits that it can operate with and should verify additional circuits before they are used for further testing.

Naturally, there's a minimum set below which it's impossible to reduce the circuitry and still have a functional unit. This "hard core" is the absolute minimum hardware needed for initial testing. Further, it varies with different systems. It depends on various design factors such as system organization, configuration, boot strategy, etc. Designers can substantially reduce it by careful design choices. Minimizing the hard core also minimizes risk that failures in the hard-core circuitry are corrupting initial tests (we assume that failures are as likely to appear in the hard core as they are anywhere else).

Only by rigorously adhering to the principles of hierarchical testing do we stand a chance of escaping the curse of Murphy's law. The notion of remote testing over a modem, at least with present architectures, immediately violates this principle by requiring a large percentage of the circuitry to be fault-free. Present personal computer systems do not incorporate hardware that lends itself to remote diagnostic schemes.

The point I am emphasizing is that adding remote-diagnostic capability is not as simple as it sounds. It is not something that can be added post hoc. Effective remote diagnostics will not be realized by simply adding a modem and a diagnostic program to present personal computers. It will take hardware with special diagnostic features and architectures to make it happen. Systems will have to be designed from the ground up with remote diagnostic capabilities in mind. This is certainly not the way most present systems are designed.

Remote diagnostics will undoubtedly arrive. The question is when? We have the technology to make it happen now. Presently, there is not enough demand for this capability to justify the extra expense. Perhaps personal computer owners have not yet been alerted to its value. Perhaps fierce competition among vendors has caused them to avoid the extra expense.

Personal computers are growing from video-game technology to take a more serious role in our lives. Our dependence on them is increasing. As this trend continues, we will see a greater demand for reliability and testing ease as well as for effective diagnostics in general. Remote diagnostics is coming. It's just a matter of time.

PAUL PINETTE
Kingston, NH

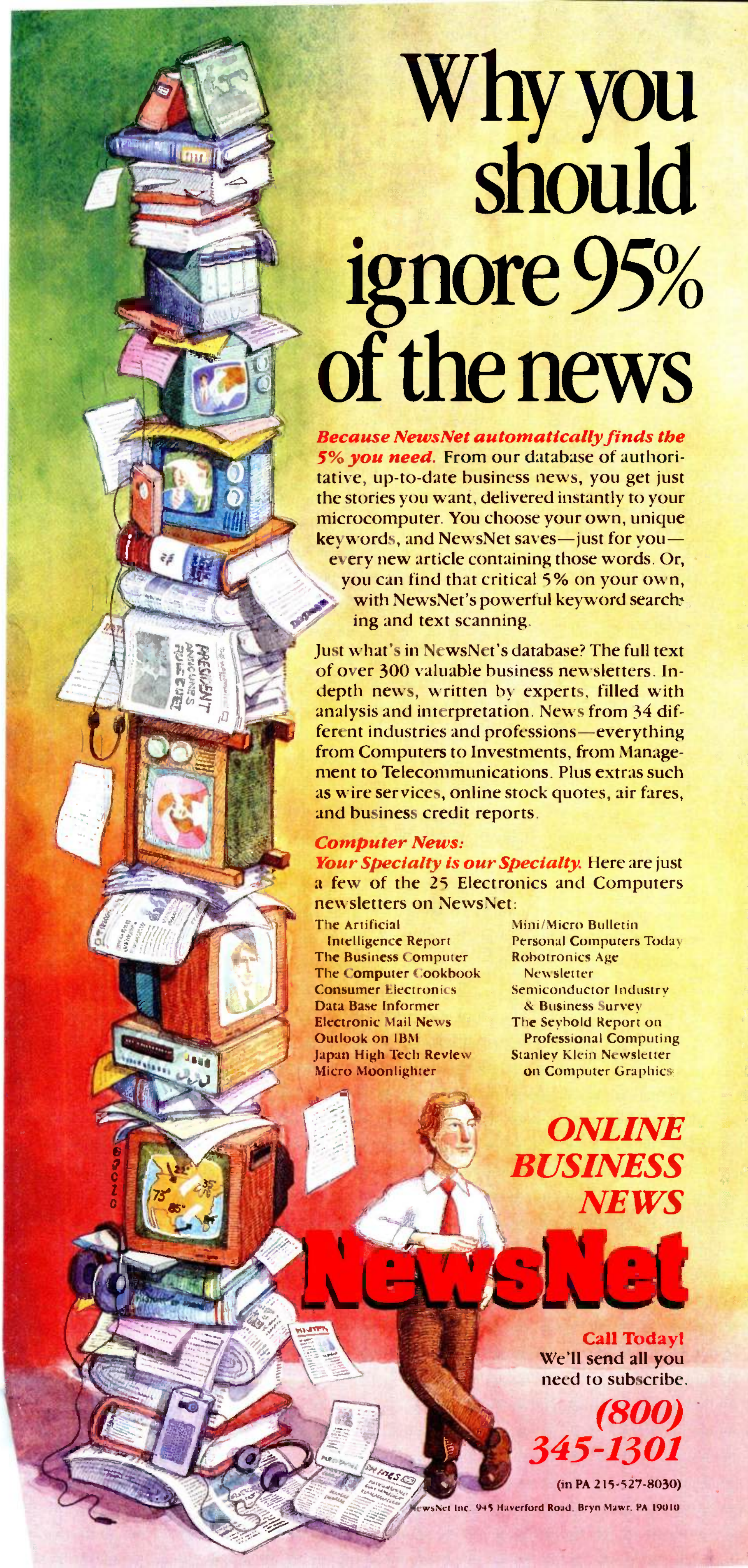
MORE LAW ARTICLES

I am writing in order to thank you for the highly informative article "The Sale of Computer Products" by Robert Greene Sterne and Perry J. Saidman (May, page 399). It is unfortunate that I didn't have access to this information before I bought my Macintosh. I could have avoided a

(continued)

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

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



costly lawsuit.

Please print more on the law and how it might affect the small-system owner. Sterne and Saidman's article is an invaluable aid to someone purchasing computer equipment. Additional areas of interest for myself and other readers would be software and the law, consumer agencies and options available to computer product buyers, and specific legal cases involving small systems and software purchase or use.

M. M. Budrionis
Norfolk, VA

Don't Give Up

Manfred F. Kirchner's comments in the July Letters ("Want My Business?" page 30) are valid, but they reflect only one side of the story. As a system integrator, I'd like to make a few comments of my own to Mr. Kirchner.

Yes, those manufacturers should have responded to your request for information. Sometimes its takes weeks if not months, but bingo cards do work. No, they will rarely acknowledge receipt of your inquiry. They'll pass it to a dealer, perhaps.

No, that you are willing to spend $13,000 for a CAD system doesn't matter. Not at that level. The person to whom it does matter is the local guy, the guy with an office or storefront, the guy you'll call when things go wrong. He cares a whole lot. If you want results, I'd suggest making some appointments, taking a weekday off (not a weekend; they'll think you're a tire kicker), and seeing every dealer you can get to.

As for bewildering, well, welcome to the club. There's so much stuff out there that even if half of it were real I'd need two more people just to keep conversant with it, never mind integrate it into working systems.

That brings me to my last point. The sad news is that your system is your responsibility. Getting the computer education you absolutely must have to make an informed choice is a tedious, frustrating, long-term effort that most users avoid. But no dealer, no matter how well-informed and well-intentioned, can take the time to demonstrate his system *in addition* to explaining what it all means. And no manufacturer has the time, or the staff, to do that either. Brochures, yes; time spent one on one, no, even if that time is merely an acknowledgment.

You're doing the right thing. Just don't give up. The time investment you're mak-

(continued)

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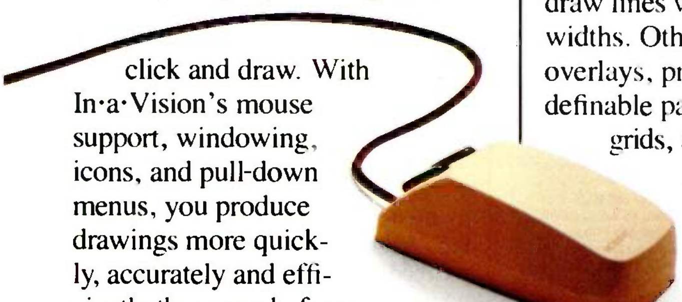

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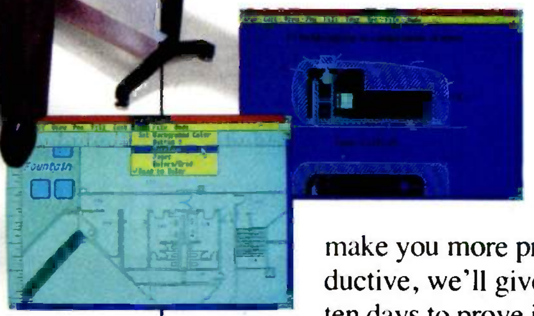

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LETTERS

ing now will at the very least pay off in better use of your eventual system and at most will prevent still one more computer horror story.

KAL ASHWORTH
St. Paul, MN

TOWARD FRIENDLIER LANGUAGES

I am not a computer expert. I have not written a compiler. I have not studied operating systems. Neither have I built a computer. What annoys me is that, when one has a job to do, half of the time taken to do that job is spent fighting the computer and having to force it to do what is required. People waste hours making computers do clever things and informing their colleagues of how clever it all is, when they shouldn't have had to do something clever in the first place.

Are people afraid that if using computers becomes too easy then anyone will be able to use them and using a computer won't be as clever as it once was? Is it too much to expect to be able to sit down at a computer with a task in mind and expect to be able to use a language to do the job without having to resort to trickery or some strange unobvious encoded cryptic command with 17 parameters? For example, graphics and I/O both seem to have been ignored by languages, and people say, "Oh how silly of you, you simply write this assembly program driver and . . . ." etc. This is an insane attitude. These days there is enough memory available for a large operating system and languages. Is there something wrong with a language having a standard set of graphics commands and I/O commands? It seems incredible to me that I can sit down in front of some toy computer and tell it to draw a line on the screen but I cannot do this on some enormously powerful mainframe in FORTRAN. I don't care why I can't do it; the point is simply that I can't. I thought computers were supposed to solve problems, not create new ones. It's like talking to people in English but not being able to discuss the weather without first learning Chinese.

Would it be possible, as a naive suggestion, to have standardized levels of language support with the lower levels being subsets of the higher levels? For example, small cheap computers would support only level one and large computers would support level three, which would include all lower levels. Level three could then support a wide diversity of standardized interfaces and graphics commands

(continued)

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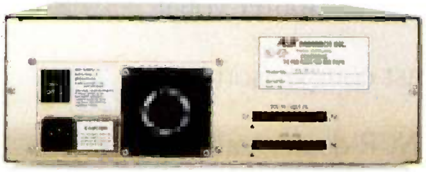

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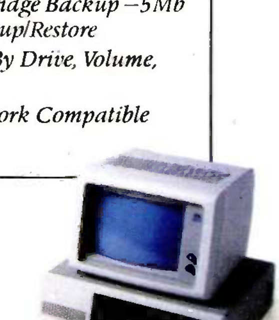

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as well as a large set of standard commands and functions from high to low level.

It is interesting that we are on the verge of huge advances in display and storage technology and processing power, but we are not hearing of many huge advances in user friendliness or versatility of languages. This is probably because good languages have to be standardized, and a standardized language is hard to change because it is standardized. But because something is difficult to achieve, it does not mean we shouldn't even think of it.

MARK POLETTI
Auckland, New Zealand

HERMAPHRODITISM STRIKES

Plugs. Jacks. Pins. Sockets. Male connectors and female connectors. The biggest pain in using RS-232C data communications is getting connectors correctly sexed. Now a new kind of connector offers us a glimmer of hope out of this morass.

A bit of history first, since it is compatibility with the past that hampers us here. The standard connector for RS-232C circuits is the 25-conductor "subminiature D-type," or DB-25. These come in male (25 pins) or female (25 sockets) varieties. There are two rows of conductors: 12 in one and 13 in the other. The "D" shape of the collar makes sure that they are properly oriented when plugged in. Originally, the choice of male versus female was highly standardized. Data-communications equipment (DCE), i.e., modems, always had sockets. (My mnemonic to remember this was that Ma Bell was female; besides that, she took the edge in maintenance costs by not having to worry about bent pins on her equipment.) Data-terminal equipment (DTE) always had pins. In the computer room, DTE was the computer. At my office or home, DTE was a terminal. In either case, a male connector was appropriate.

The confusion began when terminals became directly wired to computers in the same building. An ordinary 25-wire male-to-female RS-232C extension cable could not connect two DTE males. An expensive solution would be to use two modems, even in close proximity. A less expensive solution is a box with two female DB-25s, called a "null modem," which looks like a modem to either side. A look inside this box suggested the cheapest solution: a female-to-female cable with appropriate wire crossings, called a "null modem cable."

Unfortunately, it did not stop there.

(continued)

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Several manufacturers thought they would do us a favor by building their terminals with female receptacles. That way, you see, the straight-through male-to-female extension cable could connect computer to terminal without wire crossings. Soon PC makers adopted this habit of providing DTE in drag. It gets worse. Some modem manufacturers (Anchor Signalman is one) now build with male DB-25s. As a final blow, DB-25 connectors are now being used to carry Centronics-style parallel signals from PCs to printers. I'm surprised how few things have been burnt out in this turn of events.

Consider the fireman and his hose: With lives and property depending upon a few seconds gained or lost, there is precious little time to find male ends and female ends and adapters to get water from hydrant to flame. A fireman appreciates a coupler that is neither male or female, but rather hermaphrodite. Either end of the firehose couples to a hydrant. A hermaphroditic connector can couple with itself; any firehose can extend any other firehose. There's no need for any null firehose modem.

A sample hermaphroditic connector for data communications just landed on my desk today. I saw an ad for AMP's new token-ring connector in the June 17 *Electronic News* and phoned up AMP at (717) 780-4400 and requested a sample. It's marked "554000-3" and has just four conductors, but it's obvious that any number of conductors could be designed the same way. Even the four-wire (plus shield) version would serve most of our in-house needs at my office: We only hook up transmit, receive, and ground usually.

You see, most of the RS-232C signaling is symmetric. My "send" is your "receive"; my "receive" is your "send"; my "request to send" is your "clear to send"; my "data terminal ready" is your "data set ready"; and so on. If you take the perspective of any piece of equipment behind the connector, you can rename these lines "incoming data," "outgoing data," local device ready," "distant device ready," and so on. Data communications is inherently symmetric, so the connector should naturally be hermaphroditic!

I hope standards-making bodies will consider hermaphroditic connectors from now on, so that gender-mender adapters will become a thing of the past, and equipment hookup can be as easy as (or easier than) hooking up garden hoses or telephones.

PETE KLAMMER
Golden, CO

COMPUTER REQUIREMENTS FOR PHYSICS RESEARCH

I am a physicist doing subnuclear research.

About two years ago I decided to finally buy a 16-bit microcomputer to use in my physics research. I set the following criteria:

- full 16-bit machine (both calculational and data path) running the MS-DOS operating system (i.e., 8086 rather than 8088 processor; this excluded the IBM PC)
- 8087 mathematics coprocessor
- medium-resolution (minimum 600 by 400 pixels) eight-color graphics
- two large-capacity floppy disks (over 700K bytes; preferably 5¼-inch)

(continued)

Inquiry 197

Inquiry 312 →

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- high-level graphics development software package
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- VT-100/Tektronix color graphics terminal emulator

At that time the only machine that I could find that met my criteria was the NEC Advanced Personal Computer (APC). The only place it fell short is that it has 8-inch disks rather than 5¼-inch disks. However, the disks hold 1.25 megabytes. (I use the Kermit file-transfer program and a local-area network to transfer generic MS-DOS programs and files from 5¼-inch disks to 8-inch disks.)

I did not know that my software requirements were available for the APC when I bought it, but I was certain that it would only be a short time before they would be available because of the APC's capability. In fact, they had just become available, but it was a few months before I found out about them. The graphics development software requirement has been met by several packages, but I will not be fully satisfied until I get a Pascal or C language implementation of the GKS international graphics standard for the APC.

Within the last year several microcomputers have been marketed that meet my original hardware criteria. Some of them, in order of increasing price, are the NEC APC III, the Tandy 2000, the AT&T 6300, the IBM PC AT with enhanced graphics board and monitor, and the IBM PC AT with professional graphics board and monitor. However, of these only the NEC APC III meets most of my software criteria. The IBM PC AT with graphics add-ons is the only one that offers a GKS graphics implementation. The difference in price between the NEC APC III and the IBM PC AT with enhanced graphics board and monitor is more than a factor of two; the AT is more than twice as fast as the APC III. My department is now buying 10 APC IIIs for scientific word processing.

I expect that, within the next five years, I shall buy a 32-bit microcomputer that meets the following criteria:

- true 32-bit machine (both calculational and data path; this excludes the 68000 and its follow-ons) with floating-point processing
- runs the UNIX System V operating system with the capability of emulating the MS-DOS operating system as a task
- high-resolution (minumum 1000 by 1000 pixels) 256-color graphics
- 50-megabyte hard disk with 10-megabyte removable hard-disk drive
- two large-capacity floppy-disk drives (3½-inch and 1.5 megabytes)
- Pascal or C language implementation of the GKS international graphics standard
- scientific word-processing package with user-definable characters and laser-printer drivers
- VT-100/Tektronix color graphics terminal emulation as a UNIX task
- about a $5000 to $7500 price tag

I expect to buy also a portable (under 10 pounds) version of this machine (or some similar machine) with the two floppy-disk drives and a flat screen with

(continued)

LETTERS

the same resolution, color, and visibility capability as the larger machine. I expect the price to be about $3000.

L. DAVID ROPER
Blacksburg, VA

LONG LIVE THE MACINTOSH

It seems that every month I open to the letters section of BYTE and read yet another mindless letter about the Macintosh computer. Many letters are by people who have had little exposure to the Mac, certainly not enough use to know what they are writing about. It also seems that many frustrated closet philosophers write in to wax eloquent on the psychological significance of (Macintosh) graphics. A few people write in with a balanced perspective on the Macintosh. Most of those people are Mac owners, and many are computer professionals with an exposure to a broad selection of machines.

Let me first state my background and bias. I am a professional software design engineer with an extensive background in hardware design. I work on VAXes and IBM PCs by day and a Mac at night. The VAX is, well, a VAX. The IBM PC is, in my opinion, out-of-date technology (hardware and operating system). I love my Macintosh. Here's why.

First, the Macintosh is powered by an 8-MHz 68000 CPU. The 68000 is a well-crafted 16-/32-bit microprocessor with a more elegant architecture than the 808x (IBM PC), which is why the 68000 is the choice of hardware vendors who aren't just IBM clones. (That is, hardware vendors choose the 8088 or 8086 mostly to make an IBM-clone micro.)

Second, the other hardware aspects of the Mac deserve praise. The industry is moving toward 3½-inch hard-cased floppy disks because they have acceptable storage capacity while being more portable (smaller and well protected) than 5¼-inch floppy disks. The Mac has the 3½-inch floppy. I can carry the 3½-inch floppies around without worry about losing data by disk destruction. I can't do that with those 5¼-inch "sloppy" floppies.

The sound-generation capabilities of the Mac are superb. The four-voice sound generator produces astounding computer music, so good that the Macintosh has the only software-only speech synthesizer available on a computer of any size.

The Macintosh screen is small, but its resolution puts every other screen I see

(continued)

AMAZING DAISY

NOW! FULL SIZE, FULL FEATURE, LETTER QUALITY AT ONLY $353

If you have been searching for a letter quality printer you have probably found the flood of claims and counterclaims to be a real roadblock in your search. Not long ago we were in the same position. We tried to determine which daisy wheel printer had all the features our customers wanted, yet would not set them back a month's salary. Recently several manufacturers have introduced machines that had features we were seaching for. After a thorough assessment, we eliminated one model after the other for lack of one feature or another until we only had one left.

THE RESULTS ARE IN

We found the printer which has all the features anyone could want. The winner is the Aprotek Daisy 1120, a real heavy-duty workhorse printing at 20 characters per second. The manufacturer is Olympic Co. Ltd., a highly respected Japanese firm.

FEATURES GALORE

This printer has it all. To start with, it has a front panel Pitch Selector button with indicators which allows 10, 12, 15 characters per inch (CPI) or Proportional Spacing. There is a Select (Online) button (with indicator) and a Line Feed button. You can also set Top-of-Form or Form Feed with the touch of the TOF button. Other front panel indicators include Power and Alarm.

To load a sheet of paper, simply place it in the feed slot and pull the paper bail lever. PRESTO! The paper feeds automatically to a 1 inch top margin and the carriage aligns to the selected left margin. In this manner, each page can have identical margins automatically. You can continue to compute while the Daisy 1120 is printing. The built in 2K buffer frees up your computer while printing a page or two allowing you to go to your next job.

To really put your printer to work, the Cut Sheet Feeder option is great for automatic printing of those long jobs. Also available is the adjustable Tractor Feed option. Compare our option prices! Best of all the Daisy 1120 is quiet: only 57 dB-A (compare with an average of 62-65 dB-A for others).

COMPLETE COMPATIBILITY

The Daisy 1120 uses industry standard Diablo® compatible printwheels. Scores of typeface styles are available at most computer or stationary stores. You can pop in a 10, 12, 15 pitch or proportional printwheel and use paper as wide as 14". At 15 CPI you can print 165 columns—great for spreadsheets.

The Daisy 1120 uses the Diablo Hytype II® standard ribbon cartridges. Again universally available.

Not only is the hardware completely compatible, the control codes recognized by the Daisy 1120 are Diablo 630® compatible (industry standard). You can take advantage of all the great features of word processing packages like Wordstar®, pfs: Write®, Microsoft Word® and most others which allow you to automatically use superscripts, subscripts, automatic underlining, boldface (shadow printing) and doublestrike.

The printer has a set of rear switches which allow the use of standard ASCII as well as foreign character printwheels. Page length can be set to 8, 11, 12, or 15". The Daisy 1120 can also be switched to add automatic line feed if required.

Inquiry 28 for End-Users.
Inquiry 29 for DEALERS ONLY.

THE BEST PART

When shopping for a daisy wheel printer with all these features (if you could find one), you could expect to pay $600 or $700 dollars. The options would add much more. *Not now!* We have done our homework. We can now offer this printer for only $353. Order yours today!

NO RISK OFFER

Try the Daisy 1120 for 2 weeks. If you are not satisfied for ANY reason we will refund the full price—promptly. A full 1-year parts and labor warranty is included.

THE BOTTOM LINE

Aprotek Daisy 1120 (Order#1120) $353 w/standard Centronics parallel interface and 2K buffer.

Options

Auto Cut Sheet Feeder (#1110) $188
Tractor Feed (#1112) $77

Accessories

8' Cable for IBM PC® and compatibles (#1103) $26

Interface with cable: •TI-99/4A (#106) $66
•Apple II or IIe (#1104) $76
•All Commodore (except Pet) (#1105) $44
•All Atari (#1107) $66

Shipping is $11—UPS continental USA. If you are in a hurry, UPS Blue or Air Parcel Post (second day air) is $25. Canada, Alaska, Mexico and Hawaii are $30 (air). Other foreign is $60 (air). California residents add 6% tax. Prices are cash prices—VISA and M/C add 3% to total. We ship promptly on money orders, cashier's checks, and charge cards. Allow 14-day clearing for checks. No C.O.D.'s. Payment in US dollars only.

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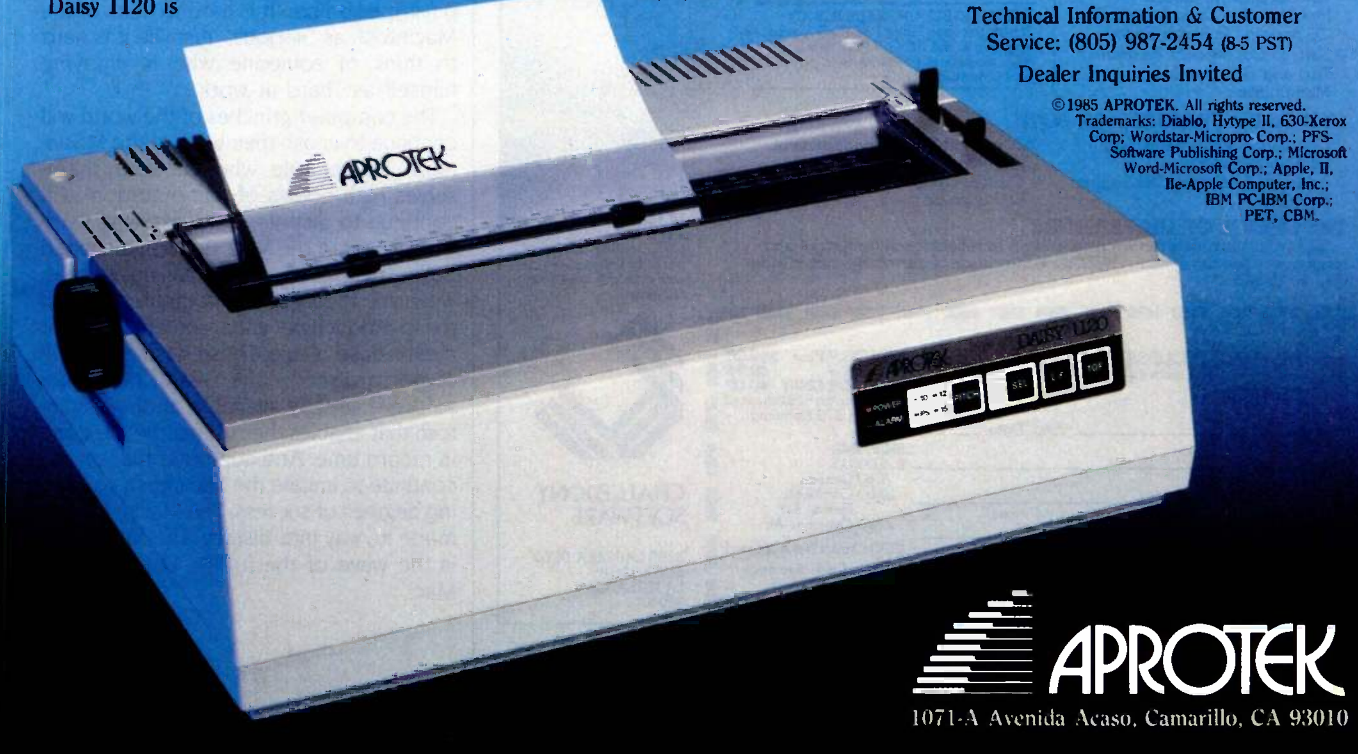

APROTEK
1071-A Avenida Acaso, Camarillo, CA 93010

to shame. I've seen PC Paint for the IBM. Don't make me laugh.

Third, the Macintosh has commercially defined the operating environment that other computer makers are widely (and wildly) imitating: graphics, mice, and pull-down menus. Imitation is still the sincerest form of flattery.

I lived in Japan several years and can read Japanese. I know from experience that Japanese reads more quickly than English because it is iconographic: Japanese characters are pictorial representations of concepts, while English is just a bunch of letters strung together, the concepts one more layer away from the mind's understanding. The graphic interface used on the Macintosh facilitates ease of use. It's that simple.

More Macintoshes were sold in the system's first year than any other computer in history. After a slow start (because the sophisticated Macintosh environment makes demands on programmers to use a consistent user interface), quality software for the Macintosh is flooding the market. I've seen the same business software on the IBM PC and the Macintosh. The Macintosh software is easier to use, more powerful, and faster.

The Macintosh is a powerful, state-of-the-art microcomputer that should appeal to businesses, programmers, and creative people alike. Yet the Macintosh is easy and fun to use. My wife, no computer wizard by any standard, loves using our Macintosh. Yet I, in programming the Mac, am excited by the challenging system environment.

I think many of the misconceptions people have about the Macintosh relate to the image of its maker, Apple Computer. The Apple II line of microcomputers brought Apple to public consciousness. The Apple II has had phenomenal success in the home and educational market segments. The look and attitude that made the Apple II successful in those markets is reflected in the Macintosh. The Mac has a whimsical name and looks cute (like a toy), with its tiny screen, small (by comparison) keyboard, and single-button mouse. The Macintosh has cute little pictures for everything. You don't have to read thick tomes to use it. Apple often advertises the Macintosh with a gleam-in-the-eye father's pride that is, well, not pinstripe somber. It is hard to think of the Macintosh as "serious," just like it is hard to think of someone who is enjoying himself as "hard at work."

The computer grinches of the world will continue to gnash their teeth at the Macintosh. The people who consider themselves high priests of computerdom will continue to disparage the extreme user-friendliness of the Mac. But well-managed businesses, especially small businesses, will come to realize that computers should mean productivity enhancement, and that means ease of use. These businesses will come to discover the wealth of quality software already available on the Macintosh that enables them to get the job done in record time. And computer makers will continue to imitate the Macintosh, to varying degrees of success. The Macintosh has made its way into history. The Macintosh is the wave of the future. Long live the Mac!

GARY W. ODOM
Melborne, FL

(continued on page 392)

F·I·X·E·S A·N·D U·P·D·A·T·E·S

UPDATE

More on Amiga

Some additional information on Commodore's new Amiga personal computer has come to our attention since Gregg Williams's article on the Amiga appeared in the August issue. (See "The Amiga Personal Computer," page 83.)

Foremost, the Amiga should be available by the time you read this. In addition, a two-volume set of technical documentation, produced by Addison-Wesley, should be available by now.

We also found out that IBM PC compatibility will be available for less than $200 and that the first units shipped will replace ROM with RAM.

The Amiga can run software for the IBM PC in two ways. The first approach involves using a preboot program, which will be priced at "under $99," that lets you run IBM software out of the box. If you own the Amiga A1020 floppy-disk drive (5¼-inch), you can run the PC version of the software. Otherwise, the Amiga's 3½-inch drives can read Data General/One formatted disks, a number of which offer IBM PC software.

Internally, the Amiga emulates the 8088 microprocessor. Thus, graphics-intensive programs will run as rapidly on the Amiga as they would on the IBM PC. However, a Commodore spokesperson cautions that numeric-intensive programs, such as spreadsheets, will run more slowly.

The second approach to IBM PC compatibility uses the preboot program and an add-in board equipped with static RAM and some ROM that contains "the most often used BIOS routines" within PC-DOS. The board enables the Amiga to run any software as fast as an IBM PC.

To prevent possible ROM-routine bugs, the first Amigas shipped will come with 192K bytes of write-protected RAM. The current version of the Amiga's ROM routines will load into this RAM. Once Commodore feels that the routines are performing satisfactorily, the Amiga will be shipped with the ROMs in place.

BYTE'S BUGS

Pseudorandom Bugs

A number of bugs have been found in the program that accompanied Charles A. Whitney's article "Generating and Testing Pseudorandom Numbers." (See October 1984, page 128.)

In listing 1 (page 462), change line 34 to line 39 and insert the following two lines of code:

```
34 IX1 = IS:IX2 = IS
36 'NSLOTS = 67'  ****Length of
      secondary list
```

In line 60, change PRINT –2 to read PRINT #2. Finally, line 2011 should read:

```
2011 JJ = INT(IX2/IM2):IX2 = IX2 – JJ*IM2
```

Additional References

The following references were inadvertently omitted from the article "Choosing a Programming Language" by Gary Elfring. (See June, page 235.)

1. Feuer, Alan R., and Nerian H. Gehani. "A Methodology for Comparing Programming Languages." In *Comparing & Assessing Programming Languages*, Bell Laboratories. Englewood Cliffs, NJ: Prentice Hall, 1984.
2. Wirth, Niklaus. "History and Goals of Modula-2." BYTE, August 1984, page 145.
3. Johnson, Stephen C., and Brian W. Kernighan. "The C Language and Models for Systems Programming." BYTE, August 1983, page 48.

Address Correction

An item in the July Clubs & Newsletters section ("An Industry First," page 58) gave the wrong address for the International MIDI Association. The correct address is 11857 Hartsook St., North Hollywood, CA 91607, (818) 505-8964.

Correcting an Oversight

We neglected to acknowledge the artist whose work appeared on our August cover.

Tyrone Depts, an artist based in New York City, was responsible for reproducing the Picasso on the Amiga's screen.

We apologize for the oversight.

The Last Shall Be First, the First Shall Be Second, Make the Second Last

A printing error resulted in the mislabeling of the photos that accompanied the announcement of QuickView Systems' Zoomracks. (See What's New, August BYTE, page 39.) The caption with the first photo should have accompanied the second photo, while the second photo's caption describes the third photo. The last photo's caption refers to the first picture.

Call for Manuscripts

BYTE is planning a theme on software aids for engineers. If you have engineering software of reasonably general utility that you are willing to place in the public domain, contact Tom Cluné, BYTE, POB 372, Hancock, NH 03449, (603) 924-9281, ext. 243, by the end of October 1985.

BYTE'S BITS

New Phone Number for BYTEnet

Effective November 1, BYTEnet Listings will have a new telephone number. The new number will be (617) 861-9764. All earlier numbers will be disconnected. ■

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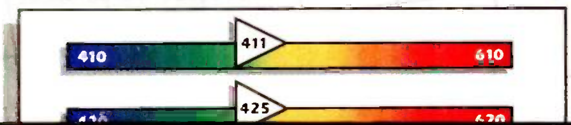

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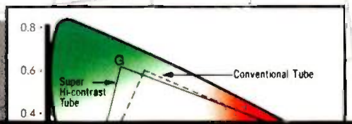

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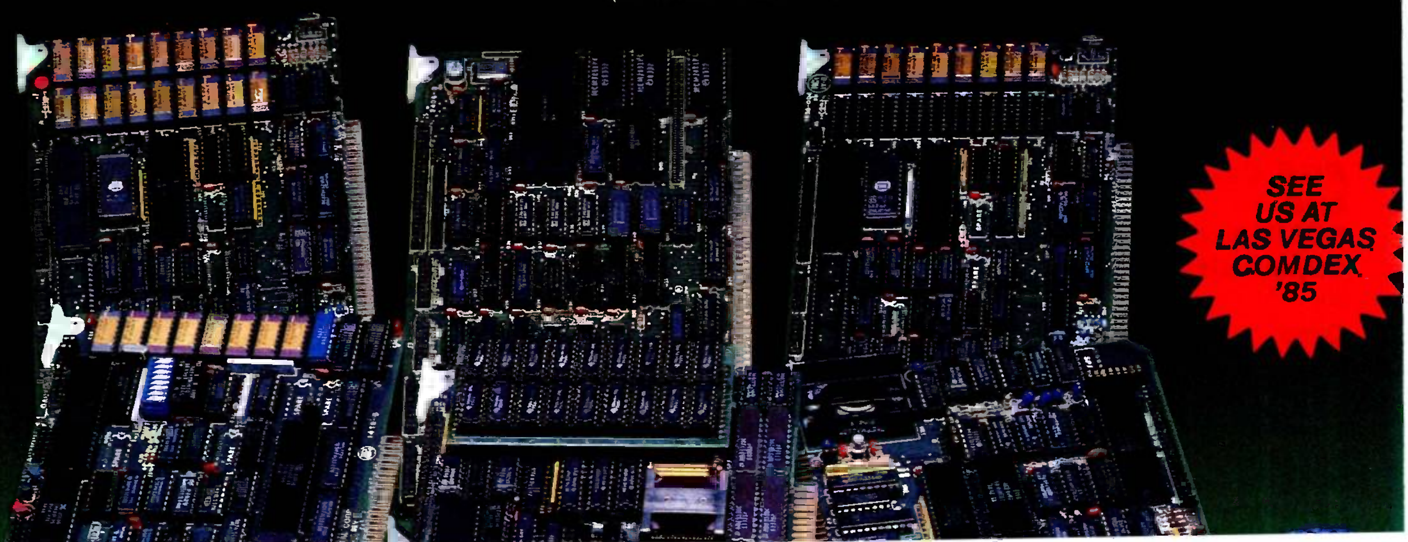
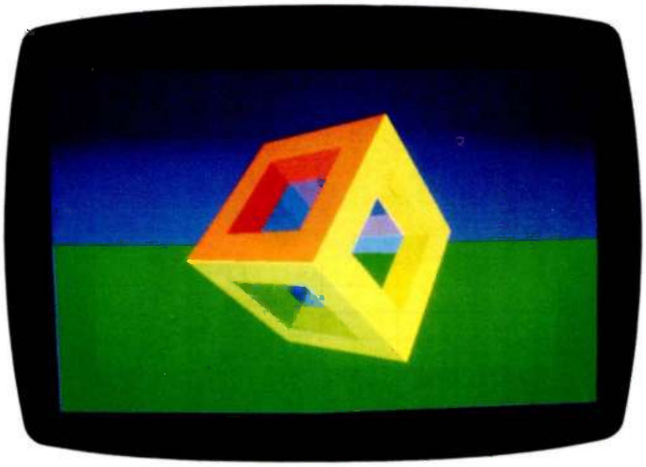




Rotating cube produced by Xtar's Polygone board.

Powerful High-Resolution Graphics Add-Ons

The Association for Computing Machinery's annual SIGGRAPH show in San Francisco was the backdrop for the introduction of a wide range of high-resolution graphics controllers for personal computers. Most vendors either already provide standard interfaces for VDI, HALO, and specific CAD software or plan to provide them shortly.

AT&T's Truevision Advanced Raster Graphics Adapter (TARGA) series of four cards for the AT&T 6300 (or IBM PC) can capture and display images with a resolution of 512 by 480 pixels. The TARGA boards digitize signals in real time (30 per second).

The TARGA 8 provides 256 levels of gray per pixel; the TARGA 16 lets each pixel display one of 32,768 colors, plus an overlay. The TARGA 24 supports 16.8 million colors, while the TARGA 32 has an additional eight bit planes that permit blending of still video frames and real-time video signals. The TARGA 8 accepts input from a monochrome RS-170 camera, while the TARGA 16 accepts NTSC or RGB video input. The TARGA 24 and 32 cards will use RGB input.

The TARGA 16 will be available this month for $2995; the others will be released next month. The TARGA 8 will be priced at $2295, the TARGA 24 at $3995, and the TARGA 32 at $4995. Contact AT&T, Electronic Photography and Imaging Center, 2002 Wellesley Blvd., Indianapolis, IN 46219, (317) 352-6120.
Inquiry 600.

Imaging Technology's FG-100-AT is an add-in card for IBM's PC AT. It provides digitizing and display capabilities with a resolution of 512 by 512 pixels with 12 bit planes (256 levels of gray per pixel plus four overlay bits per pixel). You can also store two 6-bit-per-pixel images. By using an RS-170 video source, the FG-100-AT can digitize 30 frames per second. The FG-100-AT sells for $3995; a $4495 version displays images in pseudocolor. Contact Imaging Technology Inc., 600 West Cummings Park, Woburn, MA 01801, (617) 938-8444.
Inquiry 601.

Xtar Electronics' high-speed graphics adapter for the IBM PC is based on Xtar's Graphics Microprocessor (GMP). Xtar's Polygone board can display images with a resolution of up to 640 by 400 pixels in up to 16 colors (or 128 colors using dithered patterns). It can draw 70,000 vectors per second and provides a polygon-fill rate of 100 million pixels per second.

Xtar offers evaluation kits of the Polygone for $3500, including development software. Xtar will also market the Polygone with an array processor board from Marinco Computer Products Inc. of San Diego. (End users can buy the card set from SubLogic Corp. for $2990; see August BYTE, page 40.) Contact Xtar Electronics Inc., 2262 Landmeier Rd., Elk Grove, IL 60007, (312) 364-4111.
Inquiry 602.

Metheus Corporation's Omega PC displays 1024 by 768 pixels in 16 colors (from a palette of 4096) from a 1024- by 1024-pixel memory. The Omega PC consists of three interconnected cards that occupy two IBM PC slots. A CMOS 2901 microprocessor is used. The card's polygon-fill rate is 30 million pixels per second and it draws vectors at 3 million pixels per second. The card can also emulate the IBM Color Graphics Adapter. The Omega PC is $2500. Contact Metheus Corp., 5510 Northeast Elam Young Parkway, POB 1049, Hillsboro, OR 97123, (800) 547-5315; in Oregon, (503) 640-8000.
Inquiry 603.

The Revolution 2048 × 4 color graphics controller from Number Nine Computer Corporation displays 1280 by 1024 pixels, panning over an image of 2048 by 4096 pixels. Virtual image space can be sacrificed in exchange for color capabilities. Only monochrome is available at 2048 by 4096, but 16 colors can be displayed (from a palette of 64,000) if a virtual image of 2048 by 1024 is used. The Revolution 2048 × 4 includes 1 megabyte of multiported display memory. The boards cost from $1495 to $3995 depending on viewable resolution, which is factory preset at 1280 by 1024, 1024 by 768, 832 by 624, or 640 by 480.

The Revolution 1024 × 8 provides an addressable 1024 by 1024 pixels (1024 by 768 displayed) with 256 colors from a 16.8-million color palette. It's priced at $3995; versions supporting 640 by 480 and 768 by 480 displays are $2995 each.

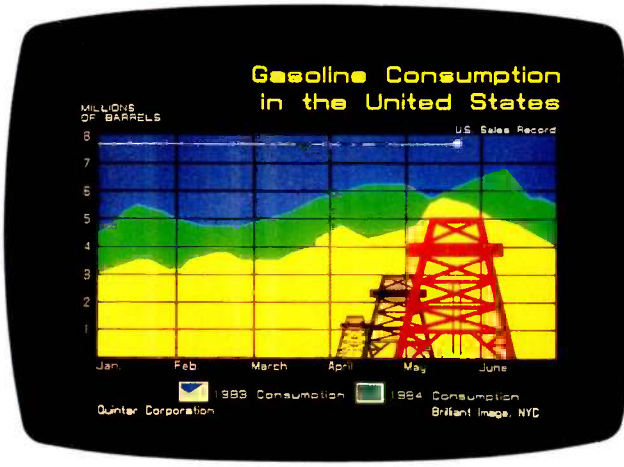
The Revolution 512 × 32 supports a 512- by 512-pixel image (512 by 480 viewable) with 24 bit planes, plus two 4-bit overlay buffers for $3995. Contact Number Nine Computer Corp., 691 Concord Ave., Cambridge, MA 02138, (617) 492-0999.
Inquiry 604.

(continued)

Verticom's M-256 graphics controller uses two slots in an IBM PC to provide 640- by 480-pixel graphics resolution, showing 256 colors from a palette of 4096. It can emulate the IBM Color Graphics Adapter and supports both the graphics primitives used by IBM's Professional Graphics Controller and Verticom's own primitives. The card uses Z80A and 68000 processors to produce a fill rate of 7 million pixels per second and to draw 5000 1-centimeter vectors per second. The M-256 costs $2850. A 16-color version, the M-16, is $2250. Contact Verticom Inc., 545 Weddell Dr., Sunnyvale, CA 94089, (408) 747-1222.
Inquiry 605.

Vectrix Corporation's PePe Graphics Board for the IBM PC AT displays 1024 by 1024 pixels on a 60-Hz noninterlaced monitor. Versions of the board can display 16 colors (either preset or from a 4096-color palette), 256 colors from a palette of 16.8 million, or 4096 preset colors. Pricing ranges from $2495 to $4495. Contact Vectrix Corp., 2606 Branchwood Dr., Greensboro, NC 27408, (919) 288-0520.
Inquiry 606.

The ACS GraphAX 20/20 provides a display resolution of up to 1184 by 884 or 1024 by 768 pixels from a virtual screen image of 2048 by 2048 with five bit planes (32 colors from a palette of 512). The IBM PC expansion card occupies one slot and includes 2½ megabytes of RAM and a NEC 7220 graphics processor. It costs $2995. Contact Advanced Computer Solutions International Inc., Suite 330, 2105 Luna Rd., Carrollton, TX 75006, (214) 247-5151.
Inquiry 607.



Sample business graphics by Quintar's color controller.

Ramtek's 2020-4220 display controller for the IBM PC AT can display 1280 by 1024 pixels; optional memory enables the card to display up to 256 colors. The 2020-4220 is an external unit that contains a 12-MHz Motorola 68010 processor, connecting to an IBM PC AT expansion card. Interfaces are also available for several minicomputers. Pricing starts at $6995. Contact Ramtek Corp., 2211 Lawson Lane, Santa Clara, CA 95050, (408) 988-2211.
Inquiry 608.

Quintar Corporation's GraphPort and Quintar 1080 color graphics controllers both display 832 by 630 pixels in up to 16 colors (up to 120 colors using dithering). The GraphPort is an IBM PC expansion card, while the Quintar 1080 provides the same circuitry in a stand-alone module that interfaces to any computer with an RS-232C serial port. The 1080 has an additional RS-232C output capable of directly driving a Polaroid Palette. The GraphPort is $1995; the Quintar 1080 is $2195. Contact Quintar Corp., 2525 Maricopa St., Torrance, CA 90503, (213) 320-5700.
Inquiry 609.

The Ultra 1280 for the IBM PC AT provides 1280 by 1024 pixels in 256 colors from a palette of 16.7 million. The unit occupies only one AT slot but takes up two slot widths due to the arrangement of its 1³⁄₁₀ megabytes of RAM. The board's single-pixel addressing mode can update 1 million pixels per second; its 20-pixel segment addressing can update 21 million pixels per second. The Ultra 1280 is priced at $4000. Contact INI Computer Products, 5198 Pinemont Dr., Salt Lake City, UT 84123, (801) 263-2300.
Inquiry 610.

The PG-1280 from Matrox Electronic Systems provides 1280- by 960-pixel color graphics in 256 colors (from 4096) and emulates the IBM Professional Graphics Controller with an increase in speed and resolution. With a 1280 by 1024 virtual screen memory, the PG-1280 is $4995; with a 2048 by 1024 memory, it's $5995. The PG-640 claims compatibility with the Professional Graphics Controller, also with increased speed; it provides 640 by 480 resolution with 256 colors for $2495.

Matrox's PIP-512 digitizes images from an RS-170 or RS-330 device at 512 by 512 pixels by 8 bits (256 levels of gray or 256 colors from 16.7 million). The PIP-512 is $1995; a 1024 by 1024 version, the PIP-1024, costs $2495. Contact Matrox Electronic Systems Ltd., 1055 Saint Regis Blvd., Dorval, Quebec H9P 2T4, Canada, (514) 685-2630.
Inquiry 611.

Io Research offers boards for the IBM PC, Sirius, Apple II, and S-100 computers. The Pluto card uses a 68000 processor and 256K or 384K bytes of RAM, providing 768 by 288 pixels in 16 colors or 768 by 576 in 8 colors. The Pluto II card uses an 8088 processor and 512K bytes to 1 megabyte of RAM to display 768 by 576 pixels in 256 colors (from a palette of 16.7 million). Options include a frame grabber and a combination of three Pluto II boards to make a 24-bit version. Pricing for the Pluto II starts at £2500 and for the Pluto I for the IBM PC at £950. Contact Io Research Computer Graphics, Io Research Ltd., Exchange Buildings, High St., Barnet, Hertfordshire EN5 5SY, England, tel: 01 441 5700.
Inquiry 612.

—*Mark Welch*

(continued)

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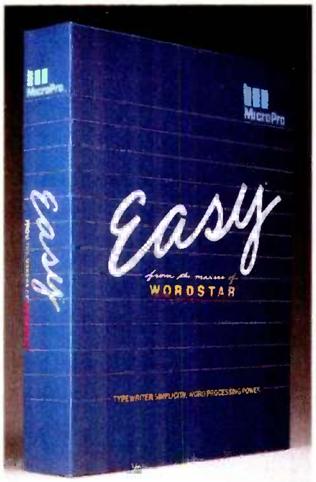

MicroPro's *Easy* word processor.

MicroPro Adds Low-End Word Processor

Easy from MicroPro International is a menu-driven word-processing program for the IBM PC designed to be simple to learn and use. Although the files generated by the program are compatible with MicroPro's WordStar 3.3, the programs are not command-compatible: Easy uses pop-up menus for all functions. Easy has no document size limit and can handle column widths up to 240 characters. An "undo" capability is included to restore the most recently deleted text. The program also features context-sensitive help, access to DOS directories and paths, automatic text reformatting, and a 65,000-word spelling checker. Easy requires PC-DOS 2.0 or higher and a minimum of 256K bytes of RAM.

The $150 price includes an interactive tutorial. Contact MicroPro International Corp., 33 San Pablo Ave., San Rafael, CA 94903, (415) 499-1200.

Inquiry **613**.

BASIC Compiler from Microsoft

Programs compiled by Microsoft's new QuickBASIC are said to run 3 to 10 times faster than when executed by Microsoft's BASIC interpreter. QuickBASIC is compatible with all versions of the Microsoft BASIC interpreter (the BASIC that's part of the MS-DOS and PC-DOS packages). The compatibility encompasses all the interpreter's commands, including sound and graphics.

Programs written for the interpreter need little or no modification before QuickBASIC can compile them. Small changes, such as moving DIM statements to the beginning of the code, might be necessary.

Several features of QuickBASIC make structured programming easier. Line numbers are not required, and lines can also be identified by alphanumeric labels. Subprograms that support local and shared variables can be called by name and then have parameters passed to them. A QuickBASIC program can define a multiline function, which can also be called by name and have parameters passed to it. The function will then return a value to the caller. Because QuickBASIC allows separate compilation, you can break programs into modules and build libraries of routines.

QuickBASIC offers increased DOS access, including a file-specification syntax for indicating the path for a device or disk file and more flexible use of DOS functions through the SHELL, IOCTL, IOCTL$, ERDEV, ERDEV$, MKDIR, RMDIR, CHDIR, and ENVIRON$ keywords. Network support is an integral part of QuickBASIC, which runs with the IBM and Microsoft network for MS-DOS or PC-DOS 3.1. Files or records can be locked and unlocked.

Although some of Microsoft's other compilers (MS-BASCOM 5.36 and MS-Business BASCOM 1.10, for example) cannot work with programs or data that occupy more than 64K bytes, QuickBASIC can work with programs as large as available memory. Data in QuickBASIC is still restricted to 64K bytes of memory space.

QuickBASIC costs $99 and requires an IBM PC, XT, AT, or compatible with 256K bytes of RAM recommended and MS-DOS 2.0. It will not run on generic MS-DOS machines.

QuickBASIC is based on the same compiler technology as Microsoft's high-end compilers and is compatible with them. The high-end compilers do contain some features that QuickBASIC does not: a BCD math package and extended string handling (MS-BASCOM 1.10 for $450) and support for ISAM and dynamic arrays larger than 64K bytes (IBM BASCOM 2.00 for $395).

Contact Microsoft Corp., 10700 Northup Way, Bellevue, WA 98004, (206) 828-8080.

Inquiry **614**.

Tape Controllers from Sigen

Sigen Corporation has introduced two streaming-tape controllers for the IBM PC, XT, AT, and compatibles. The T-36 and T-44 are compatible with the industry-standard QIC-36 or QIC-44 interface half-height cartridge tape drives.

The controllers are functionally identical. They offer mirror image and file-by-file backup as well as single-file restore from image. These selections are contained within a menu-driven software utility provided with the controllers that features continuous screen reporting of activity (such as rewind and copy progress).

Either controller (along with a streaming-tape drive) can back up a full 20-megabyte Winchester in less than five minutes. Both the T-36 and the T-44 are designed to operate with any Winchester controller compatible with the IBM standard protocol.

The T-36 and T-44 fit any IBM slot (including the short slot) and consume 600 mA while operating. They feature a selectable I/O register base address and jumper-selectable interrupt and DMA priority levels.

The T-36 and T-44 are priced at $150 in quantities of 100 and are available as plug-in cards or in complete subsystem configurations. Contact Sigen Corp., Suite 7, 1800 Wyatt Dr., Santa Clara, CA 95054, (408) 988-2527.

Inquiry **615**.

Pop-up Outline Processing

Living Videotext's Ready! is a memory-resident utility for MS-DOS machines. It is based on the outline-processing structure of the firm's ThinkTank (see "Idea Processors" by William Hershey, June BYTE, page 337). Although Ready! lacks ThinkTank's word-processing features, it includes some new functions designed to

(continued)

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

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

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

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

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

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

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

SideKick only: PCjr requires the not copy-protected version.

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Inquiry 41 for End-Users. Inquiry 42 for DEALERS ONLY.

Sample screen from Living Videotext's Ready! memory-resident utility.

enhance its operation as a memory-resident program. Ready! can find phone numbers in text and dial them, and it will export data to any of several popular stand-alone applications.

Thus, a Ready! outline can be used as a notepad for quick reference, as a hierarchical database to store information, or as a worksheet to prepare material in outline format for eventual use in other programs (an example would be labels for the left column of a spreadsheet).

Ready! comes with setup files for exporting to 30 programs, including MS-DOS, Symphony, Framework, MultiMate, WordStar, Lotus 1-2-3, and ThinkTank. You can define additional export macros for other needs and install 10 configurations at any one time.

Another new feature is the ability to create data-entry forms and store them as function-key macros. Pressing the function key inserts the form into the outline; you then can fill in the rest of the record. One common use for such a feature is a card-file database.

Ready! uses 128K bytes of memory and will accommodate a 32K-byte outline file. You can also reconfigure it to use 112K bytes of memory with a 16K-byte outline. The program works with a mouse and supports the Lotus/Intel/Microsoft enhanced memory specification.

Not copy-protected, Ready! costs $99. Contact Living Videotext Inc., 2432 Charleston Rd., Mountain View, CA 94043, (415) 964-6300.

Inquiry 616.

Tools for Turbo Pascal

Quinn-Curtis has introduced a family of science and engineering software tools for the Turbo Pascal programmer. Incorporating these procedures into a Turbo Pascal application program helps to save program development time. All the software tools are supplied on IBM PC-compatible disks in Pascal source code and can be compiled using IBM PC, XT, or AT Turbo Pascal and Turbo Pascal with 8087 support, revisions 3.0 and higher.

The Science and Engineering Tools package (model number IPC-TP-006) includes procedures for general statistics, multiple regression, curve fitting, integration, FFTs, file transfers to Lotus 1-2-3, simultaneous-equation solving, matrix math, linear programming, data smoothing, and graphics (line plots, bar graphs, scatter plots, semilog graphs, log graphs, and windows). This package retails for $69.95 plus $5 shipping.

The Turbo Pascal Data Acquisition and Control Tools package (model number IPC-TP-007) supports the IBM DACA (Data Acquisition and Control Adapter), Cyborg Isaac 41I, and Cyborg Isaac 91I. Analog inputs can be sampled at up to 18,000 per second. Procedures are also supplied for analog output, digital input and output, thermocouple linearization, PID control, real-time graphics (bar graphs and line plots), and FFTs. Menu-driven example programs for data logging, high-speed data acquisition, process control, and real-time graphics let the user start acquiring and analyzing analog data immediately. The data-acquisition and control package is compatible with Turbo Pascal and Turbo Pascal with 8087 support and requires the IBM DACA support software. It retails for $94.95 plus $5 shipping.

Contact Quinn-Curtis, 7 Fredette Rd., Newton Centre, MA 02159, (617) 969-9343.

Inquiry 617.

Touchpad Integrated with Keyboard

Key Tronic Corporation has integrated a touchpad with a keyboard for the IBM PC, XT, or AT. The KB 5153 Touch Pad Keyboard supports four separate modes of touchpad operation, some simultaneously. These modes simulate cursor or mouse movements, translate absolute coordinates, and support up to 36 operator-defined function areas. The touchpad is capable of 3600- by 3600-point resolution.

The Touch Pad Keyboard costs $399. Contact Key Tronic Corp., POB 14687, Spokane, WA 99214, (509) 928-8000.

Inquiry 618.

Digital Joystick for CAD/CAM

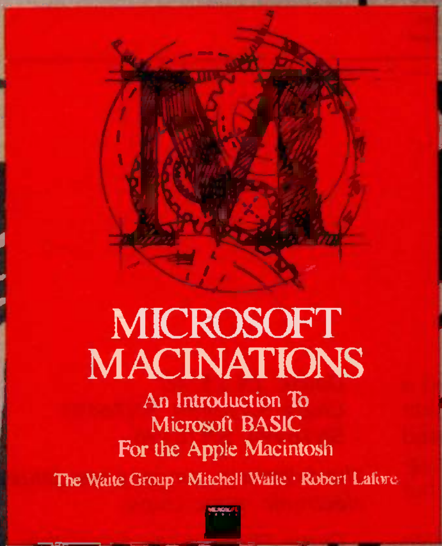
The Microstick from CH Products is engineered for CAD/CAM, CAE, text-editing, and graphics applications. This point-and-select device comes equipped with eight modes of movement, including one that emulates the PC Mouse (from Mouse Systems) and another that emulates the Bit Pad One (from Summagraphics Corp.). The other six modes have an ASCII format ouput that you can interface to the host computer or terminal.

The Microstick can change from high resolution (of 1, 4, or 8 parts in 4096) to rapid cursor movement at the touch of a button. A full RS-232C serial interface is standard but 5-volt TTL or TTL inverted are available.

Suggested retail price is $279.95. Contact CH Products, 1558 Osage St., San Marcos, CA 92069, (619) 744-8546.

Inquiry 619.

(continued on page 395)



A BASIC fact. The one book to turn to. Microsoft Macinations

Take the de facto industry standard Microsoft BASIC. Add the feature-rich enhancements that customize it for the Macintosh. Bring in the developers of Microsoft BASIC, along with Mitchell Waite, Robert Lafore, and The Waite Group, authors of best-selling computer books since the early days of microcomputing. And you've got: *Microsoft Macinations*. The most comprehensive resource available for Microsoft BASIC on the Macintosh.

Microsoft Macinations is packed with hands-on tutorials and in-depth information on accessing the Mac's unique characteristics through BASIC: its menus, windows, buttons, "event trap" programming, animation, QuickDraw graphics, and sound-generation capabilities.

In addition to Waite's advice on programming techniques and concepts, there is a wealth of programming examples that are inventive, amazing, *and* instructive: a clever pattern-maker, a program synthesizing a four-voice Bach concerto, a fast-moving animation program, and much more.

Whether you're a beginner or expert programmer, make the most of Microsoft BASIC. Pick up a copy of *Microsoft Macinations* wherever books and software are sold. ■ $19.95

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MICROSOFT PRESS

A·S·K B·Y·T·E

Conducted by Steve Ciarcia

NUISANCE AVOIDANCE

Dear Steve,

As you know, junk mail has now been expanded to include junk phone calls, those inquiring if I would like to add aluminum siding to my home or telling me of the wonderful prize I have just won.

I have heard a rumor that an incoming telephone signal carries with it a code that identifies the calling number. Do you know if this is correct? If so, would it be possible to have my Apple IIe answer the phone with the modem, identify the calling number, check it against a file of known numbers, and then inform me who is calling? Or could a device be constructed that would do this without the benefit of the Apple?

Thanks much for any information that you have.

LEON WEBSTER
Indianapolis, IN

With the revolution currently in progress in the telecommunications industry, it won't be long before such devices are created. In the meantime, other methods must be employed.

One such method was described in the March 1984 issue of Radio-Electronics *magazine. "No More Wrong Numbers" by Gary McClellan describes a circuit that will seize the line when an incoming phone call is detected. It then waits 10 seconds for the caller to enter a code, either pulse or Touch-Tone. If the code is correct, the device beeps for 10 seconds informing you of the call. If it is incorrect, the device disconnects the call from the line.*

The nice feature is that you determine the code and give it to your friends and relatives. You can also change the code at will to further increase security.

This device would provide a solution to your problem.—Steve

FLUX REMOVAL

Dear Steve,

Over many years of reading ham radio, electronics, and computer magazines, I've never come across any solid advice on cleaning flux from circuit boards after a project is finished.

Friends suggested using methyl hydrate, but it didn't accomplish much. I tried a spray marketed by Radio Shack, but that also appeared to be an alcohol-based product. More recently, it has been suggested that I use carbon tetrachloride, but I believe that's a known carcinogen.

Do you have any effective and safe recommendations?

RONALD HANDS
Hamilton, Ontario, Canada

Denatured alcohol is a good flux solvent. It's mostly ethyl alcohol and safer than methyl alcohol. This is the solvent usually used in liquid flux, but it still takes some time and scrubbing to clean a board by hand.

General Cement makes a flux remover, type 22-270, that is available at most electronics supply houses.

A couple of alternatives you might consider are water-soluble flux and solder with flux that needs no cleaning. Ersin makes one of each kind: Hydro-X is the water-soluble kind, and Xersin requires no cleaning. Both are available from electronics supply houses.—Steve

SOUND PRODUCTION

Dear Steve,

My main interest in electronics is to produce digitally controlled audio synthesizers. The problem is that I'm unfamiliar with the musical chip market. Could you help me in locating musically oriented chips? I really would appreciate it.

BARRY M. BLINK
San Bernardino, CA

A number of companies now make chips with bus interfaces that can be used for sound production. Here are some of them, along with relevant part numbers:

General Instrument
Microelectronics Division
600 West John St.
Hicksville, NY 11802
(516) 733-3107
Chips: AY-3-8910, AY-3-8912, AY-3-8913

Texas Instruments
Semiconductor Products
POB 809066
Dallas, TX 75240
Chips: SN76489, SN76493, SN76494, SN76496

The following company specializes in electronic music chips:

Curtis Electromusic Specialties Inc.
110 Highland Ave.
Los Gatos, CA 95030
(408) 395-3350

Many music synthesizers now come with the MIDI (musical instrument digital interface) port, for which some computer interfaces are available. Check your local music store.—Steve

BUILDING A CLOCK

Dear Steve,

I am trying to design and build a computer clock for the Apple II that will be the ultimate in accuracy. I intend to receive and decode the 100-hertz subcarrier from radio station WWV's transmission from the National Bureau of Standards in Fort Collins, Colorado. Could you give me a couple of clues on how to get the signal from the radio into the clock? I expect to use a microprocessor to run the show, probably a 6502 so that I can do the machine-language software on my Apple II+. Long-range plans include using this device for a data-acquisition port, if possible.

Thank you very much for any assistance you can toss my way.

LELAND FOX
Klamath Falls, OR

TTL Cookbook *by Donald E. Lancaster (Howard W. Sams) describes the basics of using WWV to synchronize timing pulses. The exact circuit required to get the data to the Apple would vary with the amount of National Bureau of Standards data to be transferred. If all you need is hours and minutes, you could read the time data through a parallel interface using a PIA chip like a 6520 or 6821. If you need more data than that, use TTL buffers, such as a 74LS541 or 74LS244, enabled by a decoder and read 2 BCD digits in each byte at each decoded address. Using pin 41 (Device*

(continued)

Select) on the Apple bus as the enable signal with a 74LS154 decoder, you could read in 32 BCD digits of data.

The easiest way to get the time into the Apple would be to purchase the Heathkit GC-1000 clock that receives NBS broadcasts and outputs time data via an RS-232C interface. The kit sells for $249.95, and the RS-232C interface, GCA-100-1, is $49.95.—Steve

Capacitance Measurement

Dear Steve,

I would like to build a capacitance meter driven by my SwTPC 6809. I would appreciate your feedback on a particular idea I have in mind and suggestions on any other tack I might take.

It seems to me that capacitance measurement might easily be done by using program control to apply a precision reference voltage to the capacitor under test, which has a charge/discharge path through a precision resistor. Using an A/D converter IC, I should be able to measure how long the capacitor takes to discharge and thus be able to calculate the capacitance.

I've seen a more hardware-intensive scheme whereby the capacitor under test is part of a 74121 one-shot circuit, and its value is computed and displayed with perhaps two dozen ICs derived from the timing characteristics the capacitor gives the one-shot circuit.

I could also use a refresher on resistor-capacitor time constants. If I remember correctly, one time constant for a series resistor-capacitor circuit is equal to R × C. Does it take five of these time constants to fully charge or discharge the capacitor through the resistor? Is this figure exact or an approximate rule of thumb?

Thank you for your help.

Keith Alexander
Detroit, MI

The conversion time of the A/D converter would have to be compensated for, and the converter itself would require triggering. A simpler technique would use an IC timer to determine capacitance. Two sources for suitable circuits are TTL Cookbook *by Donald E. Lancaster (Howard W. Sams) and* VIC-20 Interfacing Blue Book *by V. J. Georgiou (Microsignal Press). Both feature timer circuits based around the 555 IC and will measure nanofarads to microfarads.*

The 555-based circuits could be adapted for capacitances less than 100 picofarads by using a TTL one-shot in place of the 555. TTL one-shots are more stable and repeatable with these small capacitances and consequently output narrower pulse widths. This technique does have its limits, and the results with extremely small capacitances may not be reliable. A one-shot can produce a measurable output pulse with no external timing capacitor at all because of the inherent capacitance in the circuit and its connections. The capacitor being tested must be large relative to this parasitic capacitance for the results to be consistently reliable.

The time constant for a simple capacitor charging through a resistor is the time required for the capacitor to reach 63.2 percent of its full charge. It can be expressed by the simple formula: $T = R \times C$, where T = time in seconds, R = resistance in ohms, and C = capacitance in farads.—Steve

Multiuser Capabilities

Dear Steve,

When I decided to purchase a computer to aid me in the administration of our parish, I found a friendly one with all the storage I would ever need in an Eagle IV. Though I am very pleased with the Eagle, I am not happy to hear that the company that made it has been battling bankruptcy.

We would like a system that would let us access the 10-megabyte hard disk that came with the Eagle with four terminals so that a number of people in our office could use the data on it simultaneously. Some hardware items that allow one to network a variety of different computers and terminals are on the market, but I am confused by most of the advertising.

Is it possible to take out the hard disk to be used as an external storage device interfaced with a computer that will handle multiusers? What is entailed since the Eagle uses a Z80A running at 4 MHz? Does this mean that I am forever locked into using hardware at that frequency?

What is the best way to gain multiuser capabilities in light of what is presently available and by using what I already have with the Eagle IV? Any advice will be greatly appreciated.

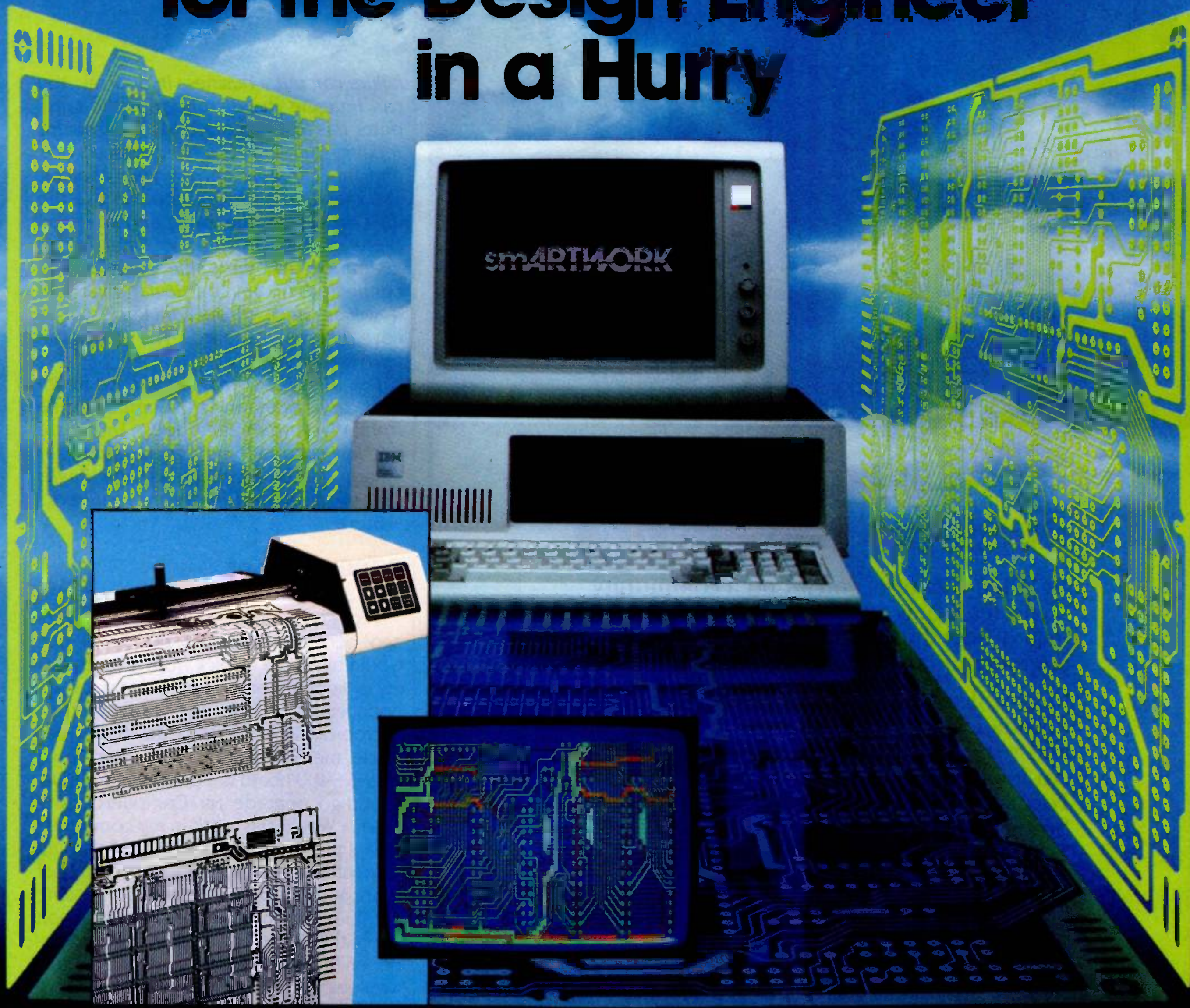
Joseph DeVliegher
Killeen, TX

Since you are not a computer expert, you should find a dependable computer store that sells high-end personal/business computers.

When a multiuser computer is implemented, many critical documents, lists, etc., are stored in it, and equipment

(continued)

Circuit-Board-Artwork Software for the Design Engineer in a Hurry



For only $895, smARTWORK® lets the design engineer create and revise printed-circuit-board artwork on the IBM Personal Computer. You keep complete control over your circuit-board artwork — from start to finish.

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- ☐ IBM Graphics Printer or Epson FX/MX/RX series dot-matrix printer
- ☐ Houston Instrument DMP-41 pen-and-ink plotter
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In Europe contact: RIVA Terminals Limited, Woking, Surrey GU21 5JY ENGLAND, Telephone: 04862-71001, Telex: 859502 *failure can put a business in disarray. You can imagine the disruption if the computer has to be shipped to California for repairs. Therefore, you need local service, and this can help narrow your choices. You may find a dealer who can use the disk drive from the Eagle and save you quite a bit of money. There's no guarantee that the Eagle's disk can be connected to any particular machine, however, since these Winchester disks have different standards. The dealer can tell you for sure.*

The IBM PC AT may soon have multiuser capabilities, and the CompuPro line from Viasyn definitely does. These are not low-cost systems, but no multiuser system will be as cheap as your Eagle, due to the added hardware required.
—Steve

S-100 Upgrade

Dear Steve,

I bought a Heath H/Z-100 a few years ago because I thought the S-100 bus would allow me to pick from a wide variety of add-on boards. But recently, the announcement of the next generation of microprocessor boards for the IBM PC has made me jealous. The new Macrotech 80286 S-100 board is, I understand, a plug-in-and-go upgrade for CompuPro computers. Would this work in my computer?

I am primarily interested in maintaining compatibility (staying in the Intel family of microprocessors), but I have done some 68000 programming, and the instruction set of the Z8000 looks nice. I have no experience with hardware interfacing, so I would appreciate any help you could give me.

Peter J. Eddy
Athens, OH

The S-100 bus has many restrictions. The most severe one in the early days was its being an 8-bit bus. It has now been expanded under the IEEE-696 standard to 16 bits. The problem is that boards and systems that do not comply with the standard are not guaranteed to work with others that do. Since the original microprocessor board actually uses only the 8-bit transfers requested by its 8085 and 8088, you can't be sure that the system will work perfectly in the 16-bit mode unless you know it has been tried already. Ask the dealer to verify that a specific board will work in a Heath machine first. Don't overlook CompuPro products from Viasyn, sold by many dealers, as this company sells boards

(continued)

AZTEC C

The C for Microcomputers

PC-DOS, MS-DOS, CP/M-86, Macintosh, Amiga, Apple II, CP/M-80, Radio Shack, Commodore, XENIX, ROM, and Cross Development systems

MS-DOS, PC-DOS, CP/M-86, XENIX, 8086/80x86 ROM

Manx Aztec C86

"A compiler that has many strengths . . . quite valuable for serious work"

Computer Language review, February 1985

Great Code: Manx Aztec C86 generates fast executing compact code. The benchmark results below are from a study conducted by Manx. The Dhrystone benchmark (CACM 10/84 27:10 p1018) measures performance for a systems software instruction mix. The results are without register variables. With register variables, Manx, Microsoft, and Mark Williams run proportionately faster, Lattice and Computer Innovations show no improvement.

	Execution Time	Code Size	Compile/ Link Time
Dhrystone Benchmark			
Manx Aztec C86 3.3	34 secs	5,760	93 secs
Microsoft C 3.0	34 secs	7,146	119 secs
Optimized C86 2.20J	53 secs	11,009	172 secs
Mark Williams 2.0	56 secs	12,980	113 secs
Lattice 2.14	89 secs	20,404	117 secs

Great Features: Manx Aztec C86 is bundled with a powerful array of well documented productivity tools, library routines and features.

Optimized C compiler	Symbolic Debugger
AS86 Macro Assembler	LN86 Overlay Linker
80186/80286 Support	Librarian
8087/80287 Sensing Lib	Profiler
Extensive UNIX Library	DOS, Screen, & Graphics Lib
Large Memory Model	Intel Object Option
Z (vi) Source Editor -c	CP/M-86 Library -c
ROM Support Package -c	INTEL HEX Utility -c
Library Source Code -c	Mixed memory models -c
MAKE, DIFF, and GREP -c	Source Debugger -c
One year of updates -c	CP/M-86 Library -c

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

Aztec C86-c Commercial System	**$499**
Aztec C86-d Developer's System	**$299**
Aztec C86-p Personal System	**$199**
Aztec C86-a Apprentice System	**$49**

All systems are upgradable by paying the difference in price plus $10.

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

C-tree $395	**Greenleaf $185**
PHACT $250	**PC-lint $98**
HALO $250	**Amber Windows $59**
PRE-C $395	**Windows for C $195**
WindScreen $149	**FirsTime $295**
SunScreen $99	**C Util Lib $185**
PANEL $295	**Plink-86 $395**

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

Manx Aztec C68k

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

Computer Language review, April 1985

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

Optimized C	Creates Clickable Applications
Macro Assembler	Mouse Enhanced SHELL
Overlay Linker	Easy Access to Mac Toolbox
Resource Compiler	UNIX Library Functions
Debuggers	Terminal Emulator (Source)
Librarian	Clear Detailed Documentation
Source Editor	C-Stuff Library
MacRam Disk -c	UniTools (vi,make,diff,grep) -c
Library Source -c	One Year of Updates -c

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

Aztec C68k-c Commercial System	**$499**
Aztec C68d-d Developer's System	**$299**
Aztec C68k-p Personal System	**$199**
C-tree database (source)	**$399**
AMIGA, CP/M-68k, 68k UNIX	**call**

Apple II, Commodore, 65xx, 65C02 ROM

Manx Aztec C65

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

NIBBLE review, July 1984

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

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

Aztec C65-c ProDOS & DOS 3.3	**$399**
Aztec C65-d Apple DOS 3.3	**$199**
Aztec C65-p Apple Personal system	**$99**
Aztec C65-a for learning C	**$49**
Aztec C65-c/128 C64, C128, CP/M	**$399**

Distribution of Manx Aztec C

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

Manx Cross Development Systems

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

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

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

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

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

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

Manx Aztec CII

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

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

Aztec C II-c (CP/M & ROM)	**$349**
Aztec C II-d (CP/M)	**$199**
C-tree database (source)	**$399**
Aztec C80-c (TRS-80 3 & 4)	**$299**
Aztec C80-d (TRS-80 3 & 4)	**$199**

How To Become an Aztec C User

To become an Aztec C user call 1-800-221-0440 or call 1-800-832-9273 (800-TEC WARE). In NJ or outside the USA call 201-530-7997. Orders can also be telexed to 4995812.

Payment can be by check, COD, American Express, VISA, Master Card, or Net 30 to qualified customers.

Orders can also be mailed to Manx Software Systems, Box 55, Shrewsbury, NJ 07701.

How To Get More Information

To get more information on Manx Aztec C and related products, call 1-800-221-0440, or 201-530-7997, or write to Manx Software Systems.

30 Day Guarantee

Any Manx Aztec C development system can be returned within 30 days for a refund if it fails to meet your needs. The only restrictions are that the original purchase must be directly from Manx, shipped within the USA, and the package must be in resalable condition. Returned items must be received by Manx within 30 days. A small restocking fee may be required.

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featuring almost every 16-bit microprocessor chip made.

Using a 68000 or Z8000 will likely involve writing your own BIOS, since it is unlikely that the implementers of operating systems like CP/M-68 have written a BIOS for this exact combination of microprocessor, disk controller, and video-display controller. In fact, finding an operating system to run the Z8000 on the S-100 bus with your other hardware will prove to be impossible. None at this time will run without a hard disk.

One last area is performance. If your existing memories identify themselves as 8-bit only transfer, and your microprocessor board is capable of breaking its 16-bit transfers into two halves, you will suffer a large performance degradation that will spoil the tremendous power of the true 16-bit microprocessors. The only difference between the 8088 and the 8086 is the width of the transfer.

Remember that the more powerful the microprocessor, the bigger the programs you want to run on it! In other words, be prepared to add more memory to your system if you upgrade.—Steve ■

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

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

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

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

Ask BYTE
c/o Steve Ciarcia
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Glastonbury, CT 06033

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

The Ask BYTE staff includes manager Harv Weiner and researchers Larry Bregoli, Bill Curlew, Jeannette Dojan, Roger James, Frank Kuechmann, Dick Sawyer, and Robert Stek.

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COLOR MAGIC (16K byte version) .. $595.00

■**THUNDER 186** single board computer provides a high performance 16 bit computer all on one board. It is an ideal companion to the COLOR MAGIC to provide a low cost, high performance IBM-PC compatible system. The 8Mhz 80186 offers 10Mhz 8086 performance. THUNDER 186 provides all the components necessary to form a complete system including: 256K bytes of no wait-state RAM, 2 serial ports, a parallel printer port, high performance floppy disk controller controls both 5¼" and 8" drives simultaneously, full IEEE 696 (S100) bus for system expansion. The COLOR MAGIC and THUNDER 186 combine to provide performance you won't find in other compatibles. The price includes the powerful Concurrent DOS operating system.

THUNDER 186 .... $1195.00

■**NV-DISK** is a solid state memory with software to emulate a disk drive under MS-DOS, Concurrent DOS, and CP/M-86. NV-DISK is entirely COMPUPRO software compatible allowing COMPUPRO users to take advantage of the lower cost and battery protection support offered by NV-DISK. It offers the advantage of high speed access and no moving parts. It can be battery protected to allow data to stay even while powered down. The board is available in either 512K or 2 Megabyte configurations and multiple boards may be used to create disk drives with up to 16 Megabytes of storage.

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LOMAS DATA PRODUCTS has been shipping 16 bit microprocessor S100 bus products for five years. We have earned a strong reputation for reliability and performance over these five years. We were running MS-DOS (SCP-DOS/PC-DOS) before IBM knew the operating system existed. We offer a wide range of 16 bit operating systems including MS-DOS, CP/M-86, CONCURRENT CP/M-86 and CONCURRENT DOS. All our products are backed by a one year guarantee. We offer no 8 bit products and concentrate entirely on high performance 16 bit systems. *If you are looking for the highest performance possible on the S100 bus, you can be sure LOMAS DATA PRODUCTS offers it.*

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Concurrent CP/M-86, concurrent DOS, trademark of Digital Research

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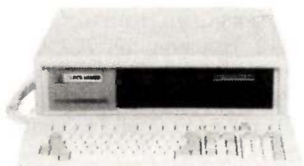

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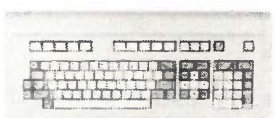

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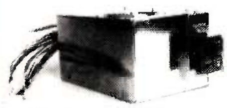

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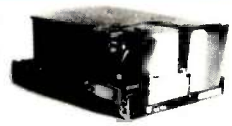

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CARNEGIE-MELLON MACINTOSH USERS' GROUP (CMU-MUG), POB 661, 5115 Margaret Morrison St., Pittsburgh, PA 15213. Monthly newsletter and meetings. Annual fee: $24, includes subscription.

APPLE III OWNERS & USERS GROUP INTERNATIONAL, H. Joseph Dobrowolski, PSC Box 1000, Langley AFB, VA 23665. Monthly newsletter, public-domain software library. Annual dues: $5.

OSBORNE USERS CLUB HOUSTON (OUCH), POB 500343, Houston, TX 77250-0343; Dan Barry, (713) 688-8149. Monthly meetings, public-domain library, RCP/M and BBS at (713) 488-5619. Affiliated with FOG. Send SASE.

NEC/APRICOT CLUBS, Debra Danny and Alex Danny, 15227 Russell Ave., White Rock, British Columbia V4B 5C3, Canada, (604) 536-0266. Separate groups for NEC APC and PC-8201A users and for Apricot users. Newsletters, meetings.

THE APPLE CRACKERS (TAC) APPLE CLUB, RFD 2, Box 106, Lake City, MN 55041. No meetings; communication by mail and upcoming BBS. Disk produced each month with public-domain programs. Dues: $4 a month; $44 annually.

PROBLEM SOLVERS UNANIMOUS (PSU) INTERNATIONAL, Joe and Ann Reid, POB 3244, Scottsdale, AZ 85257. Group for users of the Victor 9000 and Sirius I; newsletter, public-domain software.

KINGS BYTE COMPUTER CLUB INC., Morty Libowitz, (718) 763-4233. For users of all types of computers. Monthly meetings in Brooklyn, NY, demonstrations, 24-hour BBS at (718) 837-2881.

TWIN CITY EXPRESS, James Meehan Jr., Box M, Mendota, MN 55150. 24-hour Commodore BBS at (612) 778-0506 for information and message bases; a second line at 778-0594 for downloads.

STANFORD MACINTOSH USERS GROUP (SMUG), 205 Tresidder Union, POB 6805, Stanford, CA 94305. Meetings, demonstrations, newsletter, public-domain software.

IBM PCJR REPORT, PCjr Club, POB 95067, Schaumburg, IL 60195. Bimonthly; monthly in 1986. Annual subscription: $20.

MADISON AREA ATARI USERS GROUP (MAAUG), POB 56191, Madison, WI 53705. Monthly meetings, newsletter, group purchases, SIGs, public-domain software library.

NORTHERN ILLINOIS NEC USERS GROUP (NINECUG), 5501 South Kenwood Ave., Chicago, IL 60637. For NEC PC-8000, PC-8800, and APC users. Monthly meetings, newsletter.

ALAMO PC ORGANIZATION (APCO) INC., POB 16433, San Antonio, TX 78216. For users of the IBM PC and compatibles. Monthly meetings, 24-hour BBS at (512) 340-7634, newsletter. Annual dues: $20.

LIST (LONG ISLAND SINCLAIR/TIMEX) GROUP, POB 438, Centerport, NY 11721-0438. Monthly newsletter and meetings, library of member-generated software. Annual dues: $15.

SOUTHWEST PC USERS GROUP (SWPCUG), Bill Barker, Suite 308, 806 East Abram, Arlington, TX 76010, (817) 261-7120. Monthly meetings, newsletter, and disk, BBS. Annual dues: $30.

INTEGRATED SOFTWARE FEDERAL USER'S GROUP (ISFUG), Richard Campbell, Room 446-4, 300 13th St. SW, Washington, DC 20239. Primarily a Federal employee–oriented group; others welcome. Newsletter, weekly open meetings, SIGs, BBS at (301) 948-5718.

ARK-LA-TEX COMMODORE USERS EXCHANGE (CUE), POB 6473, Texarkana, AR-TX 75503. Monthly meetings and newsletter, SIGs, public-domain software library, BBS forthcoming. ■

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COMPUTER CULTURE:
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INTELLECTUAL, AND
SOCIAL IMPACT
OF THE COMPUTER
Heinz R. Pagels, editor
New York Academy
of Sciences
New York: 1984
288 pages, $66

NUMERICAL METHODS
FOR ENGINEERS
Steven C. Chapra and
Raymond P. Canale
McGraw-Hill
New York: 1985
570 pages, $34.95

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APPLE IIe
Jim Sather
Quality Software
Chatsworth, CA: 1985
372 pages, $24.95

DIGITAL COMPUTER
FUNDAMENTALS
(6th edition)
Thomas C. Bartee
McGraw-Hill
New York: 1985
624 pages, $39.95

COMPUTER CULTURE:
THE SCIENTIFIC, INTELLECTUAL, AND SOCIAL
IMPACT OF THE COMPUTER
Reviewed by Kenneth W. Kerber

The effects of widespread applications of computer technology may not be just a matter of more complicated products, new banking practices, alterations in work habits, or the many other ways that computers directly affect daily life. In his introduction to *Computer Culture: The Scientific, Intellectual, and Social Impact of the Computer*, editor Heinz R. Pagels argues that the computer revolution is causing important changes in our world view, but in such a subtle manner that even many intellectually aware people are ignorant of the changes. To highlight alterations in our outlook on the world that are a consequence of the computer revolution, Pagels organized a symposium on this topic under the sponsorship of The New York Academy of Sciences. *Computer Culture* is the product of that symposium.

The 29 contributors to the book include some of the best-known names in the computer field. John McCarthy, founder of two of the most important academic centers of research on artificial intelligence (AI), contributes a paper on the need for commonsense abilities in some expert systems. Pamela McCorduck, novelist and author of *Machines Who Think*, analyzes the economic, intellectual, and social promise of the fifth generation of computers. Seymour Papert, developer of the Logo computer language, participates in a panel discussion concerned with the impact of AI research on our understanding of human thinking. And Daniel Dennett, a philosopher who has argued that computers can extend the range of our senses and our imagination, discusses the computer as a metaphor in understanding the human mind. The list goes on, but the point is that Pagels succeeded in bringing together some of the most important leaders of the computer revolution.

Computer Culture includes 18 relatively short papers and two lengthy panel discussions. Many of the papers are followed by transcripts of brief question-and-answer sessions with the authors. References are included with most of the papers.

(continued)

ILLUSTRATED BY PAUL MOCK

Many of the contributions to *Computer Culture* are technical discussions of theoretical and research issues in computer science. For example, Herbert Schorr describes the field of experimental computer science. He argues that, in the past, computer science was more like engineering art than science. Computer design typically consisted of a succession of ad hoc improvements without the guidance of basic principles. In contrast, Schorr advocates testing hypotheses under controlled conditions; for example, scientists might empirically analyze different computer architectures to detect which is most efficient. This type of research, he argues, would lead to the discovery of basic principles that allow a systematic approach to computer design.

In another paper, Edward Feigenbaum raises questions about AI research and knowledge engineering. How can the computer facilitate the acquisition of knowledge so that human expertise can be transferred to the symbolic data structures of the computer? How is knowledge represented as data structures in the memory of the computer? How can this knowledge be used to solve problems? Feigenbaum offers detailed examples of several expert systems to clarify these issues. Other technical papers deal with methods of computer image synthesis, the ultimate physical limits of computation, and the use of computers in biological research. In general, these papers describe the technical foundation of progress in computer science and reveal the scientific impact of the computer.

SOCIAL IMPACT

Other contributors deal with the social effects of innovations in computer science. Michael Dertouzos briefly describes special-purpose computers hidden in appliances, expert systems in education and recreation, and advanced robots capable of sensing their environment, as well as other developments. Dertouzos then provides a balanced discussion of many purported negative effects of such applications. For instance, he contrasts the idea that computers encourage dehumanization by promoting a narrow, technologically based way of thinking with the notion that computerization offsets some of the dehumanizing trends brought on by the industrial revolution. Thus, computers can be used to tailor goods and services to the needs of individual consumers and may increase human communication through computer networks.

In another paper, Alphonse Chapanis argues that automated systems will be accepted more readily in the workplace if the pace of the job is determined by the individual rather than by the computer, if concentration is required in short bursts rather than continuously, if workers can take rest pauses at will, and if the job as a whole is meaningful.

Other papers describe what computers can and cannot do, how computers can be used to reorganize work, and how computers can be better tailored to the needs of technologically unsophisticated users. In general, these articles avoid technical descriptions in the interest of explicit

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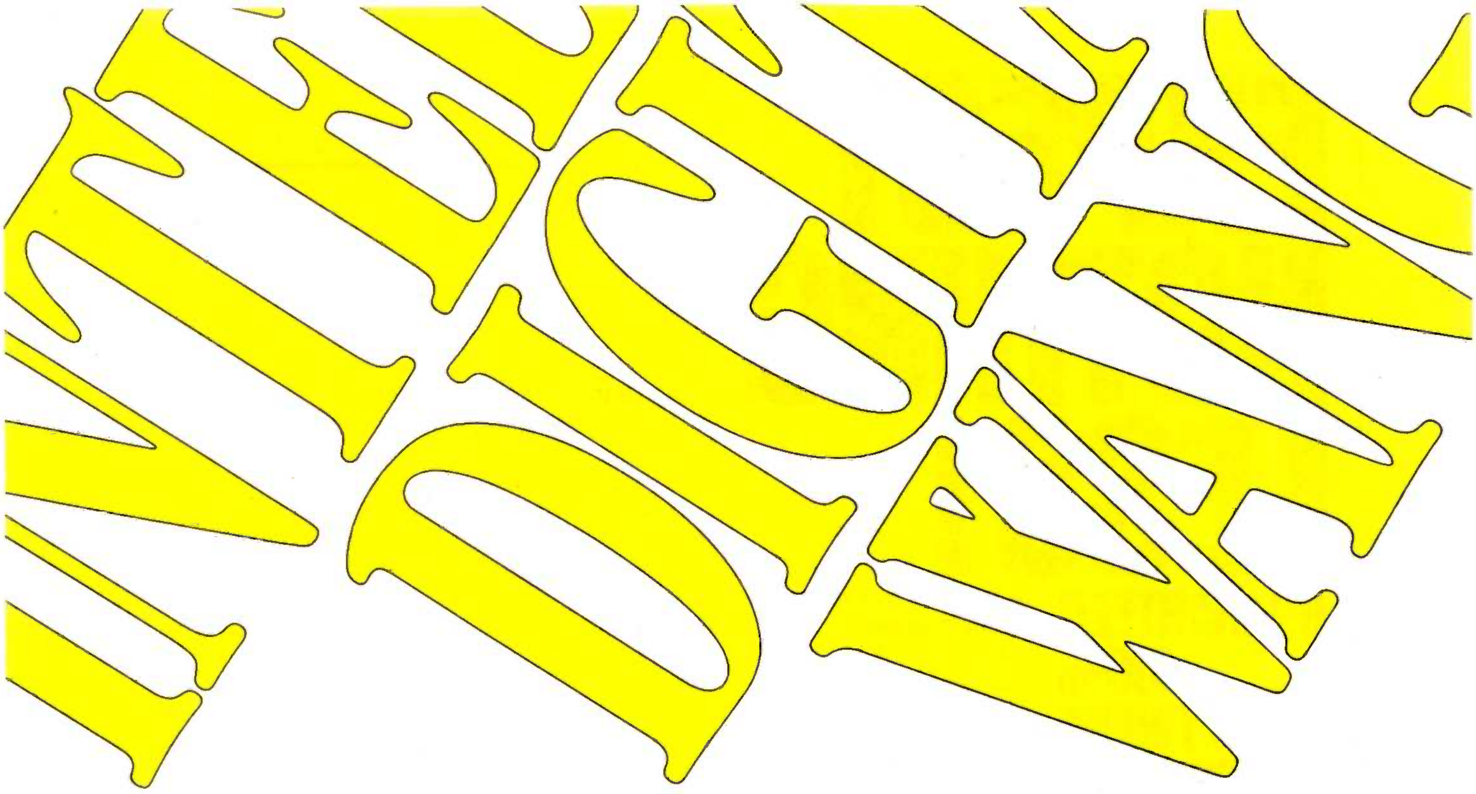

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discussions of behavioral and psychological effects of computer applications.

ARTIFICIAL INTELLIGENCE

Approximately one-fourth of *Computer Culture* (four papers and one panel discussion) deals specifically with artificial intelligence. The panel discussion on the impact of AI research is the most thought-provoking contribution in the book. As you might expect, this discussion is not so concise as an article dealing with the same topic, but the interaction among the panel members is intriguing. The panel consists of two philosophers (Hubert Dreyfus and John Searle) and three computer scientists (John McCarthy, Marvin Minsky, and Seymour Papert). Much of the discussion is spent identifying important questions about AI. Each panelist has a distinct viewpoint, resulting in a diversity of questions. Among these, however, two issues are of overriding concern: Can machines think? If they can, is machine thinking the same as human thinking?

The panelists seem to agree that computers can be used to study thinking, if for no other reason than to provide a contrast with human thought processes. On the other hand, the suggestion that appropriately programmed computers could duplicate human thought processes is much more controversial.

Aside from the philosophical issues, Papert makes a very important point when he argues that it is dangerous to reassure people that machines will never be able to challenge the intellectual capabilities of human beings. If people are lulled into a sense of security about machine capabilities, they will be ill prepared to deal with situations in which machines become better than people at doing specific jobs, he says. Whether or not the machines are described as thinking in these situations, the social and psychological issues raised by machine capabilities demand attention.

INTELLECTUAL IMPACT

According to Pagels, the main purpose of *Computer Culture* is to highlight important changes in our world view caused by the computer revolution. So what are these changes? In general, most of the contributions to *Computer Culture* provide only the raw materials for readers to draw their own conclusions. A notable exception is the last paper, by Daniel Dennett. Dennett draws an analogy between the public reaction that greeted Darwin's theory of evolution and current reactions to computers. While the public reacted strongly to Darwin's theory, Dennett argues, its importance was widely misperceived. People recognized that the theory was a threat to their peace of mind, but in trying to deal with the anxiety, they stressed trivial implications of the theory. Dwelling on issues such as the possibility of hairy apes in the family tree, many people failed to see that Darwin's theory changed our world view. Although Dennett is not explicit on this point, Darwin's theory challenged the idea of dualism and was perceived

(continued)

BOOK REVIEWS

as robbing human beings of their souls. In a similar manner, Dennett argues, many people are ill at ease regarding the notion of AI but disguise their anxiety by making jokes about marrying a robot or having their memory tapes erased. The anxiety is a reaction to another change in our world view.

Are such changes in our self-image detrimental? Dennett believes that progress in AI research will increase rather than diminish our appreciation of the wonder and complexity of the human mind. Of course, the reader may not agree with this idea, and the nicest feature of *Computer Culture* is that it provides a wealth of material for generating alternative viewpoints.

Computer Culture is a wide-ranging collection of thoughtful papers by participants in the computer revolution. The papers are not cohesive, but this may be too much to expect from a volume with 29 contributors. Topics in the book shift constantly, challenging the reader to formulate a personal viewpoint regarding the impact of computers. This challenge, if accepted, can make *Computer Culture* a valuable reading experience.

Given that values are important to an understanding of the impact of computers, perhaps the most serious criticism of *Computer Culture* is that the majority of the contributors appear to be technological optimists. The authors are too inclined to see computer applications as inherently good without recognizing potentially negative consequences of the new technology. This is certainly not true of all the contributors. However, the balance is tipped clearly in favor of positive conclusions regarding the impact of computers. This discussion needs to be brought to a wider audience. As Pagels points out in his introduction, "A technological revolution is too important to be left to the technologists."

Kenneth W. Kerber is a psychologist who conducts research on organizational behavior. He works at Data General Corporation in Westboro, Massachusetts. He can be reached at 240 Central St., Auburn, MA 01501.

NUMERICAL METHODS FOR ENGINEERS
Reviewed by Michael O'Neill

Don't let the title mislead you; engineers use the same numerical methods as mathematicians, physicists, statisticians, or anyone else who performs involved computations. *Numerical Methods for Engineers* is aimed at engineering students, but the methods it discusses are of general utility.

Authors Steven C. Chapra and Raymond P. Canale are of the opinion that you can use personal computers to implement standard numerical methods and greatly increase the flexibility and usefulness of these methods. They have oriented their book toward the sort of exploratory and interactive approach to problem solving that

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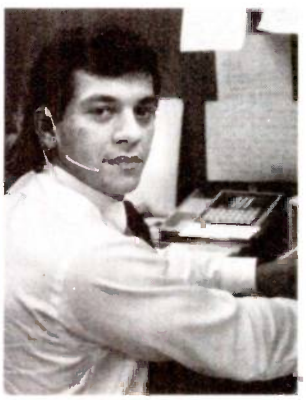

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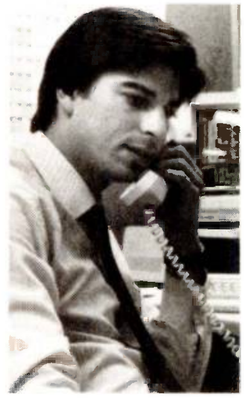

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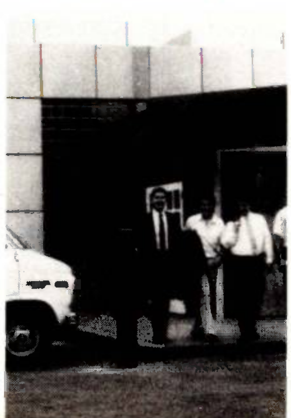

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Numerical Methods is well structured into six major sections: introduction and error analysis, finding the roots of equations, solution of linear equation systems, curve fitting (least-squares and interpolative), numerical integration, and solution of ordinary differential equations. Each section includes mathematical background, a summary of important formulas, and a list of references to more advanced methods. The main text is profusely illlustrated with examples, and each section devotes a chapter to engineering case studies. Many of these case studies are elementary, so anyone interested in numerical analysis should be able to follow them.

Chapra and Canale provide a particularly good treatment of error analysis, both in the abstract and as applied to specific methods. The authors describe occasions when errors cannot be ignored, and they suggest remedies.

"The purpose of computing is insight, not numbers." So reads the epigraph of a classic work on numerical analysis, *Numerical Methods for Scientists and Engineers* by R. W. Hamming (New York: McGraw-Hill, 1962). The insight to numbers ratio is critically dependent on the choice of method. This is the area of numerical programming where personal computers offer the greatest advantage over standard mainframe batch-processing computing styles. Chapra and Canale devote much of their text to demonstrating that convenient, interactive computers (particularly those machines that have graphics capabilities) can aid the process of exploring a problem and choosing a proper method for solving it.

CHOICE OF METHODS

It is in the area of appropriate choice of method that *Numerical Methods for Engineers* really stands out. The chapters on curve fitting include discussions of when least-squares fitting is preferable to interpolation (or vice versa) and what the statistical conditions are that justify the use of least-squares techniques. The authors point out, by means of several examples, how an inappropriate choice of method can lead to "gospel in, garbage out." They also emphasize that insight into numerical methods is necessary even if you are using canned routines, for it is you who must decide whether a method will produce meaningful results; the program cannot.

Although Chapra and Canale present the derivation and use of numerical methods well, their explanation of these methods in algorithmic form is somewhat weak. Most of the methods they discuss are accompanied by an algorithm description or a detailed flowchart. The descriptions are too sketchy to be of much use, and flowcharts are inferior to pseudocode for programming purposes. The authors give no-frills FORTRAN and BASIC versions of several of the simpler methods. I have run about half of the BASIC programs (with a few compatibility modifications); they work as advertised, but they seem to have been written rather sloppily. For instance, both the BASIC

(continued)

and FORTRAN versions of the trapezoidal rule integrator dimension an array that is never used. Chapra and Canale have made available a disk (for the IBM PC or Apple II) that they claim provides "user-friendly" versions of some of the programs in the book. I have not seen this disk to test it, but the examples they give in the book indicate that the claim of user-friendliness is justified.

I would recommend *Numerical Methods for Engineers* to anyone with a moderate background in mathematics and programming who wishes to learn the rudiments of numerical analysis.

Michael O'Neill (2227 Dwight Way #4, Berkeley, CA 94704) has been programming computers for 20 years.

UNDERSTANDING THE APPLE IIe

Reviewed by Rick Grehan

Jim Sather's earlier book, *Understanding the Apple II*, was a concentrated exploration of every nook and cranny in Apple II and II+ computers. All of my Apple-fanatic friends had a copy of that book on their shelves. I am certain that they will be ordering copies of Sather's latest, *Understanding the Apple IIe*.

In his foreword, Steve Wozniak remarks that the book "leaves no stone unturned in the search into the inner workings of the Apple IIe." He is absolutely correct. This book is a definitive work. It is a careful dissection of the Apple IIe into its major functional components by someone with hardware authority and software know-how. This book is full of useful schematics, figures, diagrams, tables, and coding examples.

Sather begins with an overview of the IIe, including block diagrams and specifications. The next chapter is a discussion of the IIe's bus structure. It also includes several useful tables, the most important of which is the "Master Address Decode Table" that contains the important system input/output and memory bank-switching soft-switch locations.

The author takes an exhaustive look at system timing and video-scanning circuitry. He examines the rise and fall of every system signal in excruciating detail; anyone interested in developing peripheral boards for the IIe should give this section particular attention.

The chapter on video generation builds on the brief overview information presented in the chapter on video-scanner timing. There is more how-to material here, however. We are shown the intricacies of mixing text and graphics, bank-switching graphics pages, and even which bit patterns create which colors. A colorful insert provides an elaborate timing diagram for various color combinations in low-resolution and high-resolution modes. This section is particularly useful to all Apple programmers interested in graphics and animation.

The chapter on the 6502, the Apple IIe's main processor,

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BOOK REVIEWS

is not so much a discussion of the processor itself as it is a description of how the processor works within the context of the IIe. Sather adds a section on the 65C02, a CMOS (complementary metal-oxide semiconductor) version of the 6502 with an extended instruction set that Apple uses in the IIc and has begun to use in the IIe. He points out important differences between the two processors and shares the results of extensive testing of various versions of the 65C02. He even uncovers some obscure code sequences that result in intermittent program crashes if you use NCR or GTE versions of the chip, which will be of interest to anyone considering upgrading an Apple II+ with a 65C02.

Chapter 5 alone is probably worth the price of the book. Here, Sather describes the IIe's memory-management system. Not only does he delve into the realm of display memory, but he describes those all-important soft switches, key to unlocking the IIe's full 128K bytes. You will probably want to read and reread the discussions on memory bank switching. Fortunately, Sather supplies us with an abundance of practical examples complete with source code and plenty of comments.

The chapter on the disk controller is not for the fainthearted, but it is certainly where the author earns his medals. He gives jewel-cutter's scrutiny to the entire disk input/output system. Simply put, everything you ever wanted to know about the Apple IIe's disk controller can be found here. If it is too much for you, just turn to the end of the chapter where Sather provides a more practical look at the disk system: a step-by-step project for installing a write-protect switch on an Apple Disk II disk drive.

Sather leaves us with a few brief pointers on Apple IIe maintenance. Although this section constitutes light reading compared to the rest of the book, the author at least performs a helpful examination of the IIe's read-only-memory diagnostic routines, and he guides us through trouble shooting some of the more common system failures. Nothing elaborate, but it just might save you a trip to the repair shop.

You should not get the idea that *Understanding the Apple IIe* is merely a hardware technical manual. Sprinkled throughout are "hardware/software applications," short but useful how-to notes that range from modifying the game port for controlling two joysticks to a machine-language program that "grabs" video data on its way to the display. The author supplies plenty of programming examples and demonstrations in BASIC as well as in machine language.

If you are at all serious about using your Apple IIe, you must get this book. If we had one book like this for every computer the world threw at us, life would be so much easier.

Rick Grehan is a BYTE *technical editor. He can be reached at* POB 372, *Hancock,* NH 03449.

(continued)

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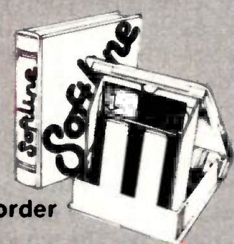

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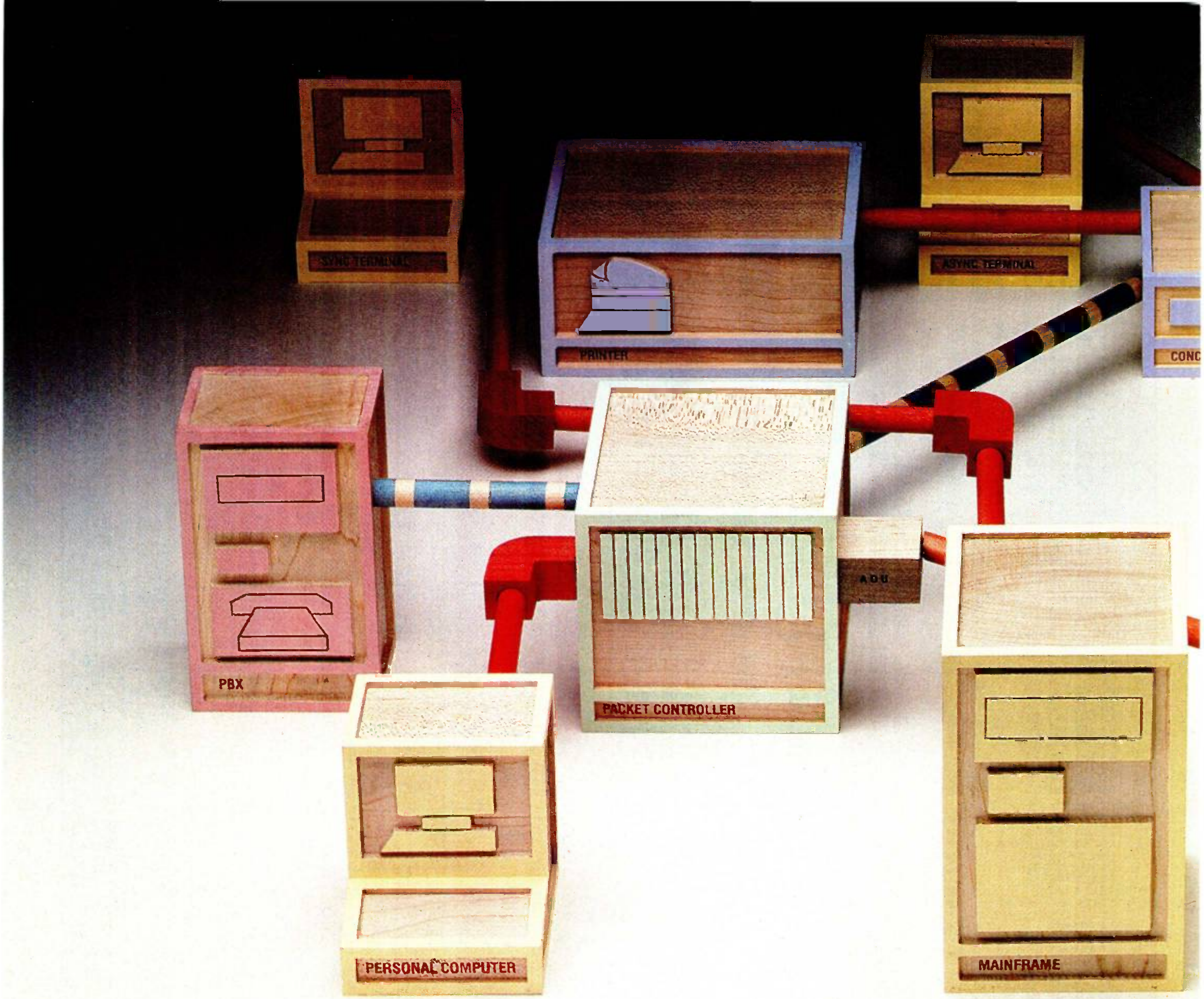

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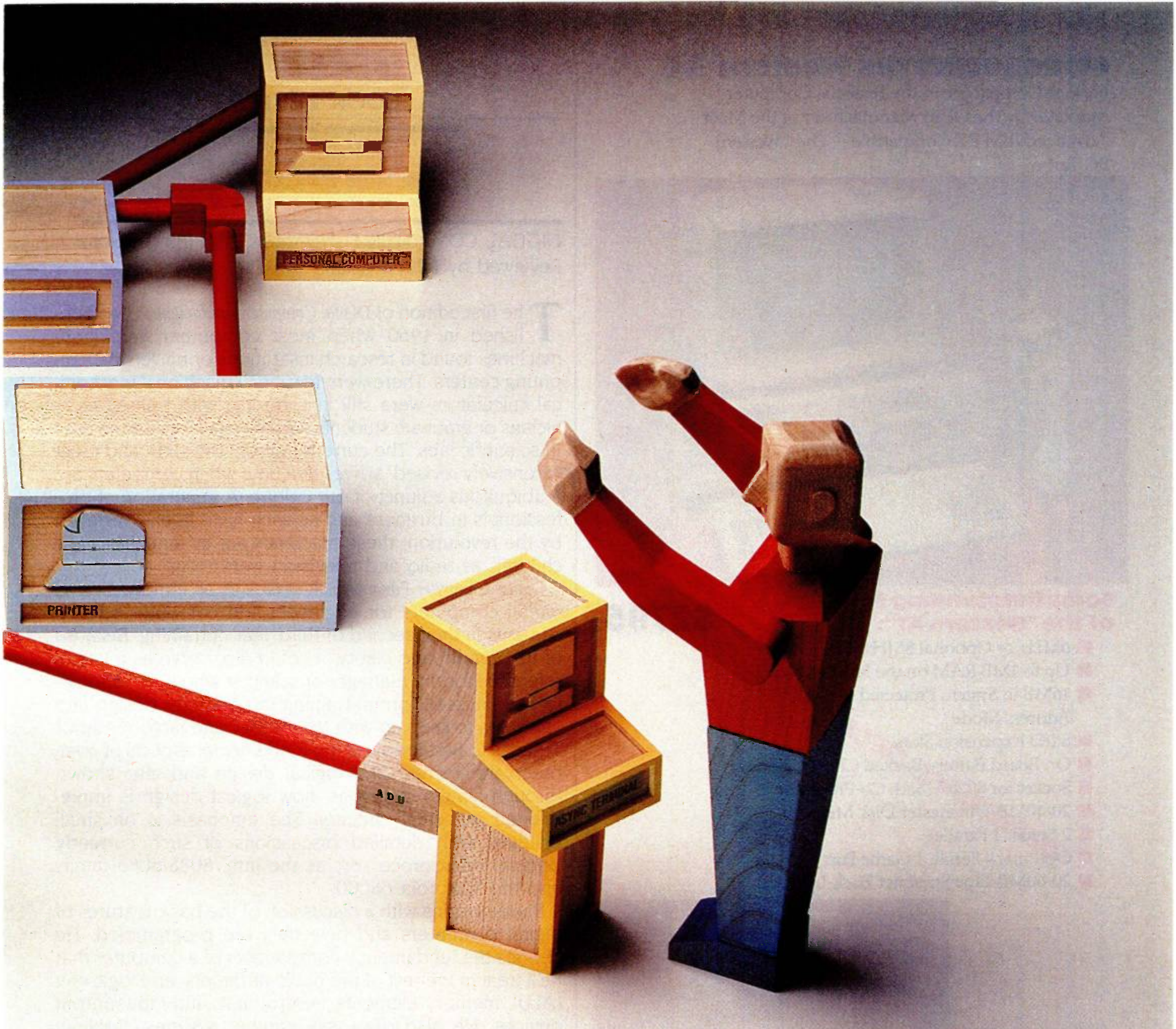

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DIGITAL COMPUTER FUNDAMENTALS (6th edition)

Reviewed by John V. Olson

The first edition of *Digital Computer Fundamentals* was published in 1960 when most computers were large machines found in research institutions or university computing centers. There were few small machines; mechanical calculators were still in wide use with trained technicians or graduate students literally cranking out the data in scientific labs. The current edition, the sixth and most extensively revised, arrives at a time when computers are a ubiquitous adjunct of our culture. A generation of professionals in business and science have been overtaken by the revolution; these machines are as familiar to our children as radio and television were to us.

Digital Computer Fundamentals serves as an introduction to digital computers for engineers and computer science students in their second or third year of training. Because of its breadth and clarity, it could also serve as a useful reference for the manager or scientist who is old enough to have missed formal training in computer design and yet wants to keep up with technology and jargon. Author Thomas C. Bartee covers the fundamental aspects of computer architecture and logical design and also shows, through simple examples, how logical design is implemented in actual circuitry. The emphasis is on small systems, with detailed discussions of such currently popular microprocessors as the Intel 8088/8086 family and the Motorola 68000.

Bartee begins with a discussion of the basic features of digital computers and how they are programmed. He defines the fundamental components of a computer that he'll treat in the rest of the book: arithmetic and logic unit (ALU), memory elements, control unit, and input/output devices. He also discusses number systems, Boolean algebra and its realization in electronic gates, and logic design that includes shift registers and counters. Next the author explains the component parts of the ALU, memory, and input/output devices. At the end of the book he covers control circuitry, bus structures, and organization of a digital machine.

The diagrams and figures are correct and easy to read, perhaps a testament to the many editions this book has undergone. Bartee includes copies of several common spec sheets supplied by manufacturers of certain integrated circuits. While this provides a sense of familiarity with current design, their inclusion seems extraneous to the material in the chapter. One example is the FPLA program table in chapter 3. Only a few of these external documents are included, and they are often part of sections flagged by the author as material that is not necessary on a first reading.

The author's approach to design is especially good. For example, in a chapter on the ALU, he begins with the construction of simple adder circuits for binary numbers using several arithmetic structures; he proceeds in a natural se-

(continued)

BOOK REVIEWS

quence to build larger structures from the elementary ones. He then shows the logical design of a binary and BCD (binary-coded decimal) adder. After introducing the concept of a shift operation and its implementation in a shift register, Bartee develops the generalized arithmetic unit and discusses multiplication and division. Similarly, he describes the necessary logical operations succinctly in terms of a few basic gates and flip-flops. Bartee also discusses the refinements necessary to achieve high-speed arithmetic.

RESERVATIONS

Of course, no book is without faults. I wonder who the author had in mind as his audience. *Digital Computer Fundamentals* contains a great deal of introductory material, and much of it is dated. For example, the mechanical details of a paper-tape reader have only historical interest these days. The careful descriptions and photographs of data terminals or telephone modems seem out of place in a text that discusses the intricacies of the timing of bus signals for the Motorola 68000 microprocessor. Readers who do not know a terminal when they see one are probably not ready for the details of ALU or bus design; those interested in such designs are surely familiar with data terminals and tape drives.

Another awkward aspect of this book comes with the author's attempt to introduce the elements of programming in chapter 1. I doubt that the nonprogramming reader could make much sense of this material. However, if the reader is familiar with some assembly language, the concepts in the book flow very naturally. I found the four-page introduction to Pascal to be completely irrelevant, even in the first chapter. Further, Pascal is never mentioned again in the book.

The details about keyboards, terminals, and tape drives, as well as the hesitant introduction to programming, weigh like excess baggage on the reader. Perhaps the author tried to capture a broader audience by including material commonly found in more introductory texts. These pieces do not mesh with Bartee's fine treatment of design philosophies and hardware implementations in digital systems. The introductory and historical material is useful to the reader interested in design, but for the reader new to digital machines, the design segment must appear incomprehensible.

These are but small points. The strength of this book lies in the clear presentation of the design details that must be considered in digital machines. Certainly *Digital Computer Fundamentals* will not make anyone a digital engineer, but reading it will enhance any technically competent person's understanding of digital machines. ■

Dr. John V. Olson is a consultant in digital signal processing. He currently conducts a research program at the University of Alaska studying low-frequency geomagnetic pulsations. He can be reached at Black Spruce Systems, 1543 Scenic Loop, Fairbanks, AK 99701.

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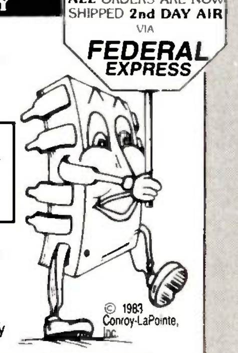

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Upgrade Quadcolor I to II kit	$ 275	$ 199
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Home Accountant Plus (PC)	$ 150	$ 90
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DOW JONES, Home Budget	$ 139	$ 92
ELECTRONIC ARTS, Get Organized	$ 95	$ 75
MONOGRAM, Dollars & Sense w/forecast	$ 180	$ 100
SCARBOROUGH, MasterType (PC or Jr)	$ 40	$ 25
Your Personal Net Worth	$ 100	$ 63
SIMON & SCHUSTER, Typing Tutor III	$ 50	$ 33

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MICROPROSE, Strike Eagle	$ 35	$ 23
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ORIGIN, Ultima III (PC or Jr)	$ 60	$ 39
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1985 ELECTRONIC ACCESSORIES SHOW, Atlantic City, NJ. Robert E. Griffin Inc., 133 West 19th St., New York, NY 10011, (212) 255-8491. *October* 10–11

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THE THIRD DETROIT COMPUTER SHOWCASE EXPO, Cobo Hall, Detroit, MI. The Interface Group Inc., 300 First Ave., Needham, MA 02194, (617) 449-6600. *October* 10–13

DCTM/DTS FALL CONFERENCE, William Penn High School, New Castle, DE. Harry Kutch, Delaware Council of Teachers of Mathematics/Delaware Teachers of Science, 24 George Read Rd., New Castle, DE 19720. *October* 11

THE FIFTH ANNUAL EDUCATIONAL COMPUTER FAIR, Cleveland, OH. Educational Computer Consortium of Ohio, Teacher Center 271, 1123 S.O.M. Center Rd., Cleveland, OH 44124, (216) 461-0800. *October* 11–12

THE 1985 ASSOCIATION FOR COMPUTING MACHINERY ANNUAL CONFERENCE, Denver Hilton Hotel, Denver, CO. ACM, 11 West 42nd St., New York, NY 10036, (212) 869-7440. *October* 14–16

THE COLUMBUS BUSINESS, COMPUTER, AND OFFICE PRODUCTS SHOW, Ohio Center, Columbus, OH. Class Productions Inc., 4207 North Clinton St., Ft. Wayne, IN 46805, (614) 224-7480. *October* 15–16

THE FOURTH ANNUAL COMDEX/EUROPE '85, RAI Congress and Exhibition Centre, Amsterdam, The Netherlands. The Interface Group Inc., 300 First Ave., Needham, MA 02194, (617) 449-6600. In Europe, Rivierstaete, Amsteldjik 166, POB 7000, 1007 MA, Amsterdam, The Netherlands; tel: 31-20-460201; Telex: 12358NL. *October* 15–17

COMPUTER GRAPHICS '85: THE INDUSTRY SHOW, Wembley Conference Centre, London, England. Online Conferences Ltd., Pinner Green House, Ash Hill Dr., Pinner HA5 2AE, Middlesex, England; tel: 01-868 4466; Telex: 923498 ONLINE G. *October* 16–18

COMPUTERS AND THE DISABLED CONFERENCE, California State University, Northridge. Dr. Harry J. Murphy, Office of Disabled Student Services, 18111 Nordhoff St., Northridge, CA 91330, (818) 885-2578. *October* 17–19

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THE SEVENTH NYC PERSONAL COMPUTER SHOW, Madison Square Garden, New York, NY. Ken Gordon Productions Inc., POB 13, Franklin Park, NJ 08823, (201) 297-2526. *October* 19–20

ANNUAL CONFERENCE AND EXHIBITION OF THE INTERNATIONAL INFORMATION MANAGEMENT CONGRESS: INFOMATICS '85, RAI Congress and Exhibition Centre, Amsterdam, The Netherlands. International Information Management Congress, POB 34404, Bethesda, MD 20817, (301) 983-0604. *October* 21–24

COMPUTER GRAPHICS '85 ATLANTA, Atlanta, GA. World Computer Graphics Association, 2033 M St. NW, Washington, DC 20036, (202) 775-9556. *October* 21–24

NORTHCON/85 AND MINI/MICRO NORTHWEST-85, Memorial Coliseum, Portland, OR. Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045, (213) 772-2965. *October* 22–24

THE FIFTH MULTINATIONAL CONFERENCE ON WORLD COMMUNICATIONS AND COMPUTERS, Hyatt Regency Hotel, San Francisco, CA. International Council for Planning, POB 17392, Washington, DC 20041, (703) 437-0027. *October* 22–26

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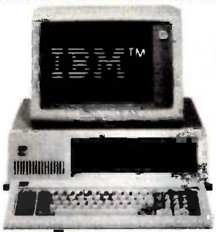

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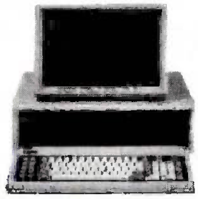

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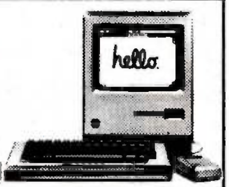

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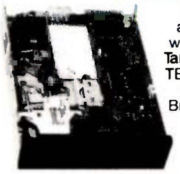

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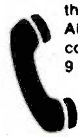

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Features

IN THIS MONTH'S concluding segment of "Build the SB180 Single-Board Computer," Steve Ciarcia discusses the SB180's software, giving special emphasis to the operating system. When Steve was planning this project, he looked for an operating system that had to meet some specific requirements. He eventually found what he was looking for in the Z-System.

Last month in our Theme section, Clifford Kelley described his homemade CPU, EGO, and its repertoire in detail. This month, the author presents the second part of that article, which explains how EGO's hardware decodes and executes instructions.

Jonathan Amsterdam also always wanted to design and construct a computer to his own specifications. But instead of dealing with gates, adders, barrel shifters, and the mess of solder, he built a virtual machine in software. He calls it VM2 and in this month's Programming Project he explains his specifications for VM2 and its implementations. Next month he will go into further detail on building an assembler for VM2 that will let you write programs as lists of mnemonics.

Skycam is an aerial robotic camera that's used for television and motion pictures. It is often seen on television, filming high over crowds, bringing a new perspective to audiences. Larry Cone explains why he and his partner, David Hastings, chose to use FORTH to write the software for Skycam. He also describes the various tests the development team performed on Skycam and explains the operation of the camera, as well as projected upgrades.

Natural phenomena are not usually uniformly distributed but are more likely to follow a normal distribution. Therefore, in simulation work it is useful to have a simple means to generate pseudorandom numbers with a normal distribution. In "Simulating the Normal Distribution," Arthur Hansen shows you how to do this with his BASIC routine.

After buying a joystick for his IBM PC, James McAdams decided he wanted to be able to use the joystick with programs he develops in Turbo Pascal. He wrote a routine that will give you access to two joysticks and four push buttons via the IBM Game Control Adapter.

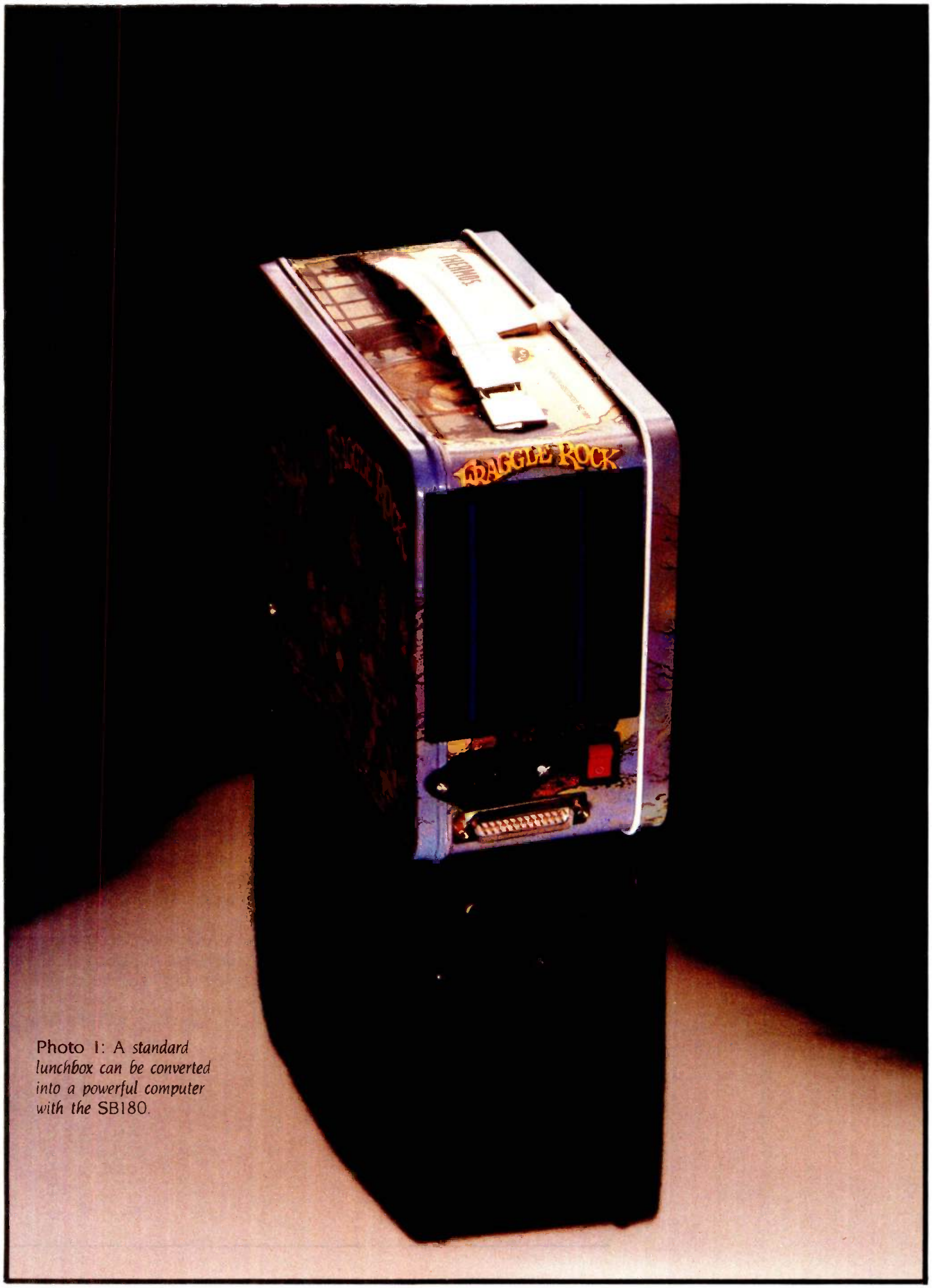

Photo 1: *A standard lunchbox can be converted into a powerful computer with the* SB180.

 PHOTOGRAPHED BY PAUL AVIS.

BUILD THE SB180 SINGLE-BOARD COMPUTER

PART 2: THE SOFTWARE

BY STEVE CIARCIA

This computer reasserts 8-bit computing in a 16-bit world

The SB180 computer system represents the state of the art in 8-bit systems (for detailed specifications of the SB180, see last month's Circuit Cellar column). It also elevates the power-per-square-inch ratio to a new high (see photos 1 through 6). However, much of the hardware's potential would be wasted if the software were not as advanced. This month, I'll continue my discussion of the SB180 with emphasis on the DOS (disk operating system).

I began with some general ideas about what the software should do. I wanted a DOS, but it had to accommodate the new 3½-inch disk drives as well as older 5¼- and 8-inch units. A primary requirement was that it needed to be compatible with the most widespread "8-bit" DOS, CP/M 2.2. However, it needed to be free of the many restrictions and quirks of CP/M 2.2 and should represent a step forward in the logical development of operating systems.

The operating system and its utilities should not be separately developed and then stitched together, like a crazy quilt, but they instead should be developed concurrently so that they use a consistent command structure. Finally, since it is a Circuit Cellar project, the system must facilitate a high degree of user customization. It must be flexible enough to operate at 100 percent of the system's potential in one application, yet it must allow a terminal to be connected and a user to interact with it even if no disk drives are connected in another application.

ADVANCED FEATURES OF THE HD64180

From a programming point of view, the HD64180 microprocessor resembles its predecessor, the Z80, but also executes 10 additional instructions. The mnemonic names of these instructions are SLP, MLT, IN0, OUT0, OTIM, OTIMR, OTDM, OTDMR, TSTIO, and TST.

The SLP instruction puts the microprocessor into a "sleep" mode that uses little power; it would not be used in a DOS situation but is available for use in a user's own programs.

The MLT instruction is an impressive feature of the HD64180. It multiplies two 8-bit quantities and results in a 16-bit product. Again, this instruction is not usually used in operating-system software.

(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.

The remaining instructions perform functions like block output with increment, decrement, and repeat; input or output of any register to an immediate I/O (input/output) port address; and nondestructive AND logic operations on the various registers, I/O ports, and immediate data.

This last group of eight instructions would be convenient for use in a DOS based on an HD64180 microprocessor. Most of these instructions could be used in accessing the on-chip peripheral hardware like the asynchronous RS-232C ports or the memory-management unit (MMU).

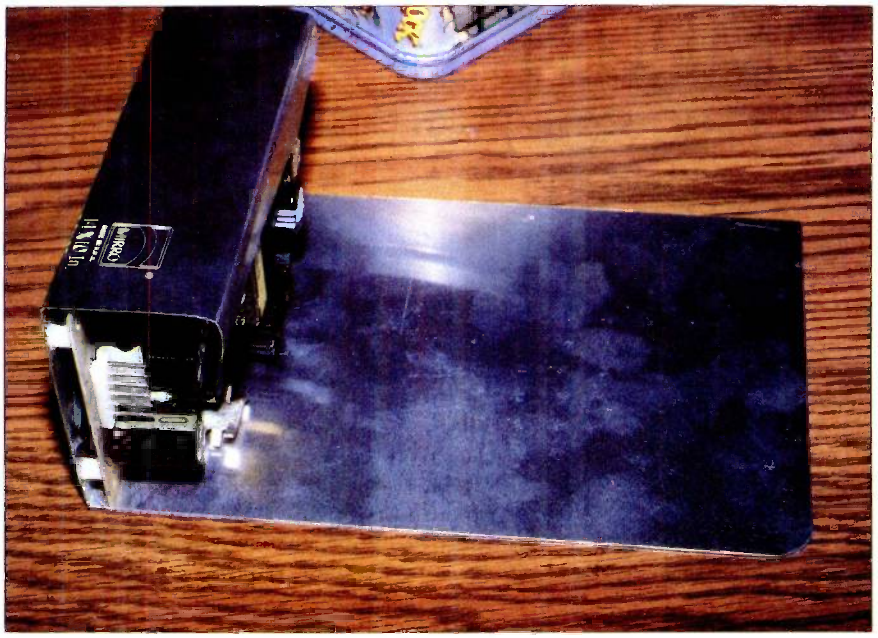

Photo 2: *A section of an aluminum cake pan is cut and bent to form a support for a small switching power supply.*

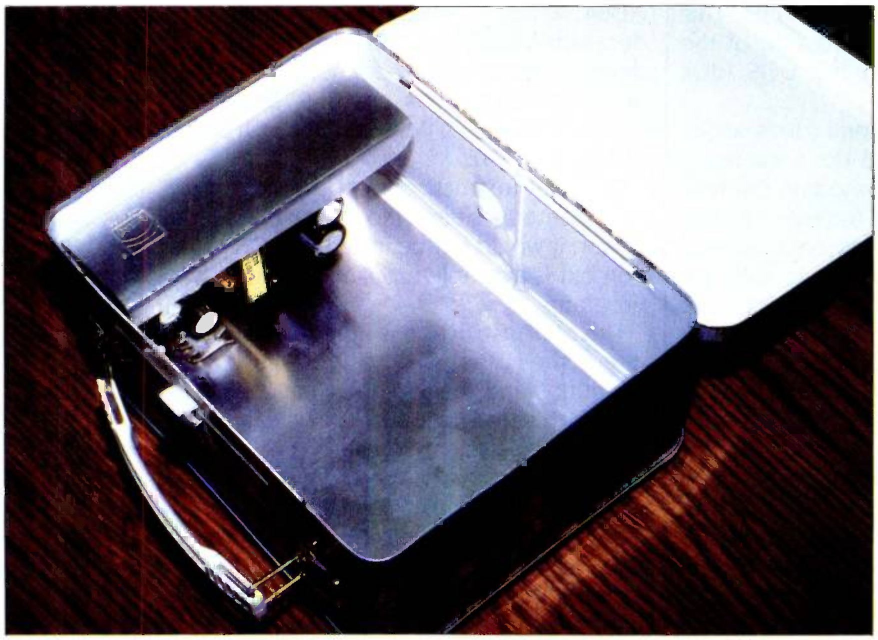

Photo 3: *The power supply is installed in the corner of the lunchbox.*

Mating Hardware and Software

I eventually found an operating system that met these challenging requirements in the Z-System from Echelon Inc. of Los Altos, California. The Z-System is compatible with programs that run under CP/M 2.2 and contains a multitude of improvements. The Z-System and its utilities were developed together in a common environment and share a common command structure. The system utilities can be used together in different ways to create new, powerful commands.

The system is adaptable, with several of the utilities being menu-driven. It even has menu processors that allow you to personalize the entire operating system to whatever level of sophistication you require. Best of all, extensive amounts of the source code to the system will be made available to those users who have the knowledge and desire to customize the system at the fundamental levels.

As I explained last month, better and faster microprocessors mean absolutely nothing if they are bound by inefficient operating systems. The SB180 with the Z-System is an unbeatable combination that seriously challenges the advertising-hyped credibility of 16-bit computers.

Introduction to the Software

The most visible component of the Z-System is the command processor, called ZCPR3. It is the most visible component because ZCPR3 acts as the user interface to the rest of the operating system: interpreting commands, loading programs that are to be executed, and more.

ZCPR3 is more than just a command processor; it is also more than 70 utility programs, all of which make use of the special features of the environment provided by ZCPR3. These utilities can be used together in many ways to create new system commands to accomplish more powerful tasks. It is similar to UNIX in the way that individual programs can be combined to make a single new program.

DOS Architecture

First, I'll define some terms. An *application program* is one that is not an intrinsic part of the operating system. Examples of this are WordStar or the ZCPR3 utilities. A *user area* is a way of partitioning the storage capacity of a disk and was originated in CP/M 2.2. Up to 32 user areas are on each disk drive; only user areas 0 through 15 are usually accessible. *Transient program area* (TPA) is the segment of memory, beginning at address 100 hexadecimal, where application programs are loaded by the command processor. A *file type* refers to the file's intended use and is indicated by the last 3 characters of a filename. In the Z-System, a filename has a total of 11 characters. (As an example, the filename FILENAME.TYP has the file type TYP.)

Figure 1 outlines the memory map of the SB180 software environment.

ZCPR3

To understand ZCPR3, you need an understanding of what a command processor is. A minimum definition is that it acts as the interpreter between you and the rest of the operating system. A command processor is the component of the operating system that prompts you for a command and then attempts to execute it.

ZCPR3 does everything mentioned above and much more. One of its most powerful features is its ability to act as an interpreter for application programs that want to generate operating-system-level commands, not just for the user. This means that programs like the ZCPR3 utilities can generate new commands that are then fed to the operating system and processed as though you had typed the command at the console.

Another aspect of ZCPR3 that needs to be understood is the concept of system segments. Six system segments are in a fully implemented ZCPR3 system. A system segment is a file that is loaded into a predetermined area of memory.

The ZCPR3 command processor and utilities can call upon a system segment to perform a function or provide information. Memory-resident segments can be overlaid with a new segment at any time, providing the ZCPR3 command processor and utilities with extended functions.

Environment Descriptor

The first, and most important, segment is the Environment Descriptor

(continued)

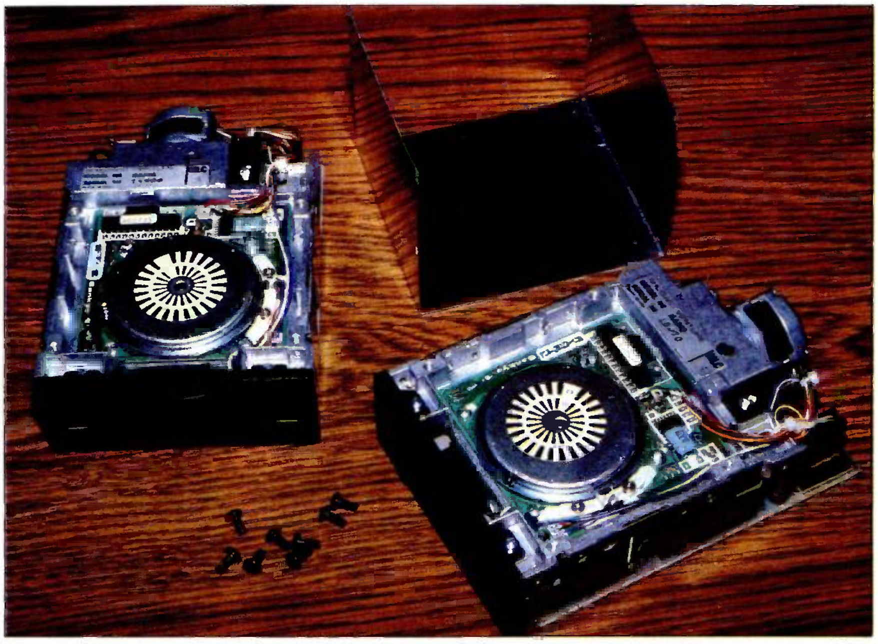

Photo 4: *Another section of cake pan is bent into a "U" shape and drilled to support two 3½-inch disk drives.*

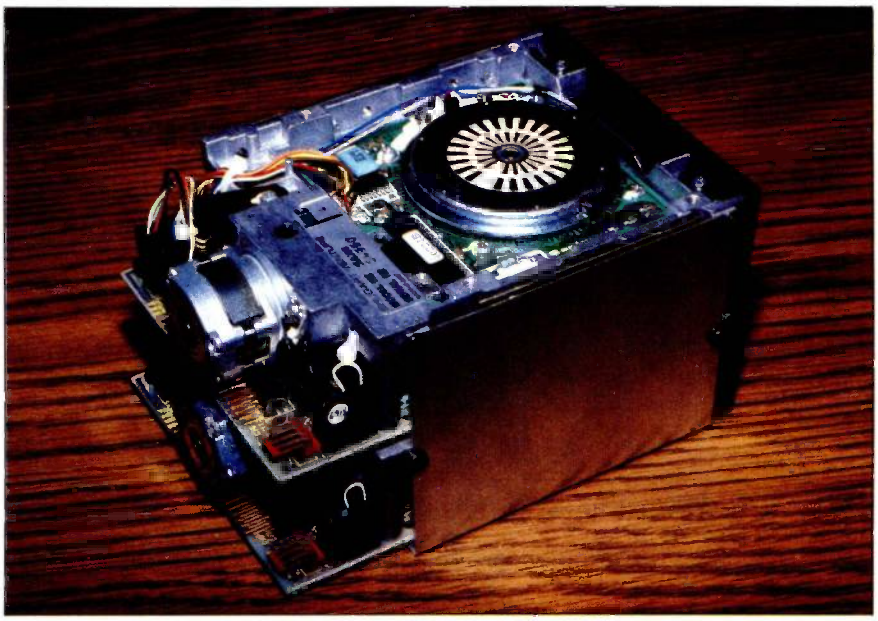

Photo 5: *The disk drives are installed in the cake-pan housing.*

(ENV), which occupies addresses 0FE00 through 0FEFF hexadecimal in the memory map (see figure 1). [*Editor's note: The addresses in this article are in hexadecimal.*] Because of the many possible choices in exactly how ZCPR3 can be implemented, ENV "describes" how that particular ZCPR3 implementation is configured. The ZCPR3 command processor and utilities use the information supplied by the ENV to determine the CPU (central processing unit) clock rate, number of disk drives installed in the system, where the other system segments can be found in memory, and more. When the Environment Descriptor segment is stored in a disk file, the file type is ENV.

Named Directory

The next segment is the Named Directory (NDR). In the memory map, NDR occupies addresses 0FC00 through 0FCFF. This segment also supplies information to the ZCPR3 command processor and utilities, as ENV does.

The NDR segment assigns symbolic names to disk drives and user areas of the system. This means that a name like BASIC may become associated with a particular user area on a disk drive. The ZCPR3 command processor and utilities will then refer to that disk drive and user area whenever a command is executed that contains the directory name BASIC. This gives you the ability to assign names to specific sections of your disk drives, which you can easily reassign by loading a new NDR segment. The file type of a file containing a Named Directory segment is NDR.

Photo 6: *The side of the lunchbox is cut out so that the drives protrude, and the drive assembly is bolted to the power-supply bracket. The SB180 is installed underneath, and cables are run for power and disk drives.*

Resident Command Package

The Resident Command Package (RCP) segment is a collection of subroutines that extend the intrinsic commands of the operating system. An intrinsic command is a routine that resides in memory and that can be executed without disturbing the TPA. As an example in the CP/M 2.2 environment, the DIR command is an intrinsic command, but the STAT command (which loads the STAT.COM program into the TPA and therefore disturbs the TPA) is not.

In the software supplied with the SB180, the intrinsic commands that reside in the ZCPR3 command processor are GO, SAVE, GET, and JUMP. The intrinsic commands added by the RCP are CP, ERA, TYPE, LIST, P (PEEK), POKE, PROT, and REN. As you see, the RCP adds many commands. Additional commands are available within an RCP, but the RCP segment must fit within a 2K-byte area of memory. The above commands make it just a few bytes short of this limit.

If you include another command, you would have to disable one of the existing commands in order for the RCP to fit into its assigned area. In the memory map, the RCP occupies addresses 0F200 through 0F9FF. The file type of a file containing a Resident Command Package segment is RCP.

Listing 1: *An example of the flow commands in a possible* STARTUP.COM *alias. Only if the operator responds with a "Y" in step 4 will the* MDSK /I *command in step 5 be executed (which will initialize the* RAM *disk). This is handy for rebooting the system after a program crash and preserving the contents of the* RAM *disk.*

Command	Comments
1: LDR SYS.RCP,SYS.FCP,SYS.NDR,SYS.Z3T;	Load system segments
2: WHEEL SYSTEM;	Set wheel byte
3: ECHO SHOULD THE RAM DISK BE INITIALIZED?;	Ask question
4: IF INPUT;	Get yes or no
5: MDSK /I;	If yes, initialize RAM disk
6: FI	Terminate IF (ENDIF)

Flow Control Package

The Flow Control Package (FCP) resides between addresses 0FA00 and 0FBFF. It is unique to ZCPR3; no comparable feature is found in any other microcomputer operating system. The FCP adds conditional testing to operating-system-level commands.

An example of conditional testing is the IF. . .THEN . . .ELSE statement in high-level languages like BASIC. The FCP gives the ZCPR3 command processor this testing capability. It is not usually used while you are entering commands at the console, but you can take full advantage of it in batch-processing operations. The file type of a file containing a Flow Control Package segment is FCP.

To understand how the flow commands are useful, you must first know about the ZCPR3 flow state, which is either true or false. While the flow state is true, the ZCPR3 command processor will execute all commands. If the flow state is false, the ZCPR3 command processor will ignore all commands except ELSE and FI.

The IF command is capable of setting the flow state to either true or false. The IF command can evaluate a number of tests: the existence of a file on disk, whether or not a file is empty, the state of the wheel byte (explained in detail later), and more.

A good example of how to use the IF command is shown in listing 1. ZCPR3 allows you to nest the IF/ELSE/FI (ENDIF) flow commands up to eight levels deep.

INPUT/OUTPUT PACKAGE

The Input/Output Package (IOP) segment acts as a traffic cop in routing input and output to and from peripheral devices. The print spooler supplied with the SB180 is an example of an IOP. Other IOPs let you set up programmable function keys or capture characters in a disk file that are normally sent to the console or list device.

The IOP occupies addresses 0EC00 through 0F1FF in the memory map, and the file type of a file containing an Input/Output Package segment is IOP.

TERMINAL CAPABILITIES

The Terminal Capabilities (TCAP) segment is actually contained within the

(continued)

```
 ----------------------------------------  3FFFF Hex
| RAM Disk (192K bytes)                  |
 ----------------------------------------  0FFFF Hex
| ZCPR3 External Stack                   |
 ----------------------------------------  0FFD0 Hex
| ZCPR3 Multiple Command                 |
| Line Buffer                            |
 ----------------------------------------  0FF00 Hex
| ZCPR3                   | TCAP         |
| Environment              --------------  0FE80 Hex
| Descriptor Segment                     |
 ----------------------------------------  0FE00 Hex
| ZCPR3 Wheel Byte                       |
 ----------------------------------------  0FDFF Hex
| ZCPR3 External Path                    |
 ----------------------------------------  0FDF4 Hex
| ZCPR3 External File                    |
| Control Block                          |
 ----------------------------------------  0FDD0 Hex
| ZCPR3 Message Buffers                  |
 ----------------------------------------  0FD80 Hex
| ZCPR3 Shell Stack                      |
 ----------------------------------------  0FD00 Hex
| ZCPR3 Named Directory                  |
| Segment                                |
 ----------------------------------------  0FC00 Hex
| ZCPR3 Flow Control                     |
| Package Segment                        |
 ----------------------------------------  0FA00 Hex
| ZCPR3 Resident Command                 |
| Package Segment                        |
 ----------------------------------------  0F200 Hex
| ZCPR3 Input/Output                     |
| Package Segment                        |
 ----------------------------------------  0EC00 Hex
| SB180 BIOS (Basic Input/               |
| Output System)                         |
 ----------------------------------------  0DA00 Hex
| ZRDOS Disk Operating                   |
| System                                 |
 ----------------------------------------  0CC00 Hex
| ZCPR3 Command Processor                |
 ----------------------------------------  0C400 Hex
| TPA (Transient Program                 |
| Area)                                  |
 ----------------------------------------  00100 Hex
| Page 0 Buffers and                     |
| Reserved Locations                     |
 ----------------------------------------  00000 Hex
```

Figure 1: *The memory map of the SB180's software system, as initially configured. You can modify the system to meet your own needs.*

Environment Descriptor segment, although it can be loaded independently. It resides at addresses 0FE80 through 0FEFF in the memory map. Information stored here describes characteristics of your terminal, specifically the strings that invoke the terminal's clear screen, cursor addressing, highlight on/off, and other functions.

Also stored in this segment are the codes generated by any arrow keys on the terminal. The ZCPR3 command processor and utilities use this information to enhance interaction with you, by offering flashy displays and using the arrow keys for various functions. The important thing to understand about the TCAP segment is that it is easily changed if you attach a different terminal. Because the ZCPR3 utilities refer to the segment for their information, they do not need to be changed as well. This feature can be described as terminal independence. The file type of a file containing a Terminal Capabilities segment is Z3T.

Other ZCPR3 Concepts

The path, originally incorporated in ZCPR2, is a ZCPR3 concept that provides a tremendous amount of flexibility. The path lets ZCPR3 search other directories (disk drives and user areas) if the program or file to be invoked is not in the active directory.

An example: The path is set up for ZCPR3 to search (in the following order) the current drive and user area, drive A/user area 0, and drive A/user area 15. When you issue a command that is not an intrinsic command, the ZCPR3 command processor begins searching for the file of that name in the current drive and user area. If the file is found, it is loaded and executed. However, if the file is not found, the path instructs the ZCPR3 command processor to continue the search at drive A/user area 0. Again, if the file is found, it is loaded and executed. If the file is not found, the ZCPR3 command processor searches drive A/user 15. Once again, if the file is found, it is loaded and executed. The SB180 software allows up to five levels of search.

The flexibility derives from the fact that the path is, like the system segments, changeable at any time. What this means to you is that your frequently invoked programs can be stored in a specific drive and user area, usually A15, and can be invoked from any currently active drive and user area without needing to specify the disk drive, as long as the path points to the appropriate directory.

The path is also used by many of the ZCPR3 utilities. For example, the Help utility will search along the path when looking for HLP files.

The Wheel

The last important component of ZCPR3 that I should describe is the wheel byte, which resides in the distribution software for the SB180 at address 0FDFF. If the RAM (random-access read/write memory) at that address contains a zero value, the wheel byte is considered reset (off); if the address contains a nonzero value, the wheel byte is considered set (on).

The wheel byte functions as a security system. All the intrinsic ZCPR3 commands can be set up so that they check the status of the wheel byte before they execute. This is ideal for situations where a security function is necessary, like a public computerized bulletin-board application. If "dangerous" commands like ERA (erase files) are set up to check the wheel byte, and a user who does not have wheel privileges attempts to use ERA, all that will happen is that the message "No Wheel" will be displayed.

Several ZCPR3 utilities will function only if the wheel byte is set on; otherwise, they abort immediately. Also, both intrinsic commands and a utility program let you manipulate the status of the wheel byte; both require a password to operate.

The ZCPR3 Utilities

All ZCPR3 utilities (there are more than 70) are included in the full SB180 software package (a subset is included with the boot disk only). See the "Z-System Utilities" text box on page 93. About 20 percent of the utilities correspond to intrinsic commands. Consequently, if you elect to omit, for example, ERA as an intrinsic command, you can use the ERASE.COM utility to perform the same function.

ZCPR3 utilities all share many common features, the most significant of which is that they reference the Environment Descriptor segment to determine information about the system configuration, e.g., to determine the location of the Terminal Capabilities segment or the Named Directory segment. However, since the Environment Descriptor segment is not necessarily located at the same addresses in every ZCPR3 configuration, the ZCPR3 utilities must be installed for that particular configuration. This is an easy task because, as you might surmise, a ZCPR3 utility will do it for you! (Note that the software supplied with the SB180 does not require this installation; it is preinstalled for the memory map of the SB180 default configuration.)

Finally, if you get lost, you can always find help. A help screen for any of the ZCPR3 utilities can be called by invoking it with a command-line parameter of //, so that LDR // as a command calls up a help screen for the LDR utility. Other command-line options are usually preceded by a single slash or a space character.

Shells and Aliases

To understand the concept of a shell, think of your computer system as an onion. It is made up of various layers of software and hardware, with the microprocessor at the very center. The outermost, and visible, layer would be an application program like WordStar. When WordStar is executing you are presented with its displays, and the computer will process your input in accordance with the commands of WordStar. When you exit WordStar, the outermost layer of the onion is removed and you see the next inner layer, which is the ZCPR3 command processor. If you looked deeper, you would see ZRDOS as the next layer, then the BIOS (basic input/output system).

While each layer has its own appearance and commands, it has to rely on deeper layers to execute these commands. A shell is an additional layer that fits between the application-program layer and the ZCPR3 command processor. A shell can present its own displays and process your input in accordance with its own commands, and it relies on the ZCPR3 command processor (the next deeper layer) to actually execute the commands. A common use of a ZCPR3 shell is that of a translator between you and the ZCPR3 command processor that converts single keystrokes you type to command sequences that are then executed by the ZCPR3 command processor.

Finally, a ZCPR3 shell can be nested. Multiple layers of shells can be simultaneously active, with only the outermost layer visible to you. This gives one shell the capability of invoking another shell. After the second shell is finished executing, control is returned to the shell that invoked it. A shell knows how and when to return to itself.

An alias is a .COM (executable binary program code) file created by the Alias program that contains one or more commands that are to be placed in the multiple command line buffer and then executed. Command strings can be built into an Alias program and then invoked by a single command. This is an impressive and powerful feature of ZCPR3.

As a simple example, you create numerous files with file types of BAK, HEX, and SYM, which are no longer required. Rather than repetitively entering the commands ERA *.BAK, ERA *.HEX, and ERA *.SYM, an alias named CLEANUP.COM is created. CLEANUP.COM contains the commands ERA *.BAK, ERA *.HEX, and ERA *.SYM. When CLEANUP.COM executes, it places its command string into the ZCPR3 command line buffer, and then the ZCPR3 command processor executes those commands, erasing the files specified.

Aliases can be considerably more powerful than this example because they are the technique used under

(continued)

Z-System Utilities

The following is a list of some of the more interesting Z-System utilities. Keep in mind that there are more than 70 utilities in all, so this is just a small sample to give you an idea of the capabilities available.

AC: This stands for archive/copy. This utility copies a file from one directory to another, with the option of copying only files that have been modified since last archived.

CLEANDIR: Clean directory removes all deallocated references to files on the disk and sorts the remaining active filenames in either ascending or descending order. Used often, and you're nearly guaranteed a successful UNERASE (see below).

CONFIG: This menu-based utility is used to configure BIOS parameters like I/O port speeds, set up the printer as serial or parallel, alter the number of CPU wait states, and more. (This utility was written specifically for the SB180.)

DPROG: This is a device-programming utility that is capable of sending predefined byte sequences to peripheral devices like printers and terminals.

FINDF: Find file searches for a file or files in all disks and user areas of the system and reports their location(s).

HELP: Invokes the help subsystem. Entering HELP ZCPR3 will invoke the ZCPR3 on-line documentation. Other help information can be created with a text editor and displayed using this utility. (This utility uses the TCAP system segment to enhance its displays.)

HELPCHK: This utility checks files to be used with the HELP program for proper structure and syntax.

MENU: This utility invokes the menu subsystem under ZCPR3. Menu files can be created with a text editor according to the instructions in the help file. This is a Z-System shell. (This utility also uses the TCAP system segment.)

PAGE: This utility sends the contents of a file or files to the console for viewing. The data is "paged," filling only one screen at a time and then waiting for the operator to strike a key. (Also uses TCAP.)

PWD: The print working directories utility shows currently available named directories.

SHOW: This is a menu-oriented display of the status of the ZCPR3 environment, which includes all system segments, the path, and more. (Also uses TCAP.)

TCMAKE: This menu-oriented utility allows creation of TCAP system-segment files in case your terminal is not already handled by the SB180 system. (An associated utility, TCCHECK, checks TCAP system-segment files for errors in structure or syntax.)

UNERASE: Does just what its name implies; it allows the recovery of accidentally deleted files if run immediately after the deletion. Usually successful if CLEANDIR is run frequently.

VFILER: This is an extremely useful utility to manipulate files in various ways, such as sending contents to printer, displaying on console, copying, unsqueezing, etc. Command entry occurs merely by pointing to the filename and selecting a command. VFILER can be personalized with up to 10 additional user-determined commands.

Z3INS: Use this utility to install all ZCPR3 utilities if any changes are made in the location or structure of the ZCPR3 system. The supplied utilities are already installed for the SB180 environment but will need to be reinstalled if the system is reconfigured in any way.

ZAS: A relocating macro assembler.

ZCPR3 to create new commands, using whatever other programs that may exist on disk in different ways to add easily invoked powerful functions. Aliases support nesting of other aliases within their command string and also support parameter substitution so that programs invoked by an alias can be fed parameters specified when the alias is invoked, in a fashion similar to Digital Research's SUBMIT.COM utility. This parameter substitution allows the command sequence contained in the alias to operate on different filenames or with different options.

ZRDOS AND BIOS

ZRDOS is the core of the SB180 operating system. It occupies space in the memory map from 0CC00 to 0D9FF. ZRDOS, like the CP/M 2.2 BDOS (basic disk operating system), creates the standard virtual machine that application programs are written for. This lets software vendors write one version of a software package, which will execute on more than one type of hardware configuration. The virtual-machine environment is provided via standardized system functions, such as sending a character to the console or checking the status of the list device. The CP/M 2.2 BDOS contains 39 functions; ZRDOS provides these same functions, thereby maintaining compatibility, and adds four more.

Two aspects of ZRDOS are visible to you in comparison with CP/M 2.2. The major significant difference of ZRDOS is that when a new disk is placed in a disk drive, it is not necessary to type Control-C to log in the new disk, as in CP/M 2.2. The other difference is improved error messages. Instead of the cryptic Bdos Err on A:, you see Read Error on A:, which is much more meaningful. ZRDOS also includes file archive handling compatible with CP/M Plus and MP/M, which can be used to make automatic backup copies of a file that has been changed. ZRDOS also recognizes what are known as wheel-protected files and does not allow modification to those files unless the wheel byte is set.

The BIOS for the SB180 handles several important functions not found in most computers and uses the on-chip hardware of the HD64180 to the fullest. It was written specifically for the SB180, with emphasis on rapid and efficient code. Disk operations are extremely quick in comparison with other machines.

The SB180 BIOS resides between addresses 0DA00 and 0EBFF in the memory map. Like the BIOS in any microcomputer, its function is to act as the interface between the software and hardware. Another way of saying this is that, because different hardware configurations may be used, a certain part of the operating-system software exists that is specially customized for that hardware configuration. Because of the customization of the BIOS, the same DOS can function on many different computer types, despite the fact that there may be significant differences between the machines.

The BIOS is responsible for interfacing all peripheral devices like floppy disks and video terminals that are used on a computer to the standard virtual-machine environment created by the operating-system software.

For example, an application program requests ZRDOS to send a character to the console. ZRDOS is the same no matter what machine it is operating on and has no way of knowing which I/O port address the console might be found at, or anything else about the console. Yet it does know that the request has to do with I/O, and ZRDOS passes this request to the BIOS to send the character to the console. Finally, the BIOS is the component that actually transmits the character to your terminal, because it has been configured to know that the "console" is actually a terminal connected to I/O port number two. This example shows how the peripheral devices attached to the machine (console attached to I/O port number two) are interfaced to the software of the machine (request to output a character to the console).

The SB180 BIOS incorporates this type of standard software/hardware interfacing and several special features. The most important feature is the integrated RAM disk. The upper 192K bytes of the memory can be set up by the BIOS to be used as an extremely fast file-storage device, which, to application programs and the operating system, looks like disk drive M. This integrated RAM disk is a powerful tool, one that gives the SB180 an incredible performance advantage. One of the two direct-memory-access controllers (DMACs) of the HD64180 is dedicated to the RAM disk, providing the best performance possible.

Table 1 lists programs that have been tested to run in the software environment of the SB180. The programs listed are not the only programs that will run; they represent all that was available to be tested.

It is important to understand that, although the Z-System is compatible with programs designed to run under CP/M 2.2, it is a case of upward compatibility. This means that these pro-

Table 1: *A list of programs tested and known to be compatible with the SB180's operating system.*

MicroPro:	WordStar 3.0, WordMaster, MailMerge, StarIndex, SuperSort
Microsoft:	Multiplan, Macro-80, BASIC-80, BASIC compiler
Digital Research:	MAC, SID, ZSID, CB-80, Pascal/MT+
Sorcim:	SuperCalc2
Ashton-Tate:	dBASE II
Borland International:	Turbo Pascal 2.0
Manx:	Aztec C 1.05g
CompuView:	Vedit
Others:	T/Maker III, The Word Plus, Punctuation and Style, MIX, Modem7, MDM7, MEX, BDS C, C/80

grams usually cannot use most of the advanced features of the Z-System but simply perform as they would in the environment they were intended for. Programs written for CP/M 2.2 can benefit from some aspects of the Z-System, but other aspects of the Z-System cannot be utilized.

STARTING THE SYSTEM

Two modes of operation are available when starting the system. The first mode is the SB180 monitor. It will be invoked if the computer is powered on without floppy-disk drives connected or if disk drives are connected but no disk is in drive A. The monitor has its own command set to perform such functions as examining and changing the contents of memory, transmitting and receiving byte values to and from the I/O ports, and more.

The monitor software resides in the on-board system EPROM (erasable programmable read-only memory) and is used for debugging the system hardware and as a bare-bones operating system for SB180 users who have not added floppy-disk drives. If the system is used in this way, simply strike the Return key so that the monitor can determine the console's data-transmission rate. (A listing of the monitor commands was provided last month.)

The second mode of operation involves attaching one to four floppy-disk drives (3½-, 5¼-, or 8-inch) to the appropriate drive connector on the SB180 and simply placing a disk that has the operating system on it into drive A and powering on, or resetting, the system.

This is referred to as cold booting and loads the operating system into the SB180's memory. Several messages are displayed in the process of cold booting, most of which are originated by the ZCPR3 utility LDR.COM. When the system has completed the cold-boot process, you are presented with the system prompt, which is A0:BASE> if you are using the distribution software. The system is now ready to accept your commands.

The cold-boot process has many stages. An important one is the execution of the STARTUP.COM program. The SB180 operating system searches for the STARTUP.COM program as the last step of the cold-boot process, and if it is found, it is executed. STARTUP.COM is created by the Alias program, and its major role in the cold-boot process is to load the ZCPR3 system segments by placing the command LDR SYS.ENV,SYS.RCP, SYS.FCP,SYS.NDR into the multiple command line buffer.

This is not the only role of the program. You can easily customize STARTUP.COM so that whenever the computer goes through the cold-boot process, an additional series of commands are executed automatically. Because each disk can have its own personalized STARTUP.COM, it is possible to create turnkey systems for specific applications. Disks could be set up specifically for word processing by using STARTUP.COM to automatically load and execute WordStar, or for a turnkey database operation. An unattended remote-access computerized bulletin board could have a STARTUP.COM set up so that if power failed and then was restored, all the needed commands to start the system again would be executed. The STARTUP.COM concept gives you a great deal of flexibility and convenience.

RAM-DISK INITIALIZATION

The RAM disk is an exciting feature of the SB180. It will improve system performance many orders of magnitude when used. Like all RAM disks, it has some characteristics that should not be overlooked. The RAM disk, unlike a floppy disk, does not retain its contents when power is removed, so you must be sure to make floppy-disk copies of files used in the RAM disk. It is quite possible to use aliases to make the process convenient, so that when you edit a file that resides in the RAM disk, it is automatically copied onto a floppy disk at the conclusion of the edit session.

The SB180 BIOS is written to *not* initialize the RAM disk when a cold boot is performed. This is so that when the Reset button of the computer is activated, the RAM-disk contents are retained. You may need to use the Reset button if a buggy program goes into an endless loop, and it is nice to reset the computer without losing the contents of the RAM disk!

A utility program called MDSK (the command is MDSK /I) is used to initialize (format) the RAM disk. It is important that MDSK /I not be used in the STARTUP.COM alias, because this will destroy the contents of the RAM disk whenever the Reset button is used. An alternative is to use the flow commands of ZCPR3 to query the user, so that the STARTUP.COM alias may perform the command or not, depending on the user's response.

CHANGING THE DRIVE/USER AREA

The Z-System accepts the generic commands found in both MS-DOS and CP/M for changing the currently active disk drive. For example, to select the B drive as active, simply

(continued)

Table 2: *The different floppy-disk formats that can be processed with the* SB180 BIOS *and their associated storage capacities. You do not need a conversion program to format, read, or write these formats (tpi=tracks per inch; dsdd=double-sided double-density; ssdd=single-sided double-density).*

Format	tpi	Sides	Capacity per disk
SB180 native	96	2	782K bytes (dsdd)
SB180 native	48	2	386K bytes (dsdd)
Hitachi QC-10	48	2	286K bytes (dsdd)
Kaypro 2	48	1	191K bytes (ssdd)
Ampro	48	1	188K bytes (ssdd)
Osborne 1	48	1	183K bytes (ssdd)

type B:. To select the integral RAM disk, type M:. When a drive is selected as active, it becomes the default drive. In other words, it is where programs and files will be searched for first, unless specified otherwise by the user or application program.

These generic commands are actually a subset of the commands available under the Z-System to select the active disk and user area. Two major types of commands are available under the Z-System for this purpose: the DU: form and the DIR: form. Both forms are recognizable by the trailing colon character.

The SB180 BIOS can automatically recognize different floppy-disk formats, so exchange of disks with dissimilar formats becomes easy. See table 2 for a list of supported formats. To change to a disk of different format, you may have to type Control-C.

The DU: form is made up of two components. D is a disk drive, and the acceptable range for it is A through P. U is a user area, and its acceptable range is 0 through 15. Thus, DU: forms of A0:, B6:, and M15: are allowed, but forms like Z0: or G33: are invalid. So, to move to the A2: drive/user area, simply type A2:. Another way of using the DU: form is to realize that the D and U are optional. This means that forms such as 3: and A: are valid.

The DIR: form is derived from the Named Directory system segment, which associates a symbolic name with a specific drive and user area. A directory name is up to eight characters in length. For instance, if the symbolic name ROOT is defined in the Named Directory segment as being associated with A15, and if you type ROOT: <cr> at the system prompt, A15 will be selected as active.

To have the list of defined directory names printed for you, use the PWD (print working directories) utility. The default configuration of the SB180 system software allows 14 directory names to be defined, but this number can be changed (see the "User Customization" section).

A characteristic of the DIR: form is that a password can be associated with a directory name. The password can be up to eight characters in length and is also defined in the Named Directory segment. If you type a DIR: form that is passworded, a prompt of PW? is presented, and if the proper password is not entered, you are not allowed to enter that directory. (Note that the DU: form, if enabled, allows password-free access to that directory. To make the DIR: passwords come into full force, reconfigure the system to not accept the DU: form.)

Secure Systems

The SB180 system software has been configured with a minimal amount of security. This was done because most users will probably not be in a situation where public access to their SB180 will be allowed.

However, the system does possess extensive options for security. If you intend to use the SB180 as a public-access computerized bulletin board, you can reconfigure the software into a more secure system. For example, you could deny use of the ERA command to "ordinary" users.

I previously discussed how the DU: form of changing the active disk drive and user area bypasses any passworded Named Directory entries. In a secure system, the DU: form may be disabled, so that the only way to refer to any other area would be to use the DIR: form. Then, because the DIR: form requires a password if one has been defined, critical areas of the system can be password-protected.

These changes are implemented by editing the source code supplied with the system to set the new options and then merging the changes into the operating-system software.

User Customization

You can customize a number of other areas in the SB180 system software. The first is the BIOS, using the CONFIG utility.

The BIOS source code is included in the full software package to make easy installation of significant changes in the hardware-configuration information. The assembler, ZAS, lets you regenerate the operating system into new and different forms. An example is if you want to rewrite your RCP so that some of its commands will respond to the wheel byte. Another example is expansion of the Named Directory system segment to handle more than 14 directory names.

Although some of the above examples require programming knowledge, a great degree of customization can be done without specific programming knowledge through the use of Alias programs and the shell utilities.

The STARTUP.COM alias is a likely candidate for personalization. It is normally executed only when the system does a cold boot. When using the SB180 for word processing, I use a STARTUP.COM command sequence that automatically copies the files I will be using to the RAM disk. Once the files I am using are copied into the RAM disk, execution of commands is nearly instantaneous. Having STARTUP.COM automatically place the appropriate files in the RAM disk to gain the benefit of the speed of access can be used in many other areas besides word processing.

Support

A full set of manuals are included with the SB180 operating-system software. This includes manuals for ZAS, ZDM, EDIT, ZRDOS, and some SB180 utilities. Documentation for the ZCPR3 utilities and ZCPR3 itself are included in the HLP files.

Experimenters

As always, I try to support the computer experimenter by rewarding diligence. If you build the SB180 from scratch, send me a picture and I'll send you a copy of the BIOS and the ROM monitor on disk (SB180 double-sided double-density format) at no charge, provided it is for your personal use.

If you build, buy, or otherwise assemble an SB180 system, I'd like to know about it. I will be designing expansion boards for the SB180 (the first one is a 300/1200-bps modem) and can notify you of them in advance of publication. In addition, having your name will greatly simplify the organization of any users groups that might arise.

The SB180 is a fully supported Circuit Cellar project. I have arranged for the hardware to be available in kit or assembled form, and I contracted with Echelon Inc. to write the BIOS and integrate it into the operating system. Echelon has telephone technical assistance available and also has affiliations with more than 40 public remote-access bulletin-board systems, called Z-Nodes. Z-Nodes are located throughout the nation, and there may be one in your area. You can find ZCPR3 utility-program updates and informative newsletters about the Z-System on a Z-Node for the price of a phone call.

In Conclusion

This has been a big project, even though it's only a small board. Sports cars have a lbs/HP rating. It's too bad there isn't an MPS/sq. in. rating that could be used to truly compare the capabilities of the SB180 to other computers.

Like the Z8 and 8052, the HD64180 has joined the Circuit Cellar preferred processor list, and you can expect it to be well supported with a variety of expansion peripheral devices. A hard-disk controller and modem are currently in the works. As soon as I figure out how to design them and gather together the software people who know how to glue it together, I'll let you know. Until then, I'll just keep plinking along with simple projects like home controllers, intelligent terminals, and voice-recognition systems. My PC board designer needs a vacation.

Circuit Cellar Feedback

This month's feedback is on page 388.

Next Month

I'll build a single-chip 1200-bps modem. ■

Special thanks to Tom Cantrell, Frank Gaude', Merrill Lathers, Dave McCord, Joe Wright, and the people at Custom Photo and Design Inc. and Tech Circuits Inc. for their contributions to this project.

Editor's Note: Steve often refers to previous Circuit Cellar articles. Most of these past articles are available in book form from BYTE Books, McGraw-Hill Book Company, POB 400, Hightstown, NJ 08250.

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

The following items are available from

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Procedural Language	Yes	Yes	Yes
Variable-Length Fields	Yes	No	No
Report Writing Features:			
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B) Row or Column Formats	Yes	Yes	No
C) Accessible Tables	6000	40	10
Password Security	Yes	Yes	No
Definable Data Entry Rules	Yes	Yes	No
Pre-Defined Macros	Yes	Yes	Yes
Application Generator	Yes	Yes	No
Application Compiler(1)	Yes	Yes	No
Run-Time Module	Yes	Yes(2)	Yes(2)
Natural Language	Yes	Yes(3)	No
Network Version	Yes	No(4)	No

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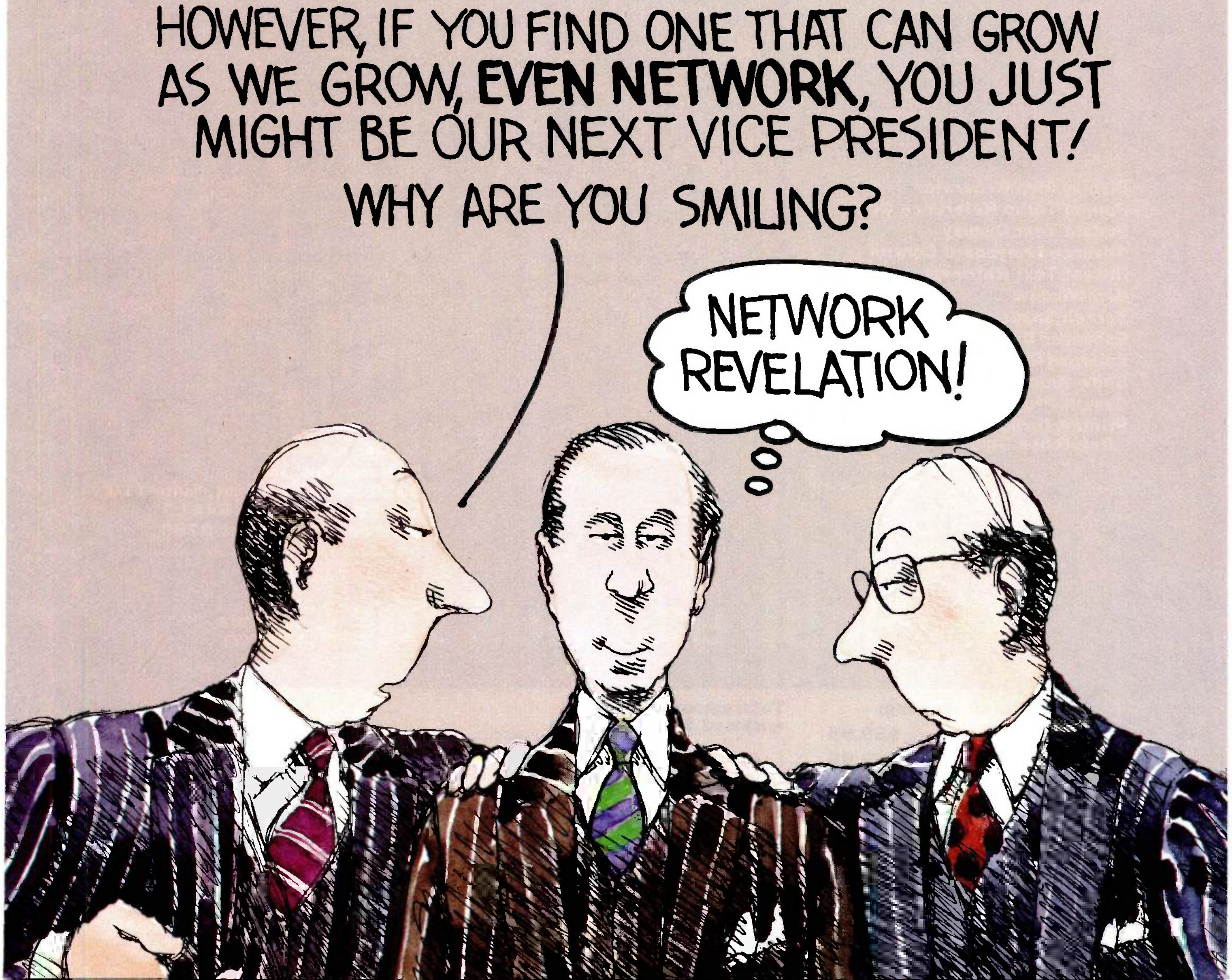

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BY CLIFFORD KELLEY

PART 2: THE HARDWARE

EGO: A HOMEBUILT CPU

How the hardware decodes and executes instructions

Editor's note: This is the second part of a two-part article describing EGO, *the author's homebrew* CPU. *It relies heavily on part 1, published in the September* BYTE, *which describes* EGO's *instruction repertoire in detail.*

The system architecture defines the physical structure of the computer. Figure 1 shows the structure of EGO. The real constraints that the instruction set imposes on EGO are the size of the memory; the number of registers (32); and the width of the data bus, ALU (arithmetic logic unit), and registers.

The IR (instruction) register is used to store the instruction that was read from memory for use by the system controller. The MA (memory address) register stores the address where memory will be accessed. The general-purpose registers are arranged like a small memory bank—only one register at a time can be written to or read from. This factor, along with my desire to keep EGO simple (only one data bus), forced me to use registers A and B as temporary storage for instruction operands, freeing the data bus for transmission of the ALU's operation results either to the TS (temporary storage) register or to a general-purpose register. The TS register is not needed for very fast transfers from the ALU to registers, but it is used as transient storage when data is sent to memory.

The ST (starting address) register holds the address that EGO accesses when it starts up or is interrupted. Currently it is hard-wired to address 0000 (all addresses are in hexadecimal), but I have made provisions so that it could be loaded by an external device.

EGO SEQUENCER PROGRAM

In effect, EGO's sequencer runs a program written in AHPL (a hard-wired programming language; for more information see *Digital Systems: Hardware Organization and Design* by Frederick J. Hill and Gerald R. Peterson, John Wiley & Sons, 1978). The program for EGO is shown in figure 2. It can be implemented either by microprogramming or by hard-wired sequential circuits. For complex machines, a microprogrammed control unit is the only feasible solution. But, since EGO's program has only 22 steps, having

(continued)

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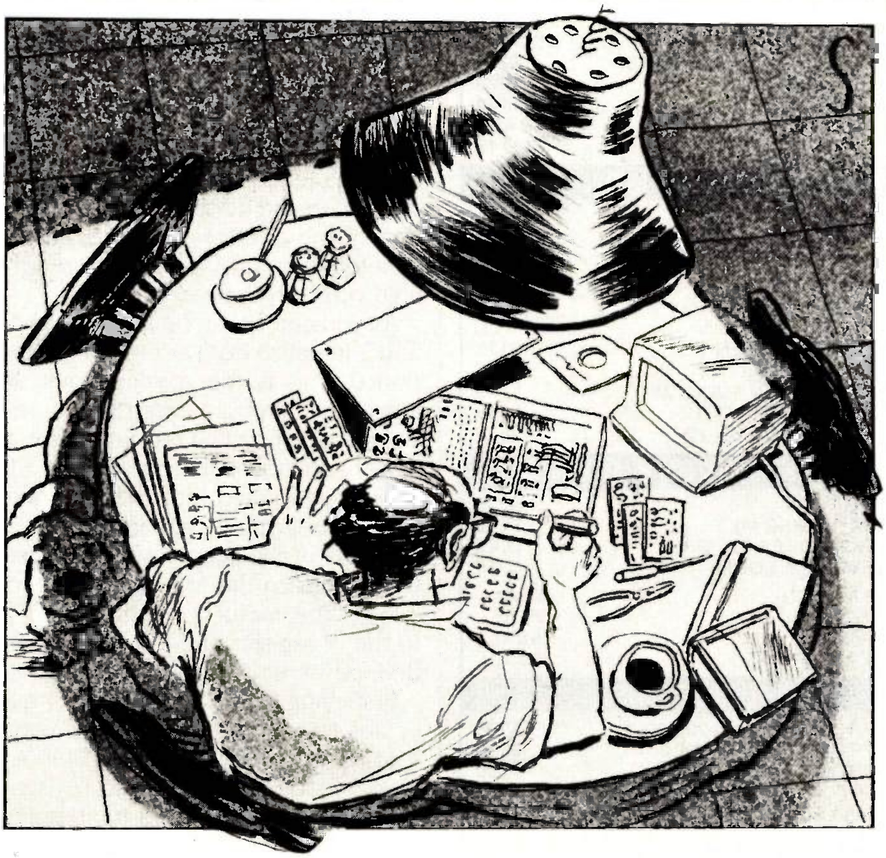

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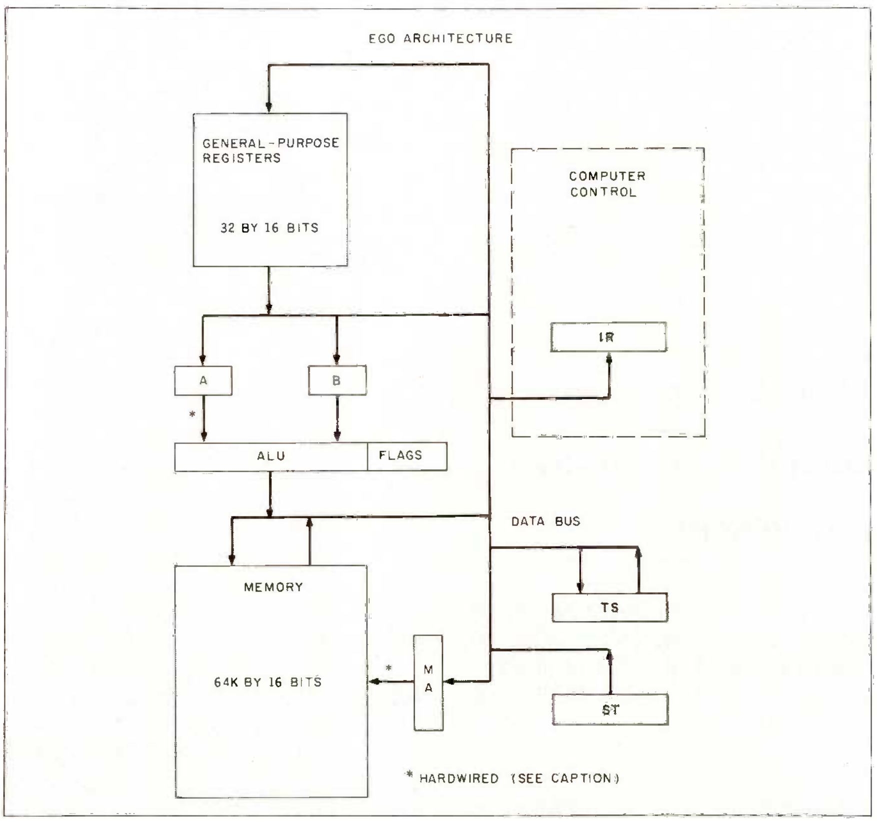

Figure 1: *A block diagram of the EGO processor's architecture. Hard-wired connections indicate signals that are never "turned off." For example, the output of the A register is always sent to the ALU, but the output of the B register can be disconnected from the input of the ALU for those instructions requiring only one operand (shifts and rotates).*

one sequential circuit per control state offers the most direct interpretation of the control sequence, eases maintenance problems, and offers high operating speeds.

As you can see in figure 2, steps 1 and 2 initialize EGO at memory location 0. This is the starting point at power-up, after an interrupt is received, or when EGO restarts after a halt instruction is executed. The ST register is loaded into the program counter (register 0), and in step 2 the contents of the program counter are transferred to the MA register. Step 3 loads the instruction from memory to the IR register and to branches as defined by each instruction type.

Branching from step 3 to step 4 executes the register instructions. Step 4 loads register S1 into register A. Step 5 loads register S2 into register B. Control then transfers to step 17, where the result is computed. This result is sent to the TS register and, since the instruction is not an indirect S2 operation, the result is also sent to register S2. At this point, control transfers to step 20, where the program counter is loaded into register A. Step 21 increments register A and sends the result back to the program counter and into the MA register. Step 21 also checks the interrupt line and, if an interrupt is detected, transfers control to step 1. Otherwise, EGO transfers back to step 3. Since the MA register holds a copy of the program counter, EGO is ready to perform a memory read to fetch the next instruction.

Branching from step 3 to step 6 executes the data instructions. Step 6 loads the program counter into register A. Step 7 increments register A and sends the incremented value

Memory : IR(16);MA(16);TS(16);A(16);B(16);REG(32:16);
MEM(65536:16);ST(16)

Logic : ALU(4)
Inputs : flags,rst,int
Outputs : cy,ldf
Bus : BUS(16)

1 BUS = ST,REG(0) <--BUS
2 BUS = REG(0),MA <--BUS
3 BUS = MEM(MA),IR <--BUS,-->($\overline{IR}_{15}\overline{IR}_{14}\overline{IR}_{9}$,$\overline{IR}_{15}\overline{IR}_{14}IR_{9}$,$\overline{IR}_{15}IR_{14}$,
$IR_{15}\overline{IR}_{14}$,$IR_{15}IR_{14}$)/(19,6,4,11,14)
4 BUS = REG(S1),A <--BUS
5 BUS = REG(S2),B <--BUS,-->(17)
6 BUS = REG(0),A <--BUS
7 BUS = ALU(INC),REG(0) <--BUS,-->($\overline{flags}$)/20)
8 BUS = REG(S2),B <--BUS
9 BUS = REG(0),MA <--BUS
10 BUS = MEM(MA),A <--BUS,-->(17)
11 BUS = REG(S1),MA <--BUS
12 BUS = MEM(MA),A <--BUS
13 BUS = REG(S2),B <--BUS,-->(17)
14 BUS = REG(S1),A <--BUS
15 BUS = REG(S2),MA <--BUS
16 BUS = MEM(MA),B <--BUS
17 BUS = ALU(op code),ldf = 1,(REG(S2) <--BUS)/($\overline{IR}_{15} + IR_{15}\overline{IR}_{14}$),
TS <--BUS,-->($\overline{IR}_{15} + IR_{15}\overline{IR}_{14}$)/(20)
18 BUS = TS,MEM(MA) <--BUS,-->(20)
19 cy = $\overline{IR}_{1}IR_{0}$,ldf = $IR_{1} \oplus IR_{0}$,-->($IR_{1}IR_{0}$)/(22)
20 BUS = REG(0),A <--BUS
21 BUS = ALU(INC),REG(0) <--BUS,MA <--BUS,-->(int,$\overline{int}$)/(1,3)
22 -->(rst,$\overline{rst}$)/(1,22)

Figure 2: EGO's *sequencer program.*

back to the program counter. If the flags logic is false, control transfers to step 20, and the instruction is ignored. (Because the program counter is incremented before the flags are tested in step 7, and because it will be incremented again in steps 20 and 21, the second word of the instruction will be skipped and the program counter will be set properly for the next instruction even if the flags logic is false.) If the flags logic is true, control transfers to step 8. In step 8, register S2 is loaded into register B. Step 9 loads the program counter into the MA register, which now holds the address of the data word of the instruction. Step 10 loads the data word from memory into register A and control transfers to step 17, where the results are computed as I described previously.

Branching from step 3 to step 11 executes the indirect-operand instructions. Step 11 loads register S1 into the MA register. Step 12 loads the memory value, pointed to by the MA register, into register A. Step 13 loads register S2 into register B and transfers control to step 17, where the results are computed.

Branching from step 3 to step 14 executes the indirect-result instructions. Step 14 loads register S1 into register A. Step 15 loads register S2 into the MA register. Step 16 loads the memory value, pointed to by the MA register, into register B. Step 17 computes the result of the operation, but this result is only sent to the TS register. In step 18, the value in the TS register is sent to the memory location pointed to by the MA register. Control then transfers to step 20 and continues as before.

(continued)

The heart of EGO's sequencer is a set of 22 D flip-flops.

Branching from step 3 to step 19 executes the miscellaneous instructions. Step 19 sets or resets the carry flag on a set-carry or clear-carry instruction. For a no-operation instruction, nothing happens and execution continues with step 20. For a halt instruction, control transfers to step 22. Control remains with step 22 until restart is "true." Then control transfers to step 1, where EGO starts instruction execution at location 0.

EGO's Sequencer

Figures 3, 4, and 5 are the logic diagrams of EGO's sequencer. Its heart is a set of 22 D flip-flops, one for every step in the control sequence. The system does not run until the "st" input is true and the "clr" input is false. The "$\overline{on}$" signal is false when any of the flip-flops are set, thus turning off the D input to step 1. This ensures that only one step will be true at any time. The "rst" and the "int" inputs are used to control step 21 and step 22. The outputs from the instruction register are used in a number of places to control the sequence, especially from step 3, where a number of options are decoded. The logic of the flags signal, along with the logic that sets up the address lines for the general-purpose register set, are included in figure 3. Figure 4 shows how the step numbers (the outputs from each flip-flop) are decoded to provide the timing signals that tell EGO what to do. Figure 5 shows the decoding of the op code combined with the sequence steps to provide the signals to control the ALU. Step 17 is the ALU operation step, while step 7 and step 21 are used to set the inputs to the ALU to increment register A.

EGO Registers and ALU

Figure 6 shows the general-purpose register set. Since the 74189 circuit inverts its outputs, the inputs are inverted from the data bus to compensate. The rest of the circuit looks much like a standard RAM.

Figures 7 and 8 show the ALU and registers A and B. One important feature is that register A is hard-wired to the ALU inputs, while the register B outputs are passed through a set of AND gates with the signal "bz" before they are sent to the ALU. I did this so that, by setting "bz" to 0 and performing an OR operation in the ALU, the contents of the A register can be transmitted through the ALU unchanged. This is used for the shift and rotate operations, which are actually performed by an array of tristate

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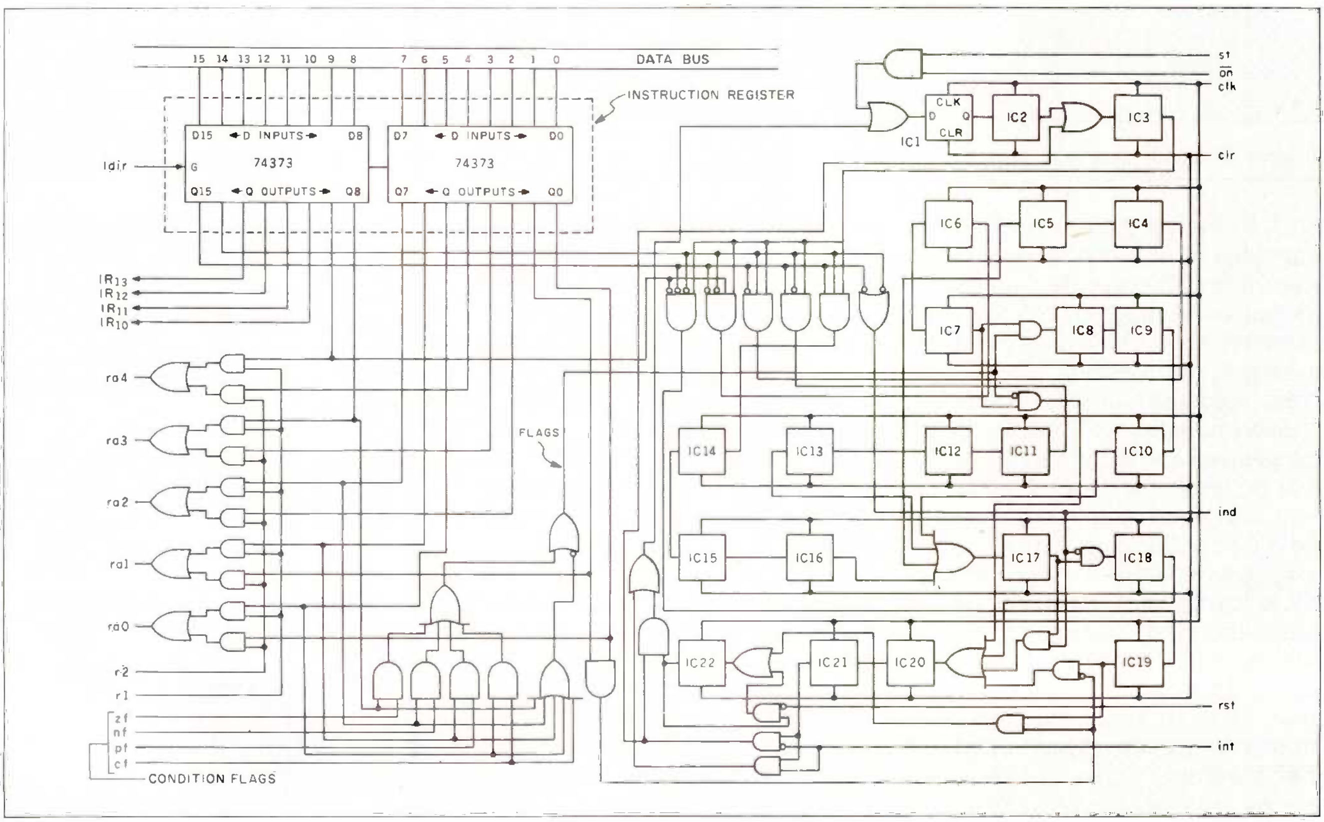

Figure 3: *The main circuit for EGO's sequencer. Note the bank of 22 flip-flops, one for each step in the sequencer program.*

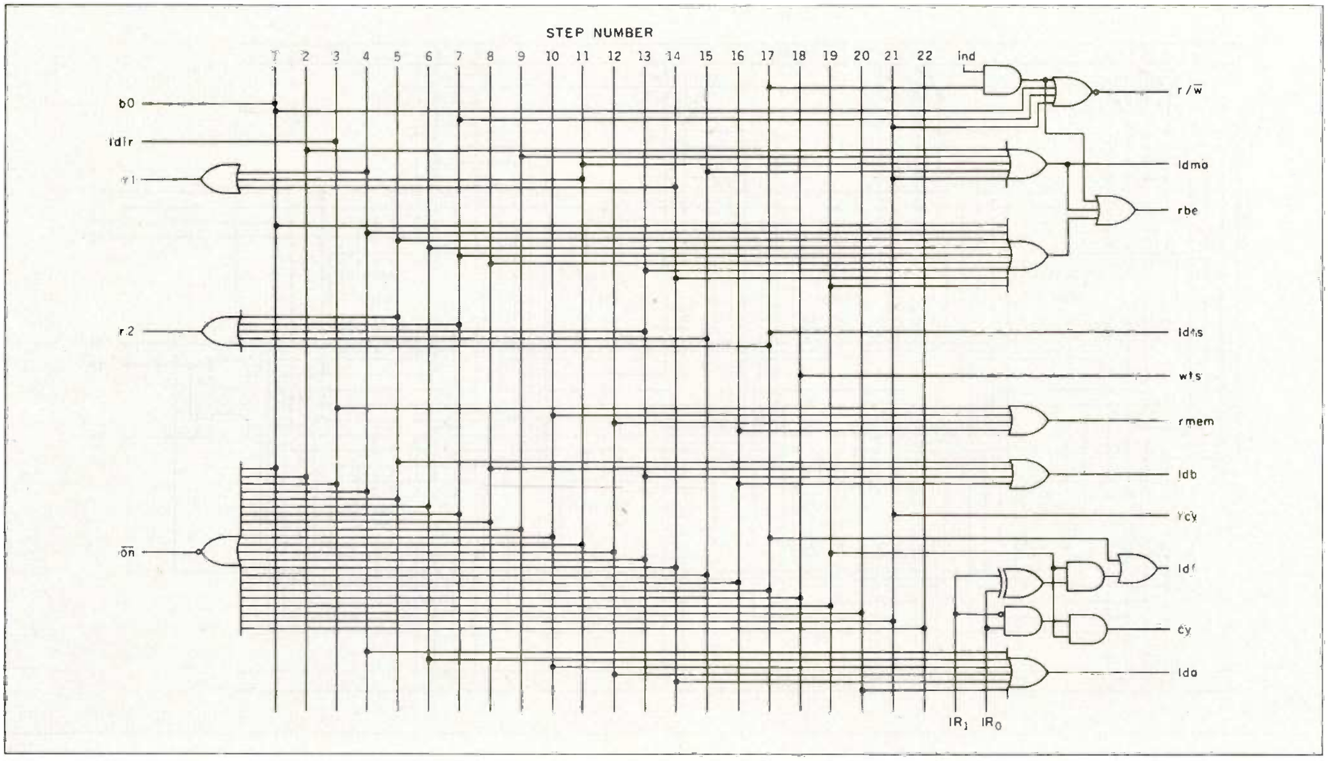

Figure 4: *Another portion of the EGO sequencer circuit.*

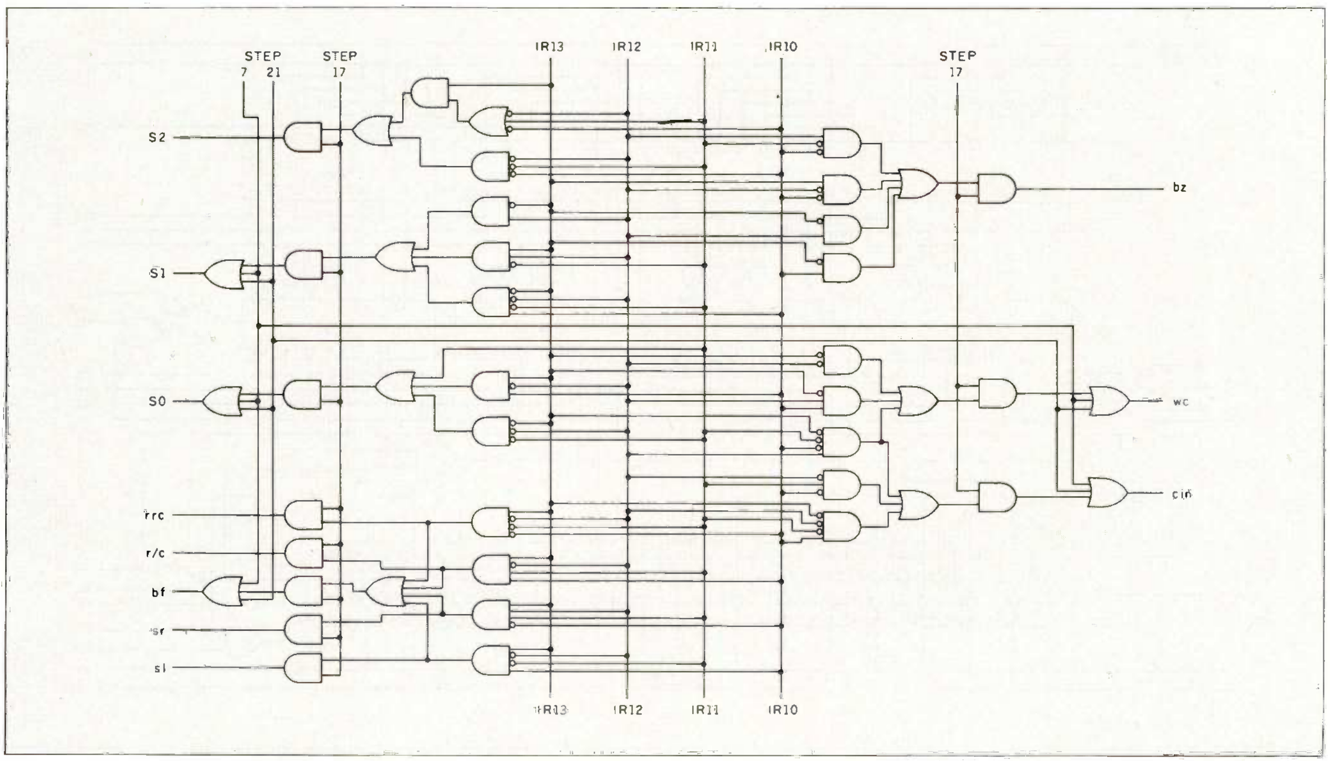

Figure 5: *This section of EGO's sequencer performs instruction decoding.*

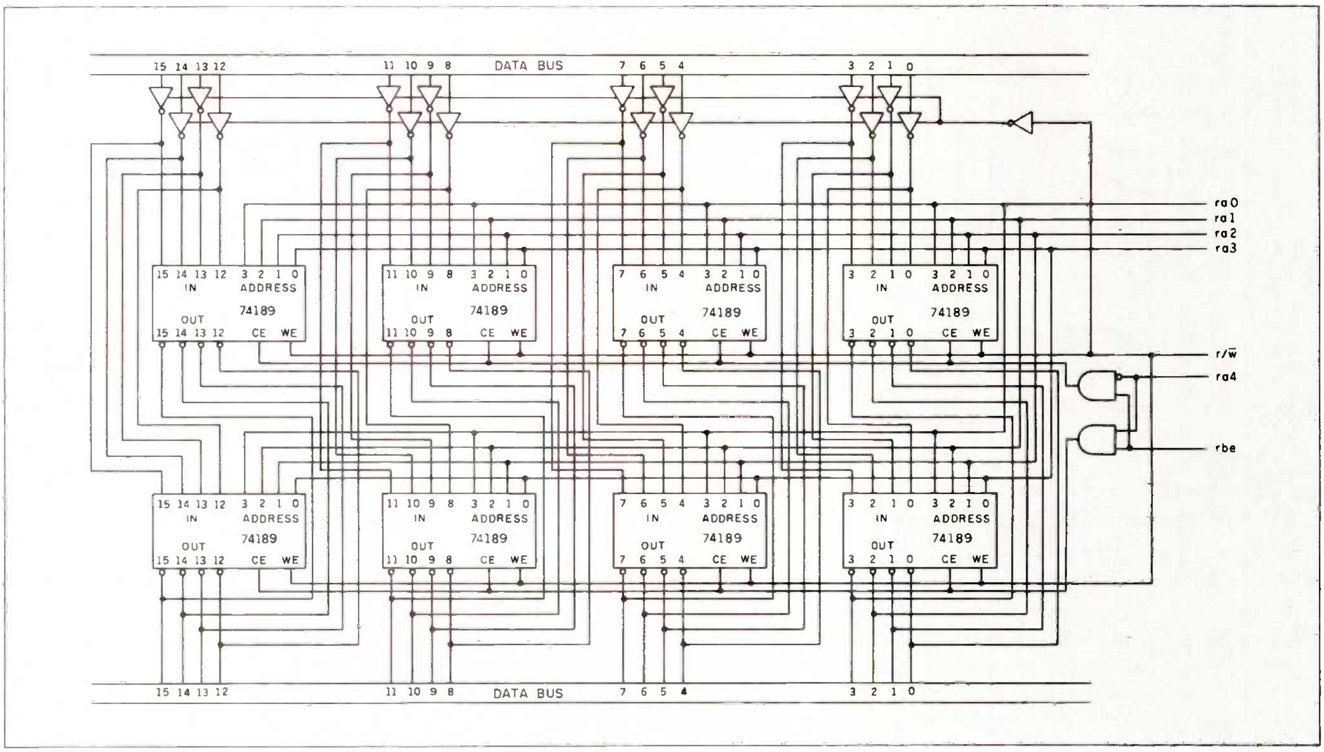

Figure 6: EGO's *general-purpose register set.*

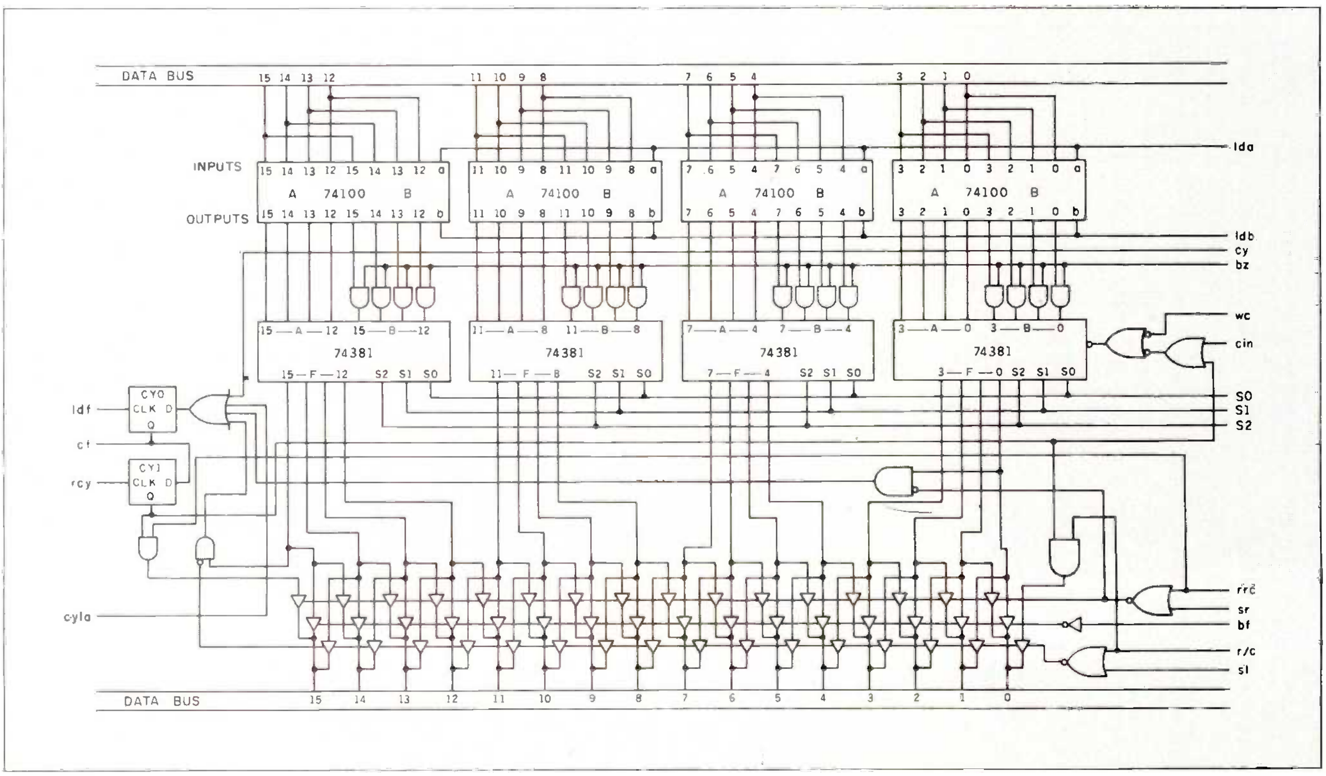

Figure 7: EGO's ALU. *Note the bank of tristate drivers near the bottom used to perform shift and rotate instructions.*

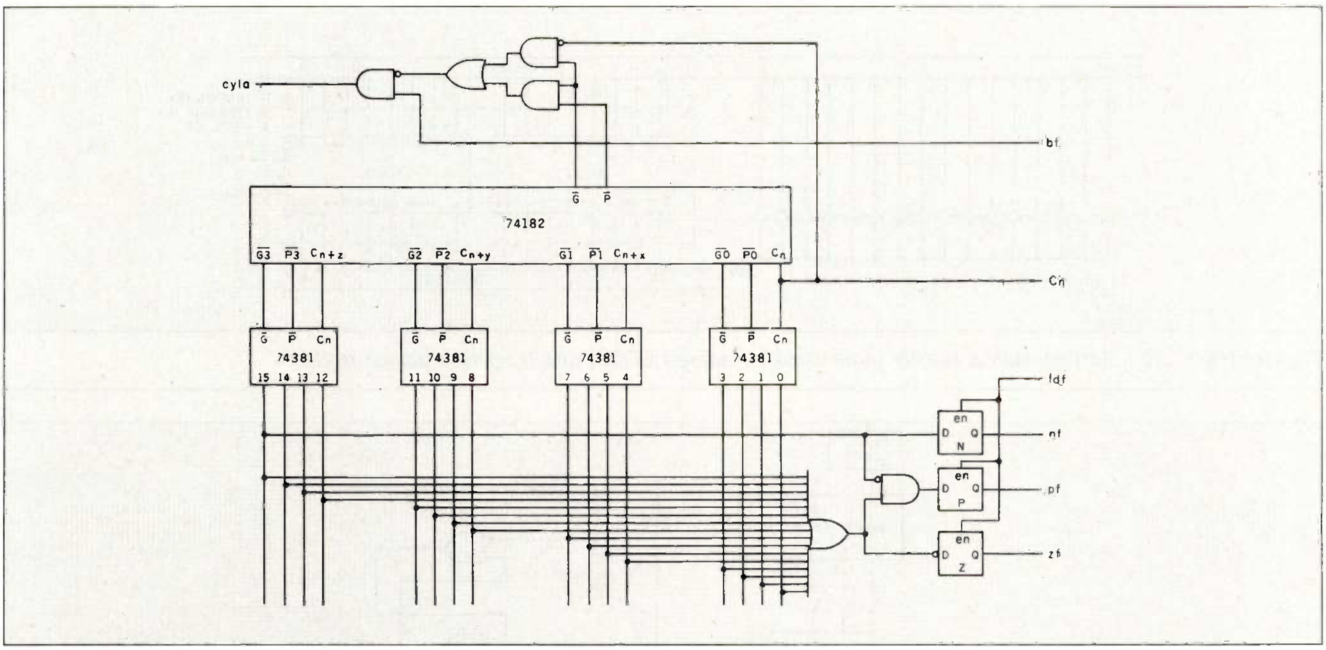

Figure 8: *EGO's circuit for generating carry-look-ahead and condition flags.*

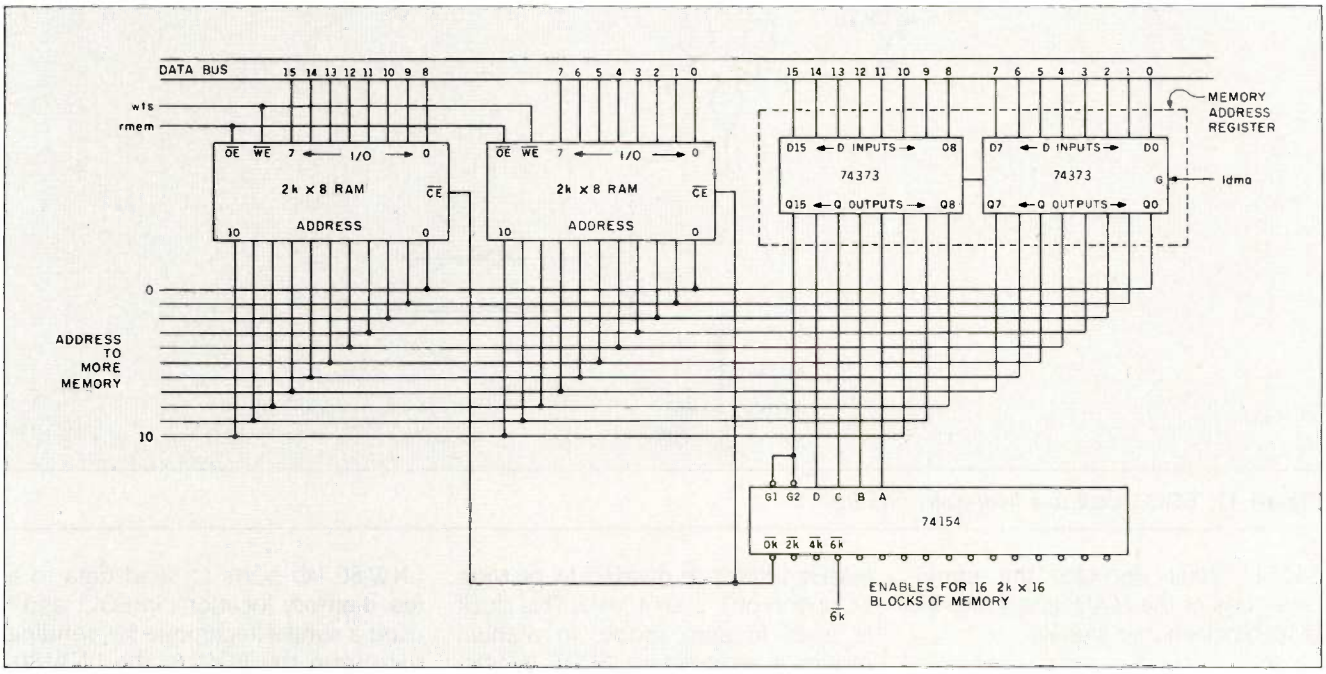

Figure 9: *The circuit for EGO's memory and memory-address register.*

drivers attached to the output of the ALU. The carry flag presented special problems because it can be affected by a number of operations (clear carry, set carry, math operations, etc.) Figure 8 shows how the carry-look-ahead circuit is connected along with the other condition flags.

EGO Memory

Figure 9 is a diagram of EGO's memory. The memory-address register can only be written to, and its outputs are always enabled. Currently, EGO is configured around 2K-byte EPROM (erasable programmable read-only memory) and RAM chips. Thus, the

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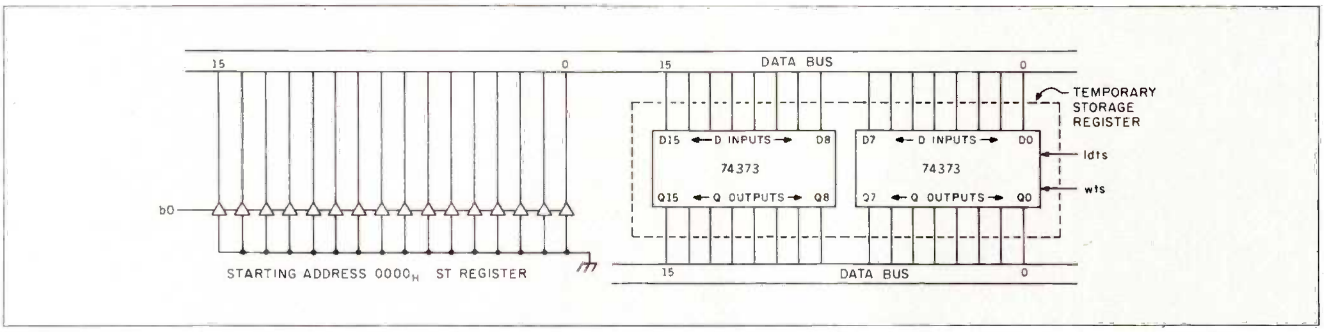

Figure 10: EGO's *starting-address register (hard-wired for address 0000) and temporary-storage register.*

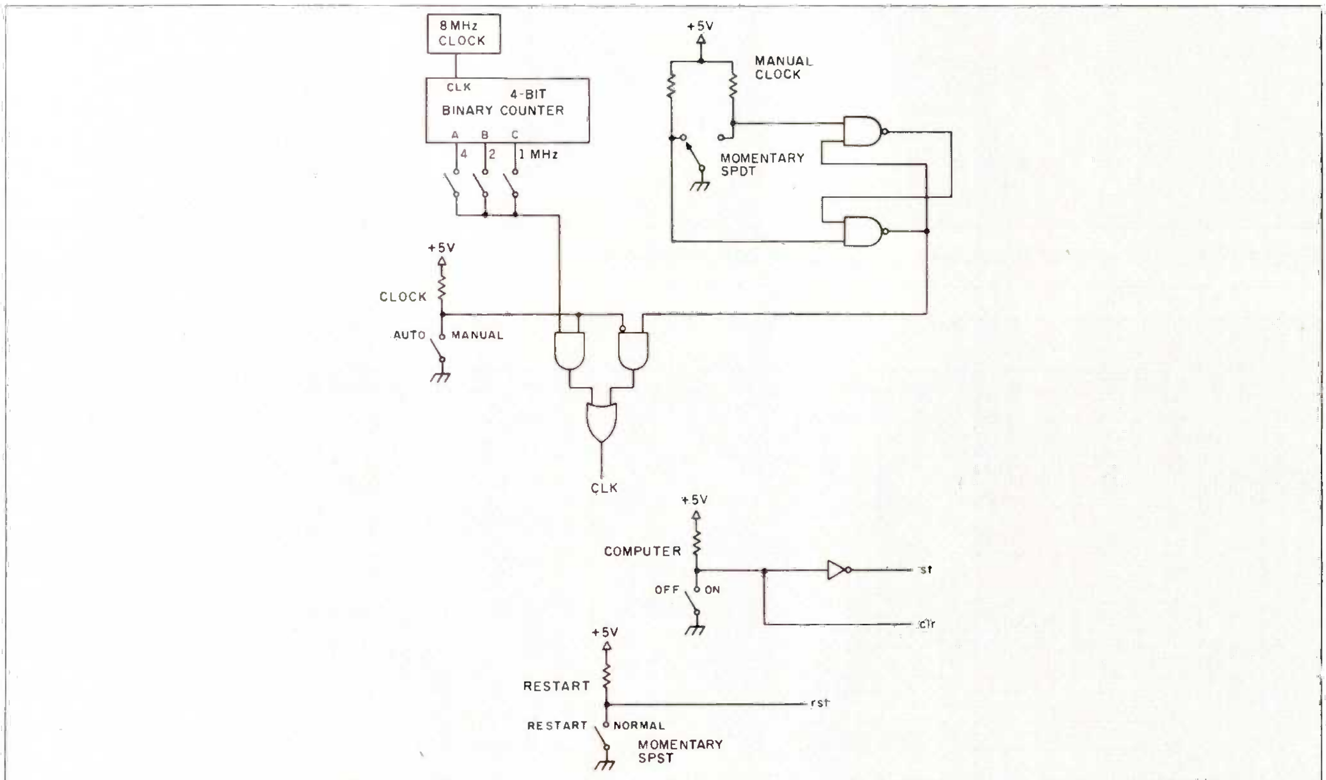

Figure 11: EGO's *clock and front-panel circuitry.*

74154 circuit decodes the upper-order bits of the MA register into 2K-byte block-enable signals.

Miscellaneous Parts

Figure 10 shows how the ST and TS registers are connected to the data bus.

Figure 11 shows the clock and control signals from the front panel. (*Editor's note: Please refer to part 1 of this article for a photograph of* EGO's *front-panel display.*) The clock is derived from an 8-MHz reference divided to provide an option of 1, 2, or 4 MHz. This clock is used in auto mode. In manual mode, a momentary SPDT (single-pole, double-throw) switch on the front panel provides the clock signal. The "st", "clr," and "rst" signals are simple switches.

Figure 12 shows the EGO I/O (input/output) interface. I designed this interface to work with an LNW-80 (a Radio Shack TRS-80 Model I lookalike). I decoded the outputs of the LNW-80 I/O ports to send data to a few memory locations in EGO, and I used a similar technique for sending data from the EGO to the LNW-80. (Although I originally designed EGO to attach to an LNW-80, it currently "talks" to a Tandy Model 2000.)

EGO Present and Future

EGO's memory consists of 2K words of EPROM and 2K words of RAM. I hope to expand this soon, but so far this small amount of memory has not

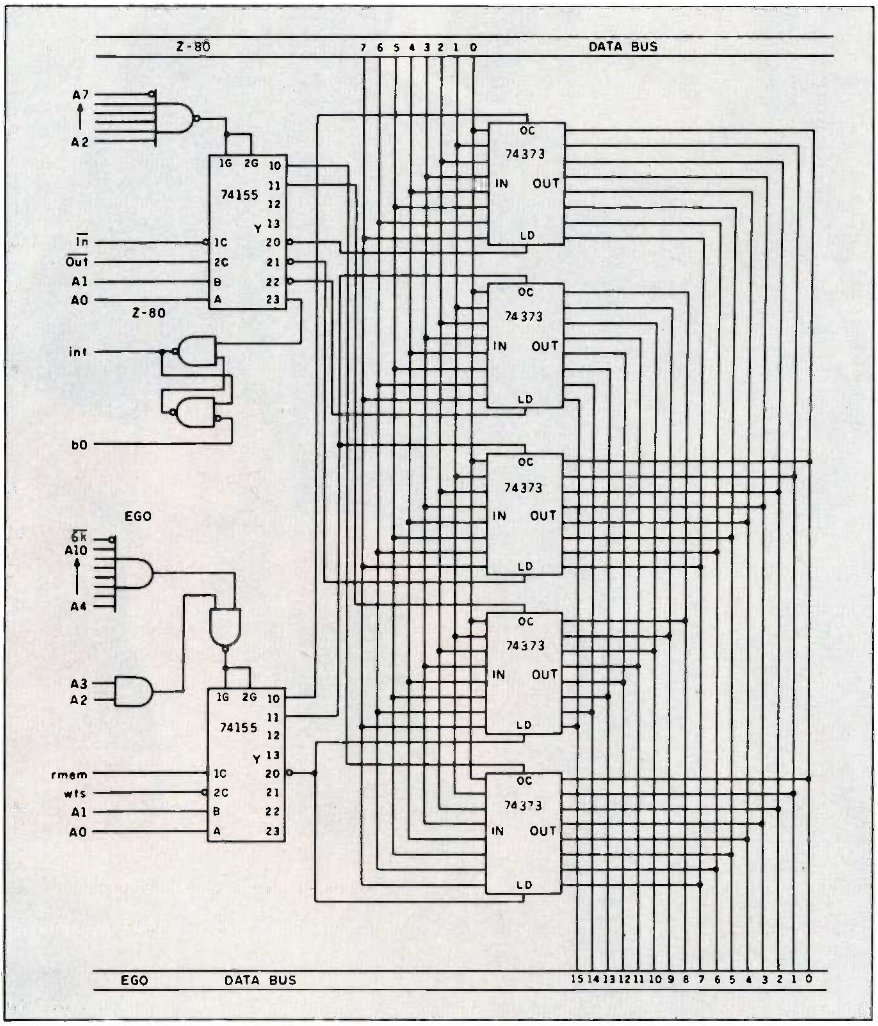

Figure 12: EGO's I/O *interface circuitry.*

hampered my programming even relatively complex programs.

I had originally thought that a clock speed of 1 or 2 MHz would be the limit of the system, but after it was finished I found it had no trouble operating at 4 MHz. This surprised me because the EPROMs have a read cycle of 450 nanoseconds (ns). However, since a valid address from the MA register is available at least 250 ns before the data from memory is requested, no special timing was required to distinguish between EPROM and RAM.

As with any project, I made a few changes along the way, and there are things I would do differently if I were doing it over again. Most of the changes I made were in the sequencer: I eliminated one step entirely and altered a branch. Even now, I could do away with other steps by combining several of them into one. Using a carry-look-ahead circuit, the ALU is probably fast enough to provide a result that could be sent to memory in time for it to be stored. If I were to build another version of EGO, I would incorporate these modifications; but with the system working so well, the incentive to modify it has not been strong. ■

ACKNOWLEDGMENT
I would like to thank Ted Davis, Bill Mealing, and Hutch Hutchison for their technical assistance.


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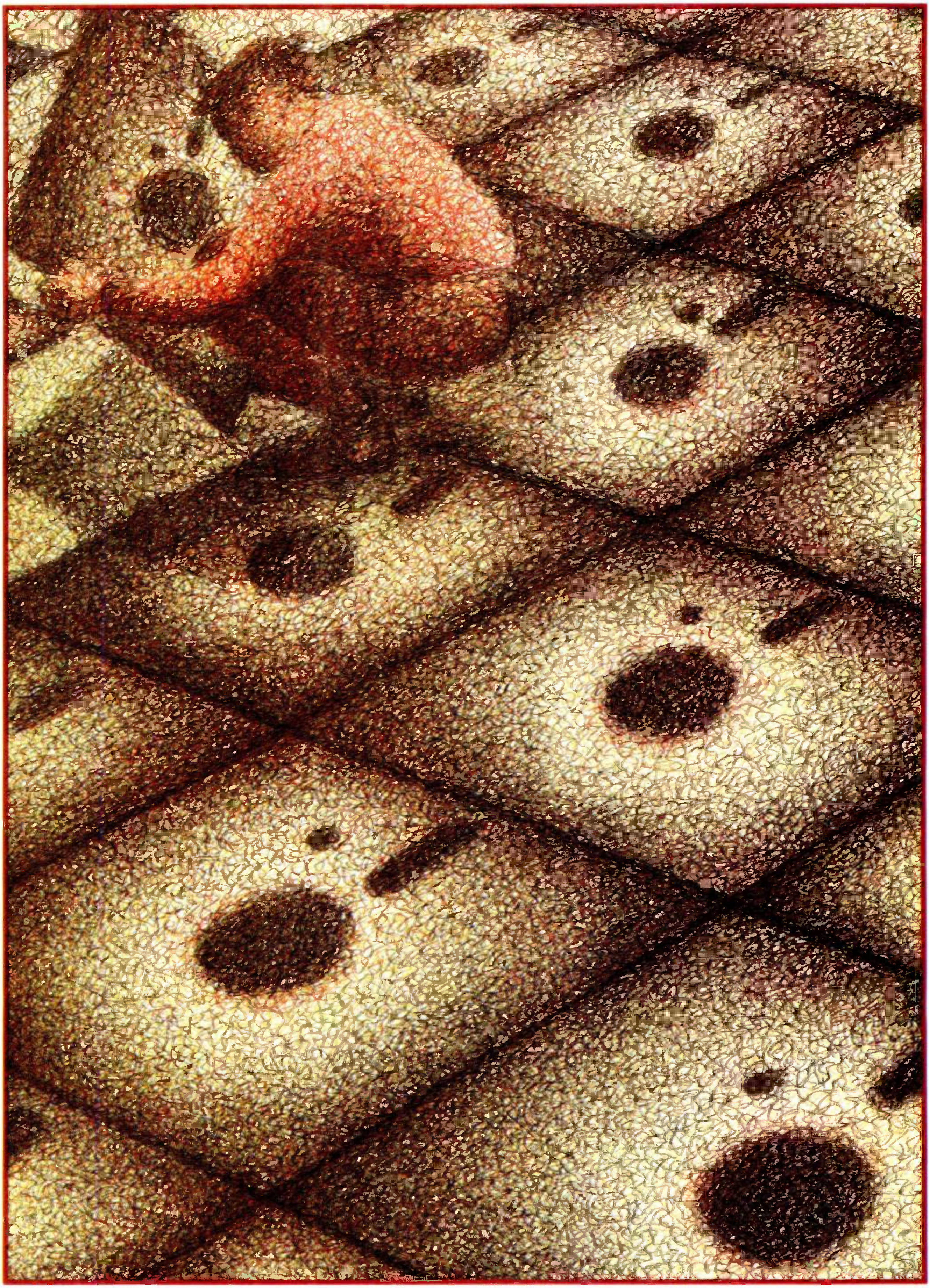

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Building a Computer in Software

BY JONATHAN AMSTERDAM

The realization of one software hacker's dream of designing a computer

I must admit that as a software hacker, I sometimes feel envious of my hardware-inclined colleagues. I dream occasionally of building a computer from the ground up, out of transistors, gates, adders, barrel shifters, and other such esoterica. It's not so much the hands-on feel of construction that I desire (though I do at times long for a whiff of melting solder); rather, I crave the power of making every decision in the design process. I would decide how much memory the machine has, how many registers there are, and what the machine's built-in instructions would be. My hardware dreams will never be fulfilled. But my design dreams can still be realized—in a program.

In other words, I can build my computer in software. And I have. That's what this programming project is all about.

Virtual Machines

A software simulation of a computer—a so-called *virtual machine*—can be a helpful tool. Its utility is obvious in designing new processors: You can test out your design in a program before committing it to silicon. But building a virtual machine has also been proved worthwhile in implementing programming languages. The idea is to design a computer ideally suited to the execution of the high-level language you want to implement. Since chances are that no real computer will fill the bill, the dream machine is simulated on a real machine. You are then free to compile the high-level language into instructions for the virtual machine, which will then be interpreted by the simulator. Because the virtual machine was designed with the high-level language in mind, writing a compiler should be relatively easy. And there is an added bonus of portability: The compiler will work on any computer on which the virtual-machine simulator is running. Writing a virtual-machine simulator for a new machine is usually much easier than retargeting a compiler to produce native code for that machine. Furthermore, because the virtual machine's instruction set can be optimized for the high-level language, the program's object code is often much smaller than a corresponding program translated directly to machine language.

The price paid for all this is speed. Because the virtual machine is interpreted in software, programs compiled into virtual machine language run more slowly than native-code programs.

(continued)

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An early use of the virtual-machine technique was in one of the first Pascal compilers. Later, Kenneth Bowles adopted the technique for his UCSD Pascal system, which is still going strong. Virtual machines for Pascal are often called P-machines, and their native language, p-code. Xerox's exciting object-oriented language, Smalltalk, also uses the virtual-machine scheme. The Smalltalk virtual machine takes the burden of manipulating objects off the compiler writer's shoulders. And Niklaus Wirth's Modula-2 has also been implemented using a virtual-machine code called m-code. In fact, the system that I used for this project, MacModula-2 from Modula Corporation (950 North University Ave., Provo, UT 84604 (801) 375-7400), is implemented this way. Wirth's computer, the Lilith, solves the virtual-machine speed problem: Its processor executes m-code instructions directly. The virtual machine and real machine are one and the same.

Soon there will be another programming language joining the virtual-machine club. I designed it, and in the near future I will be discussing a compiler for it in these pages. But before I discuss the compiler, I need to specify the virtual machine.

STACKS

My virtual machine, the VM2, makes use of a data structure called a stack. Abstractly, a stack is a sequence of elements with two operations, PUSH and POP. Pushing an element onto a stack adds it to one end of the sequence, called the top of the stack. The POP operation removes the top element from the stack. A stack data structure acts just like a stack of dishes: Things are always added and removed from the top.

There are many ways to implement stacks. VM2 uses one of the simplest. A contiguous region of memory—an array—holds the elements of the stack. A pointer into the array indicates where the top of the stack is. In VM2, the stack pointer is set initially to point to the highest memory location. When a PUSH occurs, the element is placed in the location pointed to by the stack pointer, and the stack pointer is then decremented. For a POP, the stack pointer is first incremented, then the contents of the location it points to is returned. If a POP is attempted when the stack is empty, an error occurs.

VM2 SPECIFICATION

My virtual machine is called VM2 (VM for virtual machine, M2 for Modula-2). VM2's memory is divided into an unspecified number of units called words. The size of a word is also unspecified, but it must be large enough to hold the address of any word in VM2's memory. A word is addressed by a number between 0 and one less than the size of memory. A typical "real"-size VM2 might have 64K 16-bit words, addressed from 0 to 65535. A word is the smallest, indeed the only, unit of storage. There are no bytes. I'm trying to keep things simple.

VM2 has three word-length registers. A register is a special storage location that is not part of memory. The programCtr register holds the address of the next instruction to be executed. The stackPtr register holds the address of the top of the stack. (See the text box above for an explanation of stacks.) VM2's stack grows down from the top of memory, so when the machine is reset, the stackPtr register points to the highest word of memory. The stackLimit register is a special feature designed to protect programs, which reside in the low end of memory, from being overwritten by the stack. Every time something is added to the stack, the value of the stackPtr register is compared with stackLimit. If they are ever equal, a stack-overflow error results. If you set stackLimit to point just past the top of your program, you can be sure that the stack won't overwrite the program.

The instruction set for VM2 is found in figure 1, along with an explanation of each instruction. All VM2 instructions occupy one word of memory. Some instructions (PUSH, for example) take a one-word argument, which is always located in the word immediately following the instruction in memory. I've tried to keep the number of instructions down, although I've left some redundancy in the instruction set to make it easier to write programs. For instance, you can get the effect of a PUSH by using a PUSHC followed by a CONTENTS, but I figured that PUSH would be very common.

VM2 is a so-called stack machine. That means that many instructions either expect values on the stack, place their results on the stack, or both. The ADD instruction is a prime example. First it pops two words off the stack. Then it adds them together, treating them as signed integers, and pushes the result back on the stack. The SUB, MUL, DIV, and NEG instructions work similarly. To get something onto the stack in the first place, you can use the PUSHC instruction, which pushes a constant value on the stack. PUSH is different; it treats its argument as an address and pushes the contents of that address on the stack. So PUSHC 13 will put the number 13 on the stack, while PUSH 13 will put the contents of memory location 13 on the stack. For example, the three lines

```
PUSHC 3
PUSHC 12
ADD
```

will put the numbers 3 and 12 on the stack, add them, and leave the result, 15, on the stack.

Getting things off the stack and into another memory location is done with the POPC instruction, which puts the top of the stack into the memory location specified in the instruction. If we put a POPC 25 instruction after the ADD in the program above, then the value 15 would be stored in location 25. POP is similar, but instead of the address being an argument to the instruction, it is one of the values on the stack. For instance, if the number 13 is on the top of the stack with 24 just below it, then the POP instruction will put 24 into location 13.

Several instructions change the value of the programCtr register.

BRANCH takes an argument and sets the programCtr register to it. This allows one to transfer control to any other instruction in the program. JUMP is like BRANCH but gets the new value for the programCtr from the stack. It's useful for returning from subroutines and implementing jump tables. BREQL, BRLSS, and BRGTR pop the top value off the stack and set the programCtr to their argument if the value is equal to, less than, or greater than 0, respectively.

Seven instructions work with Boolean values. A 0 is taken to mean false, and anything else is interpreted as true. The machine itself indicates true by the number 1. The EQUAL instruction, for example, compares the top two words on the stack, popping them off in the process. If the words are equal, it pushes a 1 on the stack; if they're not equal, a 0. The five instructions NOTEQL, GREATER, LESS, GTREQL, and LSSEQL work similarly. NOT complements the value on the stack; 0 is changed to 1, and anything else is changed to 0. These instructions will come in handy when I discuss the compiler.

There are four instructions for I/O (input/output). WRCHAR and WRINT write the value on the top of the stack to the screen. They differ in whether they treat the value as a character or integer. RDCHAR and RDINT read either a character or an integer from the keyboard and push it on the stack. A couple of miscellaneous instructions round out the set. CONTENTS replaces the address at the top of the stack by its contents, and HALT stops the machine.

THE VM2 INSTRUCTION CYCLE

The job of VM2 is to laboriously but accurately execute machine instructions. The basic algorithm is simple: A loop fetches the next instruction from memory and executes it. If a HALT instruction is ever seen, the loop stops. I'll now explain how to implement the loop, which is called the *instruction cycle* of the machine:

1. Get the next instruction from mem-

(continued)

Mnemonic	Instruction	Arg?	Function
Arithmetic			
ADD	Add	no	Add the top two values on the stack.
SUB	Subtract	no	Subtract the top of stack from the value below it.
MUL	Multiply	no	Multiply the top two values on the stack.
DIV	Divide	no	Divide the second value on the stack by the top one. Truncate and discard the remainder (like Pascal's DIV operation).
NEG	Negate	no	Negate the top of the stack.
Boolean			
EQUAL	Equal	no	If the top two items on the stack are equal, push a 1; else push a 0.
NOTEQL	Not Equal	no	If the top two items on the stack are not equal, push a 1; else push a 0.
GREATER	Greater	no	If the top of the stack is greater than the value below it, push a 1; else push a 0.
LESS	Less	no	If the top of the stack is less than the value below it, push a 1; else push a 0.
GTREQL	Greater or Equal	no	If the top of the stack is greater than or equal to the value below it, push a 1; else push a 0.
LSSEQL	Less or Equal	no	If the top of the stack is less than or equal to the value below it, push a 1; else push a 0.
NOT	Not	no	If the top of the stack is 0, replace it with 1; else replace it with 0.
Stack Manipulation			
PUSHC	Push Constant	yes	Put the argument on the stack.
PUSH	Push	yes	Put the contents of the location specified by the argument on the stack.
POPC	Pop Constant	yes	Put the top of the stack into the location specified by the argument.
POP	Pop	no	Put the second value on the stack into the location specified by the top of the stack.
Control			
BRANCH	Branch	yes	Set the program counter to the location specified by the argument.
JUMP	Jump	no	Set the program counter to the top of stack.
BREQL	Branch if Equal	yes	If the top of the stack is 0, branch to the argument.
BRLSS	Branch if Less	yes	If the top of the stack is less than 0, branch to the argument.
BRGTR	Branch if Greater	yes	If the top of the stack is greater than 0, branch to the argument.
Input/Output			
RDCHAR	Read Character	no	Read a character from the keyboard and put its ASCII value on the stack.
RDINT	Read Integer	no	Read an integer from the keyboard and put it on the stack.
WRCHAR	Write Character	no	Write the top of the stack to the screen, treating it as an ASCII value.
WRINT	Write Integer	no	Write the top of the stack to the screen, treating it as a signed integer.
Miscellaneous			
CONTENTS	Contents	no	Replace the top of stack with the contents of the location specified by the top of stack.
HALT	Halt	no	Stop the machine.

Figure 1: *The instruction set of the* VM2 *virtual machine.*

My approach to implementing VM2's instructions was straightforward.

ory. You know which instruction the "next" one is because, by convention, the programCtr register points to it.
2. If the instruction is a HALT instruction, stop the machine.
3. Increment the programCtr register. It will now point to the next instruction or to the argument of the current instruction if it has one.
4. Execute the instruction. This means looking up the instruction in a table and jumping to the appropriate subroutine.
5. Go to step 1.

Obviously, most of the work is done in the subroutines that implement each instruction. An instruction with an argument can find the argument by seeing where programCtr is pointing, but it has to remember to increment programCtr to point to the next instruction.

Implementing VM2

Ideally, VM2 should be implemented in assembly language for speed. But I don't enjoy programming in assembler, and there is the additional drawback that there is no one standard assembly language that everyone can read and understand (after all, portability is one good reason for using a virtual machine). Instead, I wrote VM2 in Modula-2, which is my programming language of choice these days.

Writing a machine simulator in a high-level language is a bit tricky because the machine "hardware" likes to be able to interpret memory values in different ways: sometimes as an address, sometimes as a signed integer, sometimes as a character, or perhaps even as an instruction. But many high-level languages, the so-called strongly typed languages, are rather insistent about assigning a unique type—integer, character, real, etc.—to every location. You have to implement VM2's memory words as some type, but you need to be able to treat those words as being of several different types.

Pascal programmers have long known how to defeat the Pascal type system. You set up a variant record that has one variant for each of the different types you want to use. Accessing the record as r.int, say, lets you view its contents as an integer; using r.ch lets you use it as a character. If you program in Pascal, this solution is necessary, but it is rather inelegant. It's also somewhat dangerous because its correctness depends on the computer you're using. On some machines, characters and integers may be compatible; on others, perhaps not. The Pascal compiler won't tell you.

Modula-2 has a better solution. I find it much more elegant, and while it's still machine-dependent, it's considerably safer than the Pascal approach. It also makes it easier to identify the machine-dependent parts of your code. Modula-2 has a built-in type called WORD, whose actual size is implementation-dependent, but is considered to be the smallest useful unit of storage on the machine. You can change the type of a WORD variable easily. For instance, if w is of type WORD and you want to convert it to an INTEGER, just write INTEGER(w). No actual computation is performed in converting between types; INTEGER(w) just indicates to the compiler that a value of type WORD is to be treated as an INTEGER. If INTEGERs and WORDs aren't compatible (i.e., if INTEGERs occupy more than one WORD of storage), the compiler will let you know. Happily, CHARs and INTEGERs, as well as the representations for VM2 addresses and instructions, are all compatible with WORDs in the implementation of Modula-2 I use and, I strongly suspect, in nearly all others.

With this little problem out of the way, building VM2 is a straightforward matter. Memory is an array of WORDs; registers are global variables; a CASE statement takes care of dispatching to the appropriate subroutine for executing an instruction. Instructions (called op codes in my implementation) are represented by a scalar type,

```
TYPE opCode = (Add, Sub, Mul,
  Div, . . . );
```

The Modula-2 compiler takes care of mapping the elements of this type—Add, Sub, and so on—to numbers. For instance, Add turns out to be 0 when viewed as an integer. It's important not to confuse these op codes with the mnemonics ADD, SUB, etc., which are character strings. The monitor program I've provided has facilities for converting between mnemonics and op codes.

The two workhorses of the simulator are the pushWord and popWord procedures; nearly every instruction uses one or both of them. They handle the stack, including checking for underflow (trying to pop something off an empty stack) and overflow (trying to push something past stackLimit).

In addition to the VM2 simulator, I've also made a simple monitor program available. It is of little theoretical interest but of enormous practical value in using VM2. It provides facilities for examining and storing into VM2's memory, printing out the contents of the stack and registers, running programs, and single-stepping (executing programs one instruction at a time). By the way, if you know Pascal but not Modula-2, you shouldn't be afraid to look at the program. The two languages are so similar that you ought to have little difficulty reading the code, and the only trouble involved in translating it into Pascal is the problem of type conversion that I discussed above. [*Editor's note: The code for* VM2 *can be found on* BYTE*net Listings. The phone number is* (617) 861-9774.]

Notes on Efficiency

My VM2 implementation is designed for clarity and portability, not efficien-

(continued)

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Instructions and data each occupy one word.

cy. It is possible both to increase the speed of the interpreter and to reduce the size of the instructions.

My approach to implementing VM2's instructions was straightforward. I wrote some low-level routines to do pushes and pops, then used them in implementing the instructions. So the code for ADD, for example, actually pops two values off the stack, adds them, and pushes the result back on the stack. But the pops and pushes are expensive: Each one checks for an error, increments or decrements the stack pointer, and accesses a memory location. Furthermore, using one of the routines means doing a subroutine call. We can get the same effect as my ADD more cheaply by first checking if there are at least two things on the stack (a quick test of the stackPtr register) and then, if there are, adding the top item to the one below it and incrementing the stack pointer. Although I find this stack juggling a bit inelegant, it is certainly faster.

For reasons of simplicity and portability, I stipulated that instructions and data each occupy one word. But if a word is 16 bits—a typical value, and in fact the size of the WORD data type in MacModula-2—then the instructions are much too large. An instruction size of a byte (8 bits) is more reasonable; it provides room for 256 instructions, which is plenty. You would have enough instructions to fill all your needs and still have enough op codes left over to provide useful optimizations of common instructions, which will provide a further reduction in space. For example, pushing small constants like 0 and 1 is a common operation. PUSHC 0 takes two words (or 4 bytes) in the current implementation; by making instructions 1 byte long, you could get it down to 3 bytes; but by providing a special PUSH0 instruction, you could reduce it to only 1 byte.

You could also save space by allowing byte-size as well as word-size arguments. A "Push Small Constant" instruction, which took a 1-byte argument, would make it possible to push values from 0 to 255 with only 2 bytes. Or it might treat its argument as a signed integer, allowing values from −127 to 128. The control instructions are also ripe for byte shaving. Since most branches are to nearby locations, a variety of branch instructions that took a 1-byte offset from the current address rather than a 2-byte absolute address would reduce the size of most branch sequences. It would make the most sense in this case to treat the byte as an integer between −127 and 128.

All these space-saving hacks and more can be found in the instruction sets of "real" computers. You should definitely consider them if you want to write a virtual machine for serious work on a microcomputer. But as you'll see when I discuss the compiler, you can get an even greater space reduction by encoding complicated high-level language operations, which would take many instructions on a conventional architecture, into a single virtual-machine instruction.

Where To Go from Here?

When you get your virtual machine up and running, you will discover a somewhat depressing fact: It's not much fun to program. Poking instructions into memory one by one using the monitor is only a few steps above flipping toggle switches on a front panel. Now that may send a nostalgic shiver down your spine, but being a software person, I would rather have something do the job for me. I'd like to be able to write my program as a list of mnemonics, and I'd like to be able to use symbolic names for memory locations rather than numerical addresses. I'd like a program that translated the mnemonics and symbolic names into the op codes and addresses that VM2 prefers. In short, what I'd like is an assembler, and that is what my next programming project will be about. ■

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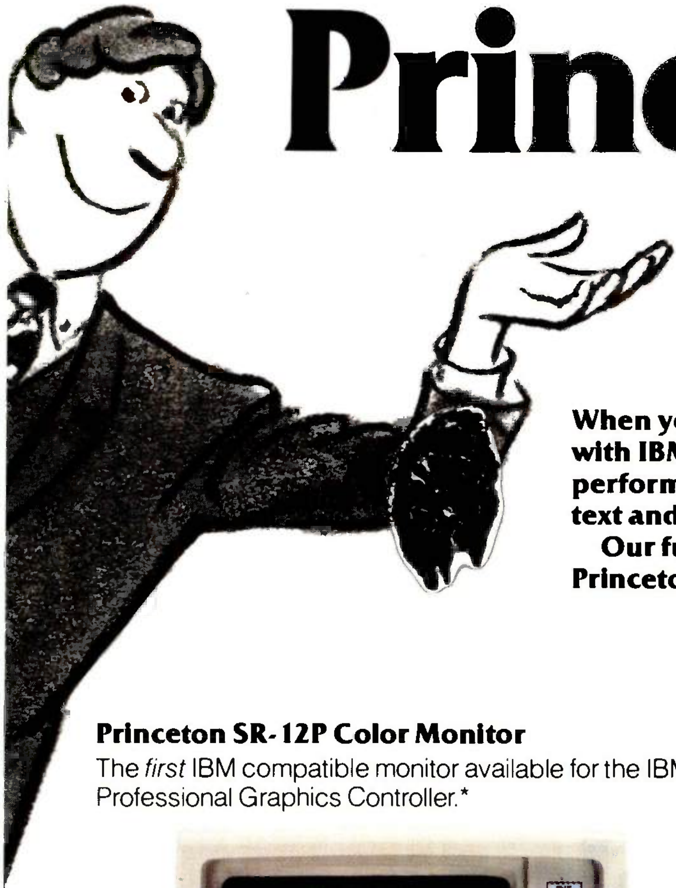

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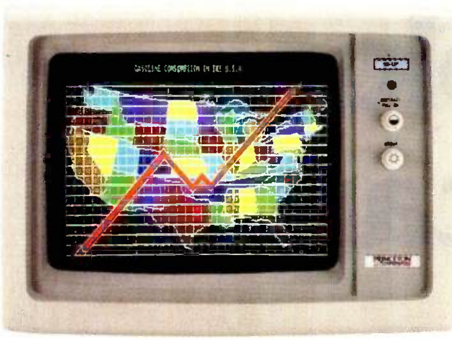

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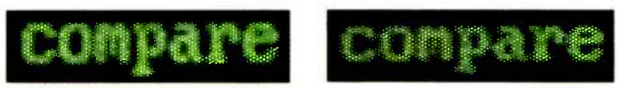

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On a morning in March 1983, a group of technicians gathered at Haverford High School in a suburb of Philadelphia. Each brought an electrical, mechanical, or software component for a revolutionary new camera system named Skycam (see photo 1). Skycam is a suspended, mobile, remote-controlled system designed to bring three-dimensional mobility to motion picture and television camera operation. (See the text box on page 128.)

I used an Osborne 1 to develop Skycam's control program in my basement, and it took me eight months of evenings and weekends. As of 3 a.m. that morning, however, the main control loop refused to run. But 19 hours later, Skycam lurched around the field for about 15 minutes before quitting for good. Sitting up in the darkness of the press booth, hunched over the tiny 5-inch screen, I could see that the Osborne 1 was not fast enough to fly the Skycam smoothly.

In San Diego 18 months later, another group of technicians opened 20 matched shipping cases and began to get the Skycam ready for an NFL preseason game between the San Diego Chargers and the San Francisco Forty-Niners. The Skycam was now being run by an MC68000 microprocessor-based Sage computer, and a host of other improvements had been made on the original. [*Editor's note: The Sage Computer is now known as the Stride; however, the machine used by the author was purchased before the company's name change. For the purpose of the article, the machine will be referred to as the Sage.*] For the next three hours, Skycam moved high over the field fascinating the fans in the stadium while giving the nationwide prime-time TV audience their first look at a new dimension in sports coverage.

Skycam represents an innovative use of microcomputers. The portable processing power needed to make Skycam fly was unavailable even five years ago. That power is the "invention" upon which the Skycam patents are based. It involves the support and free movement of an object in a large volume of space. The development team used the following experiment to test the movement and operation of the Skycam.

At a football field with one lighting tower at each of four corners, the team members bolted a pulley to the top of each pole, facing inward. Then they used four motorized winches, each with 500 feet of thin steel cable on a revolving drum and put one at the base of each tower.

Next, they ran a cable from each motor to the top of its tower and threaded the cable through the pulley. They pulled all four cables from the tops of the towers out to the middle of the field and attached the cables to a metal ring 2 feet in diameter weighing 10 pounds (see figure 1). A motor operator was stationed at each winch with a control box that enabled the operator to slowly reel in or let out the cable. Each motor operator reeled the cable until the ring was suspended a few feet from the ground, and then they were ready to demonstrate Skycam dynamics.

All four motor operators reeled in the cable. The ring moved upward quickly. If all four motors reel in at the same rate (and the layout of lighting towers is reasonably symmetrical) the ring will move straight up. In the experiment, the two motors on the left reeled in and the two on the right reeled out. The ring moved to the left and maintained its altitude. An instruction was given to the two motor operators on the left to reel out and the two on the right to reel in just a little bit. The ring moved right and descended as it moved back toward the center.

The theoretical basis of this demonstration is quite simple. For each point in the volume of space bounded by the field, the four towers and the plane of the pulleys, there is a unique set of four numbers that represents the distances between that point and each of the four pulley positions. Following the layout above for an arbitrary point on the field, you can compute the distances from that point to each pulley, then turn each motor until the computed amount of line is out between the ring and the pulley. You will find that the ring has moved from wherever it was to the selected point.

The following are needed to create a Skycam transport mechanism:

- a way for an operator to choose the destination point for the camera
- an algorithm that can calculate the set of four line lengths associated with that point
- a control mechanism at each winch assembly to run the motor in the proper direction until the right amount of line is played out

Operator Interface

The Skycam operator, or pilot, sits on the right side of a two-person console (see photo 2). The pilot is responsible for moving the camera through space. To the pilot's left sits the camera operator, who fulfills the more traditional camera operator role. The camera operator points, zooms, and focuses the camera and is responsible for the contents of the picture. Controls are connected to a multichannel RF (radio frequency) remote-control link and are used by the camera operator to communicate his or her movements to the camera.

Two joysticks are mounted to a horizontal panel (see photo 3). These are force-sensitive joysticks, which do not tilt but instead stay upright and re-

(continued)

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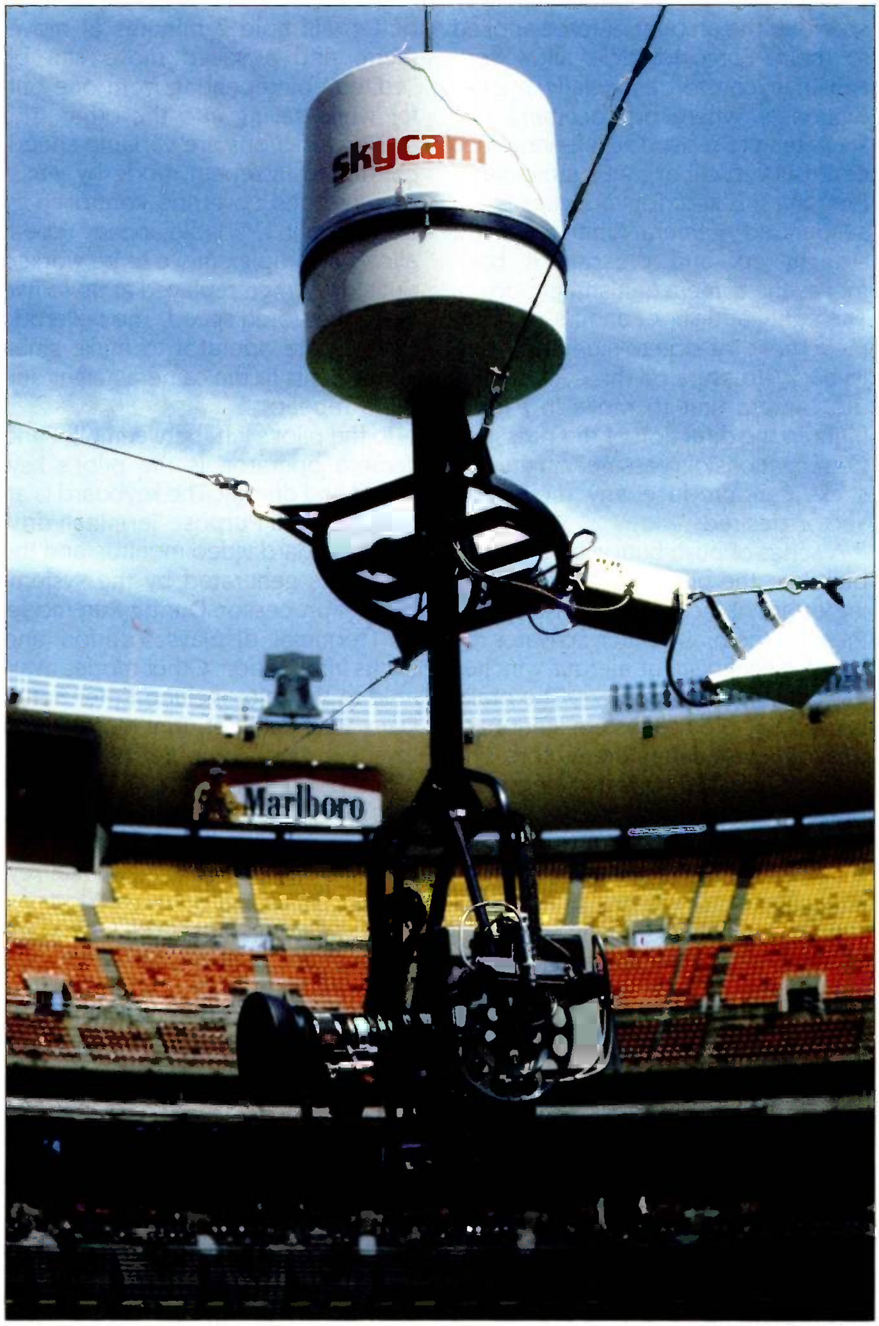

Photo 1: *Skycam rigged for action at Veteran's Stadium in Philadelphia.*

spond to the amount of force applied to them. Force joysticks allow very sensitive control, especially on the diagonals, where displacement joysticks tend to resist. The left-hand stick controls vertical or *z*-axis movement. Pressing this stick forward causes the suspended camera unit to move straight up, and pressing it back moves the camera unit straight down. The right-hand stick controls *x,y* plane movement, or side-to-side and front-to-back. Pressure on this stick causes the camera unit to move in a level flight in the direction of the pressure. Combinations of pressures on the two sticks can produce any movement vector desired.

A series of push-button switches are built into the pilot's panel. The most important of these is the brake switch. Pressing the brake switch activates the brake mechanism at all four winches and disables the joysticks. The brake is used to hold the system stationary to avoid overheating the motors. The switch is pressed again to release the brakes prior to movement.

A group of five switches controls the save and repeat functions. The software maintains two buffers that can be used to record the sequence of stick pressures that make up a movement. These recorded commands can be replayed to reproduce the original movement exactly. Each buffer will hold 2 minutes of movement, and a saved move can be "edited" by repeating from one buffer while saving into the other. The editing functions are variable speed, controlled in repeat mode by *y*-axis pressure, and *z* override, controlled by the *z* stick. Variable-speed repeat allows a complex move to be worked out slowly, then replayed at up to five times the stored speed. The *z* override enables the operator to make small adjustments to the camera height during a repeat.

To the pilot's left, between pilot and camera operator, is the pilot's keyboard and display. The keyboard is an RCA APT (All Purpose Terminal) driving a standard video monitor, and the display is generated by the system-control processor. During Run mode, the terminal displays location and status information. Other modes available to the pilot include Enter Setup Data, Boundary Set, Trim Motors, Trim Joysticks, and Computer Mode.

The pilot's console is linked to the control processor with two cables. An RS-232C link is used to update the terminal display and collect terminal keystrokes. An IEEE (Institute of Electrical and Electronics Engineers) standard interface, the IEEE-488, or GPIB (general-purpose interface bus) interface is used to input joystick values and push-button events and to output the status bits that control the panel indicator lights. The choice of the GPIB was an early design decision, influencing the selection of both the Osborne 1 and Sage computers. The Skycam development team needed an interface that was fast, reliable, and device-addressable and had easy-to-implement hardware linkages.

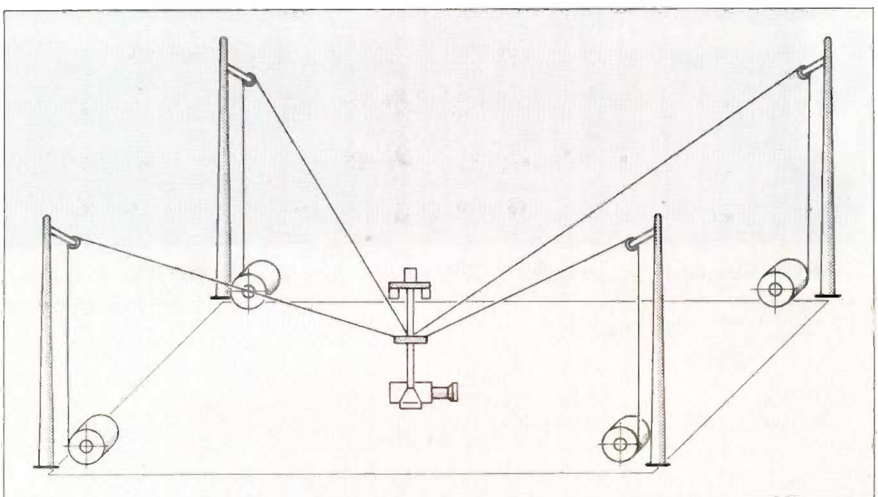

Figure 1: *The physical support and positioning system for Skycam. On a football field, this setup requires several thousand feet of cable.*

FORTH AS A DEVELOPMENT LANGUAGE

The core of the Skycam movement system is the central processor and the movement-calculation routines that run on it. These routines are implemented in software that translates the pilot's desires into commands for each of the four motors. My partner, David Hastings, and I wrote the software in FORTH, the language of process control, with time-sensitive routines written in assembly-language. The FORTH package we used is the very fast HyperFORTH direct-threaded implementation from WSM Group Inc. of Tucson, Arizona. The microcomputer is a Sage II, featuring an MC68000 running at 8 MHz with no wait states.

Due to the from-the-ground-up nature of this project, it was to our advantage that we had no preconceptions about development languages. We prepared an evaluation table listing the important factors we had to consider. Although items such as cost, license arrangements, maintainability, access to low-level hardware functions, and development productivity were listed, it was clear to us that the two most important factors were speed of execution and transportability.

David and I knew that the speed of the movement cycle would be a major factor in the performance of the system. Also, because this would be a multiyear project, the quality and speed of the hardware available would increase dramatically, thus the emphasis on transportability. We knew that we didn't know enough about the application at that point to definitively pick the target hardware configuration. We wanted the flexi-

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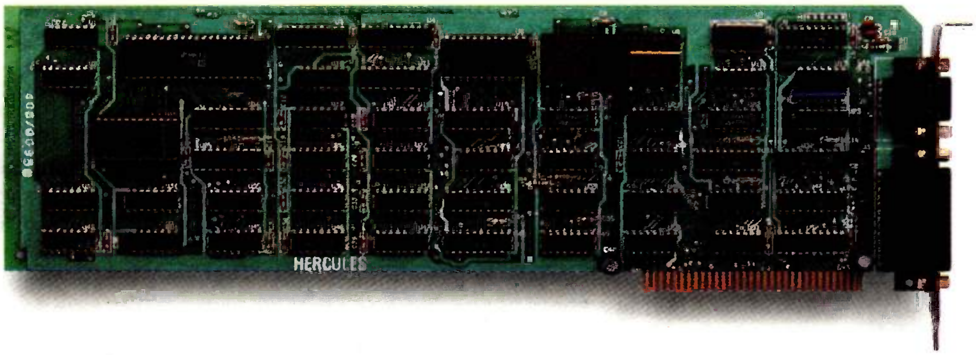

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bility to upgrade the hardware in the future without having to rewrite the software.

Based on our research, we chose FORTH. I felt that it offered the advantages of assembly language, such as speed of execution and access to low-level machine resources, without the disadvantages of lack of transportability and a slow and tedious development cycle. Also, David and I thought that FORTH's interpretive nature would be useful in validating the software. In retrospect, FORTH has been largely a successful choice. Perhaps some of our experiences are useful illustrations of FORTH as a development tool.

First, there was the learning curve. Both David and I had no previous experience with FORTH. We both found that it took about three months to become comfortable with the language and even longer to write fast, well-structured, easily maintainable code. Even now, three years after I began to code in FORTH, I am still revising my concepts of structuring and flow of control. The desire to rewrite old code is a constant threat to productivity.

The issue of transportability turned out to be crucial. Our original estimates of the desired cycle speed turned out to be too slow by a factor of four, and at least twice the estimated precision was ultimately needed. The solution was a hardware upgrade from a Z80-based Osborne to a MC68000-based Sage II. Although there are few microcomputers that are farther apart than these two, and the FORTH implementations were completely different, the conversion took a total of about 60 hours. We spent most of that time writing an IEEE-488 driver for HyperFORTH. FORTH migrations are easy. We just figured out a way to port the ASCII (American Standard Code for Information Interchange) source code, compiled it on the new machine, and wrote our own version of the low-level words that were different or not available. This ease of transportability is a key success factor when the target hardware environment is in doubt.

The third extremely critical aspect of FORTH was testing and validation. Our application involved suspending a 40-pound camera unit high above the heads of spectators, so we became very interested in bug-free software. Dave and I found that, because of FORTH's interpretive nature and stack-based module interfacing, we could write small sets of routines and check them out individually and completely before combining them into larger routines. This gave us confidence in the quality of the code. Significant productivi-

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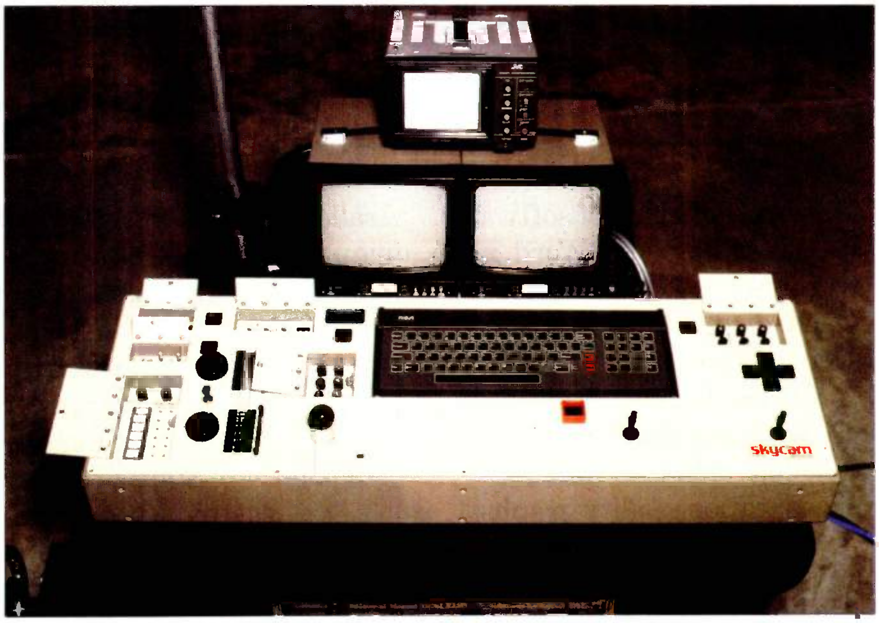

Photo 2: *The Skycam console with the camera operator's panel at the left and the pilot's joysticks on the right.*

Photo 3: *The joysticks being operated by Skycam's pilot.*

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ty gains were the result of this approach. We found that when we combined our unit-tested FORTH words into larger routines, they usually worked. Debugging was reduced from a major barrier to an integration step. As a result, in the third iteration of our development cycle, Dave and I generated about 70K bytes of complex, highly compact FORTH object code in approximately four months.

In summary, FORTH gets low marks for the length of the learning curve and almost as low marks for maintainability. Although it is possible to write obscure code in any language, when used improperly FORTH can be truly hieroglyphic. FORTH gets medium marks for speed. There are performance penalties imposed by the structure of the language, especially in the hands of novices. On the other hand, the time-sensitive words can be individually optimized in assembly language. FORTH gets high marks for transportability, testability, and programming productivity. Until you use it, you can't believe how quickly a rough-cut version of a problem can be up and running. This was particularly important for the Skycam project because our "spec" was developed and modified with successive versions of the system. Thus, FORTH is particularly well suited to the iterative approach to software development. All in all, we feel that our use of FORTH helped make our software development successful.

THE MOVEMENT ALGORITHM

Only a small part of Skycam's software does actual calculations. Most of the program deals with giving the pilot options and status data, getting stick and switch data from the pilot's control panel, saving and repeating moves, checking boundaries, and shipping data out to the motors (see figure 2). About 95 percent of the program consists of superstructure needed to support the movement-calculation routines. However, the movement calculations are pretty straightforward.

As discussed previously, each motor needs to know how much line should be out between the motor's pulley and the camera. This "length of line" can be expressed as a distance between two points if you ignore the catenary curve. We want the straight-line distance between the pulley and the desired camera position. From analytical geometry we know that if the coordinates of two points are known, the straight-line distance between the two can be calculated by applying the Pythagorean theorem. So we store the positions of the four pulleys in memory. We get the desired camera position by using the joystick inputs to modify the current position. That way the operator is always moving the camera relative to where it is currently. We use the pulley positions and the desired camera position to calculate the new line lengths. These updated line lengths are then shipped out to the four motor controllers.

Although the line-length calculations are conceptually simple, their implementation poses a few sticky questions, such as: What are the coordinates of the top of a light tower 70 feet in the air? Coordinates relative to what? How does the computer know where the camera is? These are good questions, and they prompted us to explore current engineering and surveying techniques. After talking to a lot of people and doing some experiments, we came up with the following solution: Blueprints of the proposed venue are studied, pulley mounting points are planned, and maximum operating altitude calculations are made to determine if the camera unit can operate at acceptable altitudes and clearances from lights, scoreboards, etc. After studying the plans, a coordinate system is set up

(continued)

THE ORIGIN OF THE SKYCAM CONCEPT

Skycam is the brainchild of Garrett Brown, the Philadelphia-based camera operator, writer, radio-advertisement personality, and raconteur. Brown is a unique and funny fellow whose humor and voice have been heard from coast to coast on a well-known beer commercial.

Garrett is first and foremost an inventor. He invented the Steadicam, which is a camera-mounting device that enables a skilled operator to walk, run, or skip while carrying a camera mounted to a stable platform. Steadicam is a very useful application of a complex mechanical design, and Brown won an Oscar for his work. Steadicam is also difficult to use, and, not surprisingly, Brown is the world's foremost operator. His Steadicam work has been in over two hundred films, including "Return of the Jedi" and "Indiana Jones and the Temple of Doom."

In his role of Steadicam operator, Brown has had the opportunity to observe people try many things in order to get a unique camera perspective. And so, being closely attuned to the limitations of current camera use, Garrett developed the Skycam concept.

Photo A: *Skycam with its creator Garrett Brown.*


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to determine the direction of the x- and y-axes. The determining factor is usually where the pilot will be sitting. Since layout of the axes will determine the direction of camera movement when the pilot applies x stick, it makes sense to align the axes with sidelines, foul lines, or other landmarks.

At this time an origin point for the coordinate system is chosen. The choice is completely arbitrary from the system's point of view. Any point within the bounds of the pulleys will work as long as the pulley locations can be measured relative to that point and the camera unit can be hooked up to the lines at that point. In practice, however, we found that overall system performance is best when the pulleys are in a rectangular configuration and the origin is precisely in the center. Once the center point has been located and the pulleys placed, a surveying instrument called a theodolite is set up at the origin. Using this surveying instrument, we measure the horizontal and vertical angles of the sight line to each pulley and use these angles to calculate the positions of the four pulleys relative to the point. The pulley positions are represented in x-, y-, and z-coordinates of each pulley relative to the origin point and aligned with the chosen major axes. This completes the survey portion of the setup.

We enter the pulley coordinates into the program and we set up the Skycam so that the camera starts at the origin point. This puts the software model of the system and the real-world system in sync. From then on, the computer calculates the camera's new position, and the motor controllers keep the physical system in step with the computer's commands.

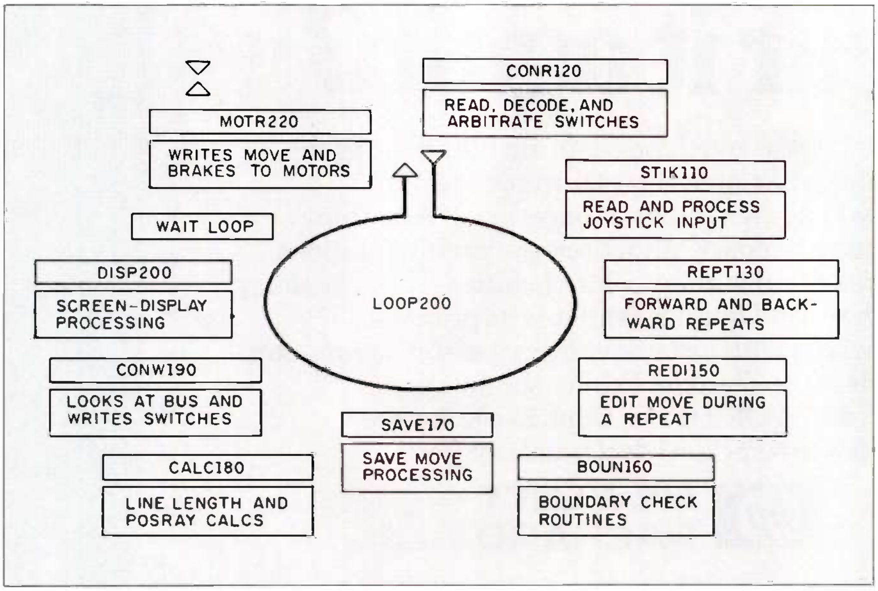

Figure 2: A *software flow-of-control diagram for Skycam's main software loop. The text above the double line in each box is a* FORTH *word whose function appears below the line.*

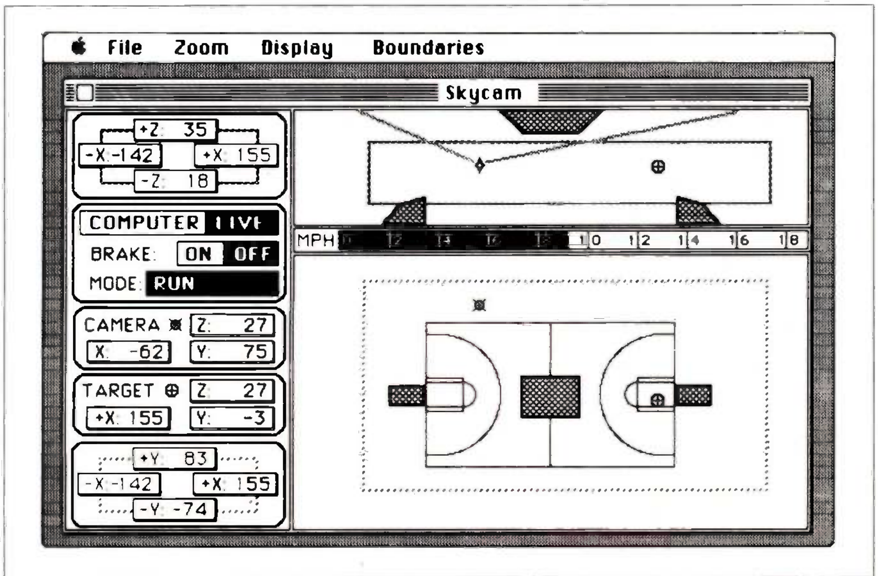

Figure 3: A *proposed Skycam basketball graphics display generated by a* Macintosh *used as an intelligent terminal attached to Skycam's computer.*

THE MOTOR CONTROLLERS

The motor controllers are separate single-board computers at each motor. An intelligent motor controller was needed to reduce communications overhead, to provide more sophisticated control algorithms, and to enable more functionality in the areas of manual control and error detection. The custom single-board computer is based on an MC6809 processor.

The motor controller receives command strings from the Sage II via an RS-422A link and decodes them. The command string contains a new line length for the motor controller. The controller compares the new line length with the old line length and turns the motor in or out to bring the line to the proper length. An optical encoder is connected to the motor shaft to provide positional control. Various sensors, including brake, amperage, voltage, and motor temperature, are monitored continuous-

(continued)

ly. The motor controller performs the difficult task of running the motor smoothly under wildly varying load conditions.

The movement loop works as follows: The joystick pressures supplied by the pilot are converted into 8-bit values and sent to the Sage II. There the *x*, *y*, and *z* values are clipped, log-scaled, and converted to a desired movement vector. This vector is added to the current camera position to give the desired position. The desired position is boundary-checked and the movement-vector components adjusted if necessary to keep the desired position in bounds. The distance between the desired camera position and each pulley position is calculated and shipped out to the appropriate motor. Each motor controller then compares the new length to the old or previous length and winds its winch in or out accordingly. Do this many times a second at very high resolution, and you can move a Skycam smoothly about a football field.

Future Developments

Skycam is far from finished. Although much work has gone into the current version, some significant improvements are in the offing. First and foremost is a graphics display for the pilot that shows a top and side view of the field with a moving position indicator. We feel that the graphics capabilities of the Macintosh make it a good choice for a smart graphics terminal (see figure 3). The design team is also planning an upgrade to a Stride 420, with a faster MC68000 and a math-coprocessor option. Software improvements that we are planning include a goto feature and improved boundary setting and obstacle avoidance.

I have described the microcomputer-based movement system, but Skycam includes much more. Some of the electronics and communications features are at least as remarkable. Skycam carries the lightest available broadcast-quality video camera. The camera is steadied by an active stabilization system featuring avionics gyros and rare-earth-magnet motors. The world's smallest microwave transmitter is used to transfer the signal from the camera to the ground. And the camera, the half-dozen motors, the 30,000-rpm (revolutions per minute) gyro, the RF receiver, and the microwave transmitter get power hanging out there on those wires through an innovative switching power supply. A trickle charge down the lines powers a light, high-efficiency power supply that delivers appropriate voltages to different parts of the camera system. Skycam is a state-of-the-art machine whose time has come because, until a few years ago, many of its components were not available. ■

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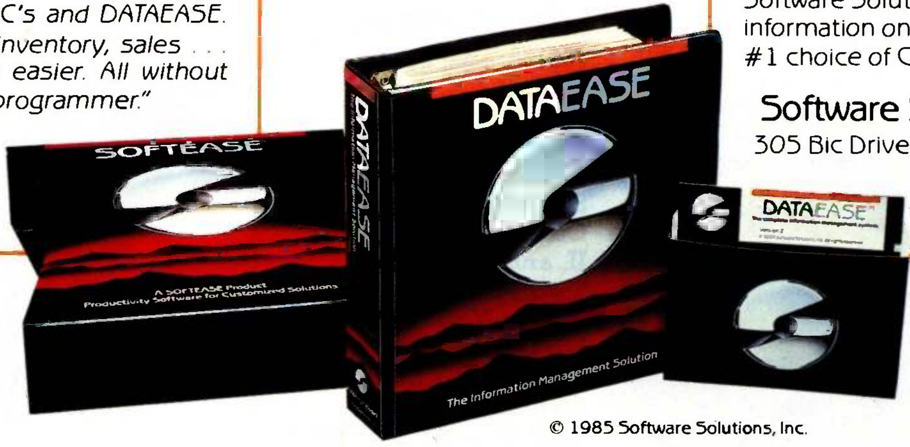

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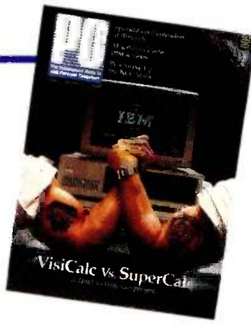

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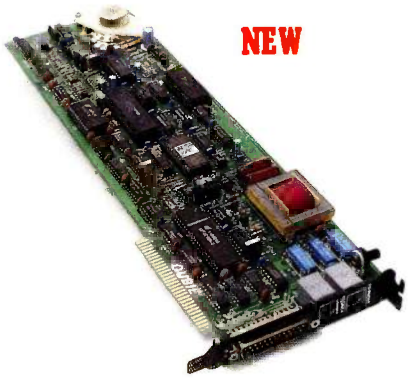

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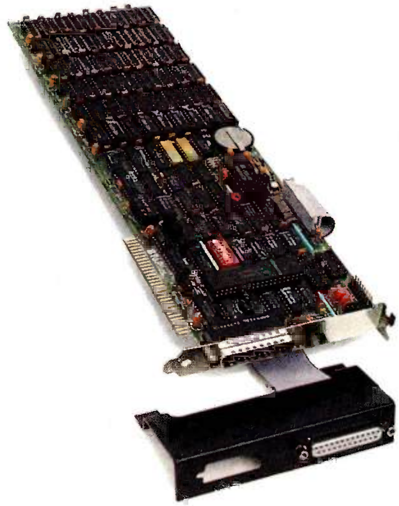

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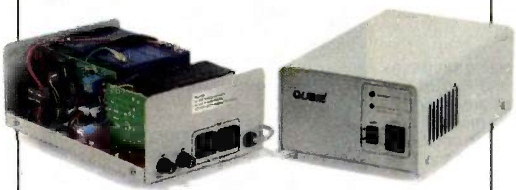

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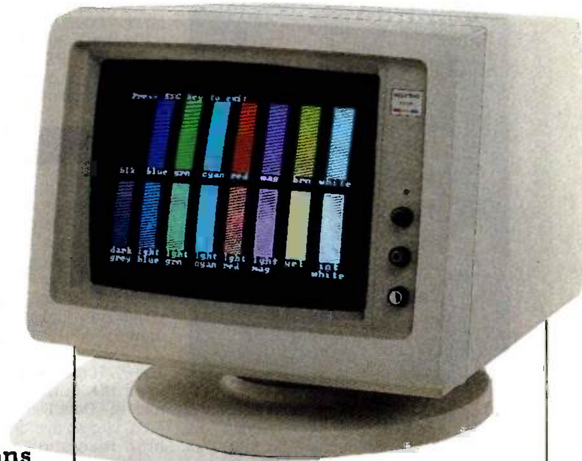

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SIMULATING THE NORMAL DISTRIBUTION

By Arthur G. Hansen

A BASIC *routine for bell-curve sampling*

WHEN YOU USE your computer to simulate natural processes, you frequently want to introduce random effects. Most computers have pseudorandom-number generators that produce sequences of pseudorandom numbers. In BASIC, for example, there is the RND(*X*) function, which produces numbers with a uniform probability density in the range from 0 to less than 1. For example, to simulate the value of a thrown die, you could use this kind of BASIC statement:

```
10 X = INT(1 + 6*RND(Q))
```

This statement will produce a sequence of integers in the range from 1 to 6, with equal probabilities of occurrence. This equal-probability property is one of the essential characteristics of uniform distribution.

The most common alternative to uniform distribution is the Gaussian (or normal) distribution, which has the well-known bell shape. Phenomena following this distribution tend to cluster about the mean value of the entire group. As values depart from the mean, they occur less frequently.

The properties of the normal distribution are well covered in most elementary statistics textbooks. If you look in the back of such a book, you should find tables of numerical data describing these properties.

There is more than tradition to the widespread use of the normal distribution. Statisticians like it because it is well behaved and predictable. They find it helpful to combine phenomena, each with its own normal distribution, into a distribution that is also normal.

Natural phenomena, such as electrical-noise voltages or annual precipitation totals, are not usually uniformly distributed. Instead, they are more likely to follow a normal distribution.

Therefore, in simulation work it helps to have a computationally simple means to generate pseudorandom numbers with a normal distribution. You can do this easily by combining uniformly distributed numbers, such as those from the RND(*X*) function of BASIC. Simply add several values from the RND function and average them. The distribution of the average of three or more uniformly distributed random numbers has a distribution that is close to the normal (see figure 1).

In addition to this delightful property, it is easy to calculate the mean and standard deviation for the resulting distribution. If your BASIC's RND function generates pseudorandom numbers that are uniformly distributed over the range from 0 to 1, then the mean value of this uniform distribution is 0.5. Thus, the distribution of the sum of *N* such numbers will have a mean of $0.5 \times N$.

The standard deviation of the means of *N* items from a uniform distribution is given by: standard deviation = 1/SQR(12*N), as shown in table 1.

By following two rules you can tailor the statistical properties of the distribution to get what you need:

1. Adding a constant, *K*, to all of the samples increases the mean value of

(continued)

Arthur G. Hansen, P.E., is the founder of Park Engineering Company (720 South Harvey Ave., Oak Park, IL 60304).

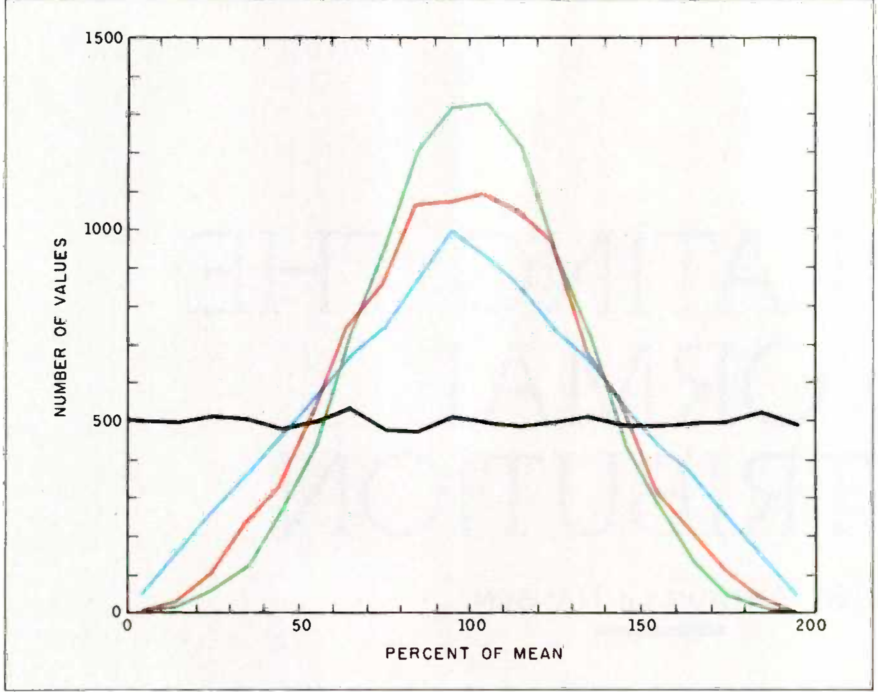

Figure 1: *A plot of distributions for* 10,000 *samples of one- (black), two- (blue), three- (red), and four-number (green) summations.*

Table 1: *Standard deviations from the mean for one-, two-, three-, and four-number summations.*

Number of Items	Standard Deviation
1	0.289
2	0.204
3	0.167
4	0.129

Listing 1: A *sample* BASIC *program to generate a three-number-sum normal distribution with a mean of* 5 *and a standard deviation of* 1.5.

```
10 MN=5 : SD = 1.5 : REM desired parameters
20 S3X = 1/SQR(12*3)) : REM standard deviation mean of 3
30 X = RND(4) + RND(4) + RND(4)
40 X = (X/3) - 0.5 : REM mean now 0
50 X = X * (SD/S3) : REM standard deviation now 1.5
60 X = X + MN
70 REM mean X is MN, standard deviation is SD
```

There is one thing to watch out for: extreme values.

the group of samples by *K*.

2. Multiplying all of the samples by a constant, *M*, changes the mean of the group by the factor *M* and changes the standard deviation by the factor *M*.

Suppose that you want to generate a sequence of random numbers with an approximately normal distribution, a mean value of 5, and a standard deviation of 1.5. Listing 1 shows how you can do it with a simple BASIC program.

However, there is one thing to watch out for: extreme values. If you're generating a sequence of pseudo-random numbers from the mean of, say, three numbers from a uniform distribution, the range of these numbers is limited. Since the original uniform distribution had a range from 0 to (not quite) 1, then the resulting distribution of the means will also be in the range from 0 to 1. No number thus generated can be more than 0.5 unit away from the mean value. Since the standard deviation of the mean of three numbers is 0.167, you cannot possibly get a number more than (0.5)/0.167 = 3 standard deviations above or below the mean value of 0.5.

The practical significance of this limitation will depend on how important these extreme values are to your simulation. If you had a "perfect" generator of normally distributed random numbers, then on the average you would get an extremely low or high value (three or more standard deviations above or below the mean) only once in about 370 trials. Of course, the more numbers you average together in the normal-distribution routine, the more extreme values you can reproduce. For example, by averaging four numbers you can reach almost 3.9 standard deviations from the mean. ■

"Symphony 1.1 now makes translating data from and to other programs push-button simple. It is the first program I've seen that is actually fun to install."

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"I'm thoroughly impressed by Symphony 1.1 and glad to have it. You're going to have to use dynamite to get it out of my machine. It's almost my whole wish list in one."

Dwight Muse, Assistant V.P., Internal Reporting
American Medical Int'l, Beverly Hills, CA

"In our work in financial planning and analysis we have found that Symphony 1.1 does two things. First, it allows us to build spreadsheets which are a little bit bigger than would otherwise fit in the computer...Second, in doing a spreadsheet layout design, we now have greater flexibility because of the new memory allocation."

Ron Diderich, Manager, Financial Planning and Analysis Consulting
Ernst & Whinney, Cleveland, OH

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2. **NEW MEMORY ALLOCATION SCHEME.** The new sparse matrix scheme provides greater flexibility and eliminates the need to arrange worksheets to conserve memory.

3. **MACRO LIBRARY MANAGER.** This permits the creation of libraries of macros that can be accessed from any worksheet and allows the development of multiple worksheet applications.

4. **8087/80287 SUPPORT.** Symphony release 1.1 can take advantage of 8087/80287 math co-processor chips, increasing calaculation speed by up to 60 times.

5. **1-2-3 COMPATIBILITY.** New Symphony supports file translations between Symphony, 1-2-3® release 1A and

"With Symphony 1.1, Lotus has again set the industry standards so high that they'll force the rest of the industry to shoot for the same."

R. L. Martin, Manager Decision Support Systems
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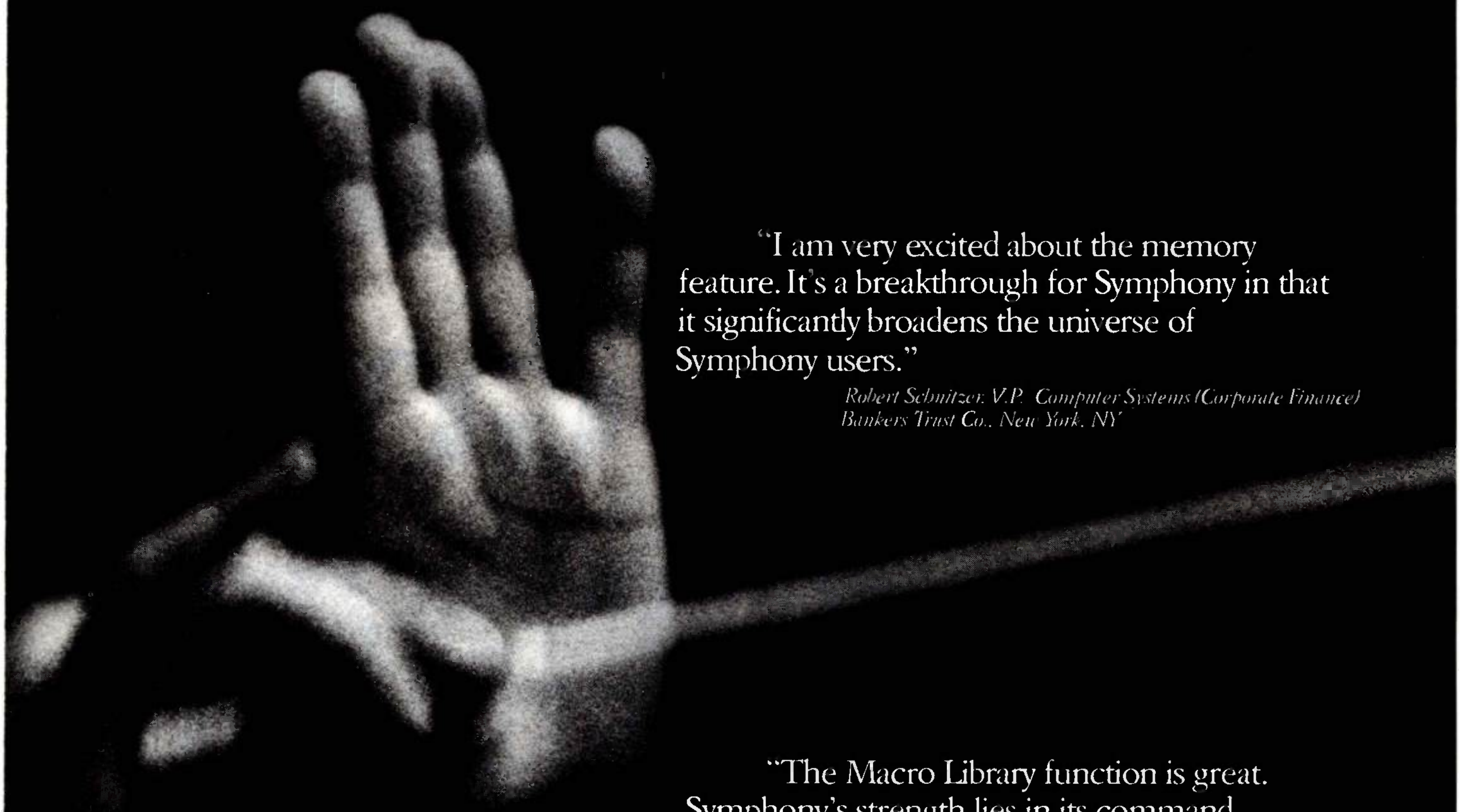

"I am very excited about the memory feature. It's a breakthrough for Symphony in that it significantly broadens the universe of Symphony users."

Robert Schnitzer, V.P. Computer Systems (Corporate Finance)
Bankers Trust Co., New York, NY

"The Macro Library function is great. Symphony's strength lies in its command language."

Sally Nagy, Senior Information Systems Analyst
Aerojet ElectroSystems Co., Azusa, CA

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Inquiry 30

IBM PC JOYSTICK CONTROL USING TURBO PASCAL

BY JAMES P. MCADAMS

In-line assembly code provides high resolution

AFTER I BOUGHT a joystick to use with my flight simulator program, I decided I wanted to use it with the programs I develop on my IBM Personal Computer (PC). The functions I came up with will give you access to two joysticks and four push buttons via the IBM Game Control Adapter.

I do most of my program development with Turbo Pascal. The Pascal functions I developed use several powerful features of that language to avoid a lot of assembly language. However, you can't avoid assembly language entirely because the IBM Game Control Adapter requires a very fast counting loop if you want reasonable joystick resolution. Therefore, my joystick position function uses the Turbo Pascal INLINE statement to implement a fast timing loop. This is probably a better use of the INLINE statement than the one described in the

(continued)

James P. McAdams, president of InterLink Systems, is a consultant in business and industrial applications of small computers. He has an M.S. in electrical engineering from Rice University. He can be reached at POB 3465, Pasadena, TX 77501.

Listing 1: *This program uses Turbo Pascal to access the IBM PC Game Control Adapter.*

```
PROGRAM JOYSTICK;
VAR
I: INTEGER;
TEMP: BYTE;

    FUNCTION BUTTON_PRESSED (WHICH_ONE: CHAR): BOOLEAN;
    (* RETURN TRUE IF THE BUTTON IS PRESSED *)
    CONST
        JOYPORT = $201; (* LOCATION OF THE GAME PORT *)
    VAR
        MASK: BYTE;
    BEGIN
    IF NOT (WHICH_ONE IN ['A'..'D']) THEN WHICH_ONE := 'A';
    CASE WHICH_ONE OF
        'A': MASK := 16;
        'B': MASK := 32;
        'C': MASK := 64;
        'D': MASK := 128;
        END;
    BUTTON_PRESSED := (PORT [JOYPORT] AND MASK) = 0;
    END; (* BUTTON_PRESSED *)

    FUNCTION JOYSTICK_POS (WHICH_ONE: CHAR): INTEGER;
    (*
    WITH A KRAFT JOYSTICK, VALUES RETURNED ARE IN THE RANGE 4
    TO ABOUT 140. IF YOUR MACHINE RUNS FASTER THAN A STANDARD
    IBM PC OR IF YOU MODIFY YOUR GAME ADAPTER CARD WITH BIGGER
    CAPACITORS, YOU WILL GET LARGER COUNTS AND YOU MUST
    MODIFY "MAXCOUNT."
```

(continued)

```
    CALLING A JOYSTICK THAT IS NOT IN USE OR ONE THAT HAS GONE OVER RANGE (COUNT REACHED MAXCOUNT)
    YIELDS A VALUE OF 0.
    *)
    CONST
        MAXCOUNT = 200; (* MODIFY THIS IF YOU CAN GET LONGER COUNTS *)
        JOYPORT = $201; (* LOCATION OF GAME INPUT PORT *)
    VAR
        COUNTER: INTEGER;
        MASK: BYTE;
    BEGIN
    IF NOT (WHICH_ONE IN ['A'..'D']) THEN WHICH_ONE := 'A';
    CASE WHICH_ONE OF
        'A': MASK := 1;
        'B': MASK := 2;
        'C': MASK := 4;
        'D': MASK := 8;
        END;
    (*
    THIS ASSEMBLY CODE CAUSES THE CX REGISTER TO COUNT DOWN FROM MAXCOUNT TOWARD ZERO. WHEN CX
    REACHES ZERO OR WHEN THE ONE-SHOT ON THE GAME ADAPTER TIMES OUT, THE LOOPING STOPS AND
    COUNTER IS ASSIGNED THE NUMBER OF COUNTS THAT TOOK PLACE. MAXCOUNT SHOULD BE CHOSEN SO THAT
    CX NEVER REACHES 0 SO THAT THE USABLE RANGE OF THE JOYSTICK WILL NOT BE LIMITED.
    *)
    INLINE (
        $B9/MAXCOUNT/        (*          MOV CX,MAXCOUNT      INITIALIZE DOWN COUNTER        *)
        $BA/JOYPORT/         (*          MOV DX,JOYPORT       PORT ADDRESS OF JOYSTICKS      *)
        $8A/$A6/MASK/        (*          MOV AH,MASK[BP]      MASK FOR DESIRED ONE-SHOT      *)
        $EE/                 (*          OUT DX,AL            START THE ONE-SHOTS            *)
        $EC/                 (*  READ:   IN AL,DX             READ THE ONE-SHOTS             *)
        $84/$C4/             (*      TEST AL,AH               CHECK DESIRED ONE-SHOT         *)
        $E0/$FB/             (*    LOOPNZ READ                REPEAT UNTIL TIMED OUT         *)
        $89/$8E/COUNTER);    (*          MOV COUNTER[BP],CX   THIS MAKES CX AVAILABLE        *)
                             (*                               TO TURBO PASCAL                *)
    IF COUNTER = 0
        THEN JOYSTICK_POS := 0 (* OVER RANGE OR NOT IN USE *)
        ELSE JOYSTICK_POS := MAXCOUNT - COUNTER;
    END; (* JOYSTICK_POS *)

    BEGIN        (****** DEMO PROGRAM—MAIN CODE ******)
    CLRSCR;
    GOTOXY (1, 2);
    WRITELN ('JOYSTICKS':10, 'BUTTONS':10);
    WRITE ('A':5, 'B':5, 'A':5, 'B':5);

    WHILE TRUE DO (* PRESS CTRL-C TO STOP THE PROGRAM *)
        BEGIN
        GOTOXY (1, 5);
        WRITE (JOYSTICK_POS ('A'):5, JOYSTICK_POS ('B'):5;
        IF BUTTON_PRESSED ('A')
          THEN WRITE ('PRES':5)
          ELSE WRITE ('UP':5);
    IF BUTTON_PRESSED 'B')
          THEN WRITE ('PRES':5)
          ELSE WRITE ('UP':5);
    END;
END.
```

Turbo Pascal reference manual.

Listing 1 shows a demonstration program that is useful for debugging the hardware hookup and for determining the count range of your joystick or paddles. (This program is also available through BYTEnet Listings. The telephone number is (617) 861-9774.) Notice that these functions are completely stand-alone; they do not share constants or variables with each other or with the main program. Either function (or both) can be inserted into your programs without any other declarations. ■

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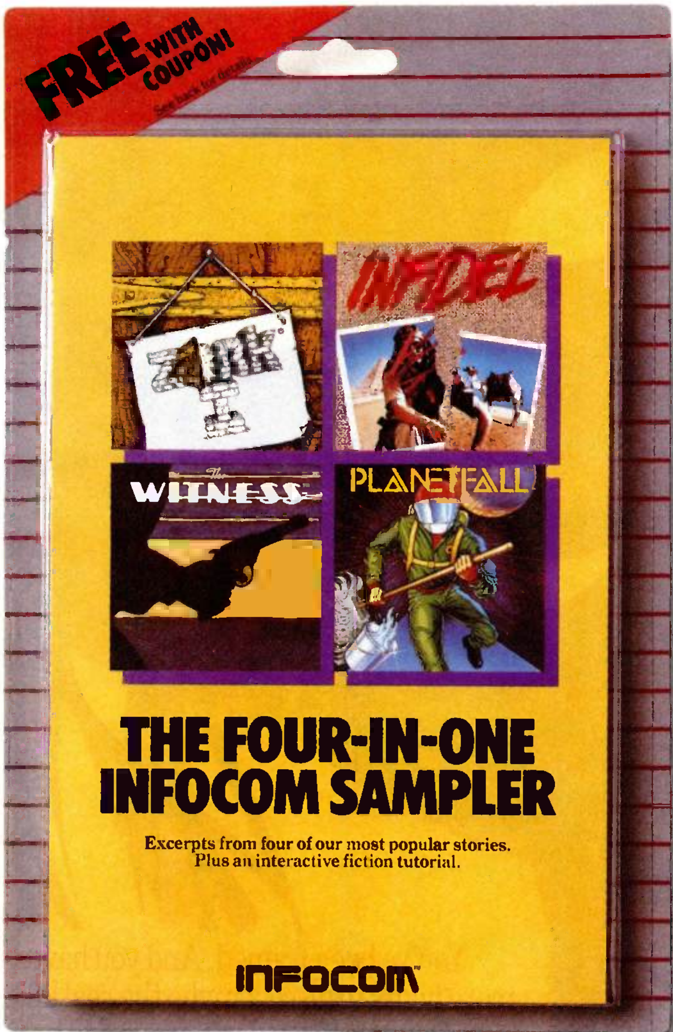

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>COCHRANE, TELL ME ABOUT SAMUEL OSTMANN

And the story responds:

COCHRANE IS UNSTEADY AND SWALLOWS A LITTLE MORE OF HIS DRINK BEFORE ANSWERING. "THAT SLIME! HE'LL GET WHAT'S COMING TO HIM ONE OF THESE DAYS. HE'S GOT AN IN WITH THE REAL ESTATE BOARD AND HE'S TIGHT WITH VERONICA. HE'S RUINING MY BUSINESS!"

And if you're clever enough, then maybe, just maybe, you'll prove your own innocence. But you'll have to hurry.

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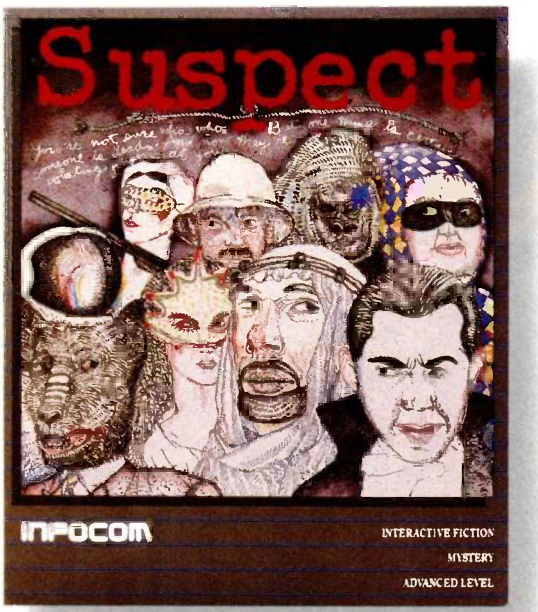

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Inquiry 171

Simulating Society

THE NEED FOR GREATER RIGOR in the social sciences has long been acknowledged. This month's theme examines computer-based simulation as a means to achieving that end. Simulation may be able to assist in evaluating hypotheses, not in the sense that an experiment in the physical sciences can test a hypothesis, but in the sense of making plain the ramifications of a hypothesis. The value of specifying a hypothesis with sufficient clarity to be amenable to programming and of examining the consequences of that hypothesis should not be underestimated. Indeed, one of the interesting aspects of the work presented here is that these researchers appear to be developing a tool for the social sciences that is not simply a poor stepchild of physical science methodologies.

Our first article, "Why Models Go Wrong" by Tom Houston, is a wonderfully readable account of the ways that you can misuse statistics.

Next, Wallace Larimore and Raman Mehra's "The Problem of Overfitting Data" discusses a difficult but important topic. Overfitting happens when your curve traces the noise as well as the information in your data. The result is that the predictive value of the curve actually deteriorates.

In "Testing Large-Scale Simulations," Otis Bryan and Michael Natrella show how validation (determining whether the specification for the simulation corresponds with reality) and verification (determining whether the simulation program corresponds with the specification) were achieved on a large-scale combat simulation they developed for the Air Force.

The ways of economic modeling are illustrated by Ross Miller and Alexander Kelso, who show how they analyzed the effects of proposed taxes for funding the EPA Superfund in "Analyzing Government Policies."

Michael Ward discusses his ongoing research in simulating the U.S.–Soviet arms race in "Simulating the Arms Race."

Several authors discuss new and surprising applications of simulation. In "EPIAID," Dr. Andrew Dean describes the development of computer-based aids for Centers for Disease Control field epidemiologists. Royer Cook explains how he fine-tuned a model in "Predicting Arson," and Bruce Dillenbeck, who uses an arson-prediction program in his work as a community activist, discusses modeling in "Fighting Fire with Technology."

Articles in other sections of the magazine that relate to this theme include Zaven Karian's review of GPSS/PC and Arthur Hansen's Programming Insight "Simulating the Normal Distribution."

When I began researching this theme, I took an excellent intensive course in simulation from Edward Russell of CACI. Dr. Russell's is the unseen hand guiding the development of this theme. Of course, any blame for bias in the choice of theme topics belongs to me, but much of the credit for the quality that is here must reside with him.

—Tom Clune, Technical Editor

WHY MODELS GO WRONG

BY TOM R. HOUSTON

You must take care in applying the principles of logic, statistics, and measurement

FROM A STONE AGE child fashioning a doll to a cosmologist speculating on the origin of the galactic superclusters, man is the animal who makes models. Scientists use models to represent, explain, predict, or estimate real-world phenomena. Beyond the central role of models in the scientific method, there seems to be a symbiotic relationship between our mental processes and these constructs that summarize, clarify, and subsequently guide our ideas. Yet as Ptolemy and Profumo have demonstrated, bad models are more readily available than good ones, and decisions guided by the wrong model may turn out badly.

A model can be a physical object: a scale-model of an ancient settlement inferred from archeological evidence, or a physical anthropologist's reconstruction of a skeleton from a few bones and fragments. Most social science models, however, are mathematical *isomorphisms* that specify one-to-one relationships between elements of the model and observable processes or entities. This abstractness gives models great versatility, but it also opens doors to potential problems. You don't need to be a naval architect to see that a model battleship has no bottom, but flaws in an equally defective sociometric model that repeatedly factors a large covariance matrix might escape casual scrutiny.

Computers have made this the golden age of modeling. Easy access to desktop computers and modern software allows people with modest statistical and programming backgrounds to construct and test elaborate formal models. Analyses that might have been considered dissertation topics 50 years ago can be completed in a few hours or days. Our current technology far surpasses that of earlier generations of students of the social sciences. We have reached the point where we just drop our data into the computer and push the button, right?

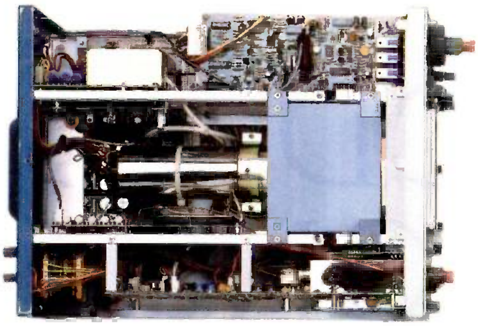
Wrong. We may in fact be on thin ice if we do not exercise logic and care in developing models to describe social processes and in applying models to the interpretation of data. Most of the logical pitfalls of modeling are much older than computers, but computers enable us to misuse models at superhuman speed and to produce enormous volumes of invalid output. This article offers a partial catalogue of the *incorrect* ways to develop or use models, particularly violations of logic in sampling, measuring, analyzing, or interpreting data, and of models that neglect some of the relevant dimensions of social phenomena.

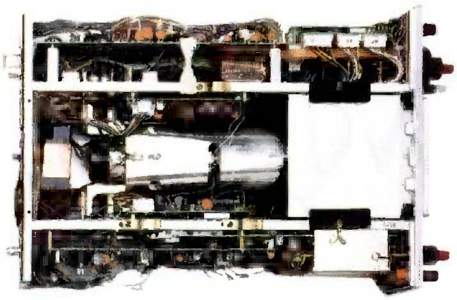
This discussion of errors considers social science models that can be written in some algebraic form, a broad class that includes survey, spreadsheet, graphic, Monte Carlo, and other quantified, statistical models. These are sometimes described as having independent and dependent variables. Independent variables are known, fixed, or preexistent attributes, like sex, nationality, socioeconomic status, or urban versus rural setting. Dependent variables are attributes that you are try-

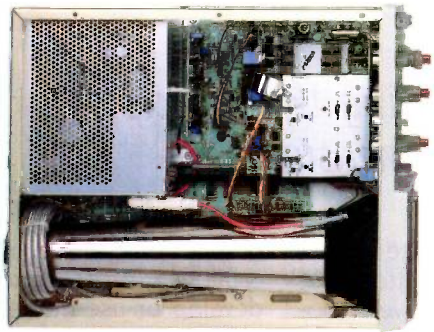
(continued)

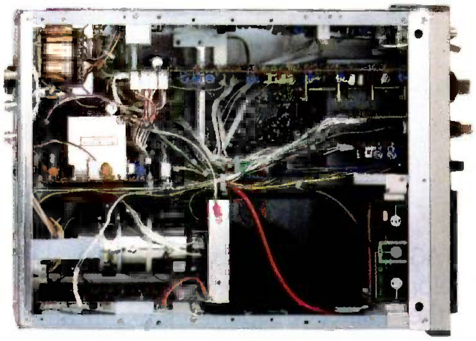
Tom R. Houston (Gifford Computer Systems, POB 1917, San Leandro, CA 94577) received his B.A. from Harvard University and his Ph.D. from the University of Wisconsin. He has taught research methodology at the Johns Hopkins University and is now the director of publications at Gifford and the editor of a newsletter on the multiuser Concurrent DOS operating system.

You can't judge a scope by its cover.









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ing to predict, manipulate, or observe as outcomes of some natural or experimental process. An independent variable in one study might be a dependent variable in another, but the distinction is useful anyway.

The ordinary purpose of any model is to enable you to make valid statements about some population. A population is characterized by independent variables (for example, "wealthy rural women"), and the supposedly valid statements concern the dependent variables (such as "money sent to mail-order companies"). In empirical work variables must be observable (like responses to questions), but theoretical models may postulate variables that you *cannot* observe directly (like "gullibility") but that you can estimate or infer from observable phenomena. Within this simple conceptual framework lurks a surprisingly rich potential for logical errors and false inferences.

The logical errors discussed here are generally insensitive to whether your model is purely descriptive (quantifying relationships among variables), projective (estimating future or unobservable characteristics), or interpretive (explicating cause-and-effect or other links among variables).

SAMPLING HAZARDS

It is usually impractical to obtain data from an entire population. Drawing a random sample yields observations that do not differ systematically from the population. In true experiments, random samples let you infer causal relationships by inductive logic (see reference 1). But sampling is a deep subject, and sampling problems often disfigure published work.

SAMPLING (STATISTICAL) ERROR

Data from a random sample will approximate the source population values but will *randomly* differ by amounts that you can statistically estimate from the sample size, the variability in the sample, and assumptions about the *shape* of each variable's distribution within the population. For example, variables that reflect the sum of many small factors tend toward a bell-shaped (called normal or Gaussian) distribution. When the variation in a population is large, a small sample provides imprecise estimates of population values, so that models derived from such data may be quite distorted. Even if you collect large samples, bad luck can give you bad data, but this is among the least of your worries in using models. The likelihood of your having nontypical samples is specified by the standard errors, confidence intervals, and significance levels found in classical statistics.

THE WRONG DISTRIBUTION

A *parametric* statistical test compares observed or simulated data with some theoretical distribution, and from this comparison assigns a probability to assertions about the population sampled or simulated (for example, whether group differences arise from chance, or whether some variables can validly predict others). Suppose that you were designing or budgeting a facility to provide sufficient emergency services to meet the projected demand of a given catchment area. The delivery system should have the capacity to support not only the anticipated cumulative volume of demand but also the real-time pattern of service requests, if serious consequences will follow from delays when too many requests are received in a brief time interval. In her text on waiting-line simulations, Susan L. Solomon (see reference 2) gives examples of how to test if a sample comes from a normal, log-normal, negative binomial, or Poisson distribution, all of which sometimes closely approximate queue data. Using the wrong theoretical distribution in a simulation or in a statistical test can

(continued)

lead you to make assertions, predictions, or conclusions that have no logical basis.

A Monte Carlo Significance Test

One remarkable ability of computers, incidentally, is to perform *nonparametric* significance tests on real data without making assumptions about the shape of the population distribution. Suppose, for example, that you were comparing samples of Warsaw Pact and NATO noncommissioned officers on some index for which the average scores of the two samples were different. What is the likelihood that the difference could arise from sampling error rather than reflecting real differences? By using a computer to pool the scores, and then randomly partitioning them repeatedly into two groups the size of your samples, you can plot the distribution of 10,000 random differences between groups. If your actual Warsaw-versus-NATO difference ranks, say, in the 3rd (or 97th) percentile of this distribution, then there is close to a 3 percent likelihood (6 percent for a two-tailed test) that a difference as large as you observed could arise by chance. A value near the median indicates no significant difference between groups. This "Monte Carlo" method of analysis can be generalized to functions of data on multiple groups or variables, but your routine to sample permutations of the data must closely approximate a random process for this technique to be valid.

Insufficient Power

The wire services and supermarket tabloids are frequent vectors of a problem arising from the noise in small samples, typically in research studies that claim to show that poverty, unemployment, pollution, rotten schools, or television programs have no harmful effects. It is easy to get counterintuitive negative results by comparing two small groups (read "too-small groups"). The *power* (probability of detecting effects of a given size) of an analysis of real or simulated data varies inversely with the variability of your sample and with the *size* of your statistical test (the risk that you tolerate of a false-positive result) but varies directly with the size of your sample: The smaller the sample, the smaller the power. Findings of "no significant difference" between groups or subgroups may only reflect a failure to sample enough members of each population to detect large real differences.

Significant vs. Important

The statistical meaning of the word "significant" (as in the Warsaw-NATO example above) is distinct from the popular sense of important or meaningful, just as bytes are different from bights, or tables of random normal deviates differ from furniture belonging to ordinary perverts. Unfortunately, the colloquial or ambiguous use of "significant" sometimes obscures carelessly written reports. Similarly confused are some discussions of very large samples, where the power of a test is so great that very small absolute differences between groups can achieve statistical significance. A study might show, for example, that overreporting of taxes in one state is significantly higher (37.3 percent of returns) than in another (37.2 percent), but so small a difference has no practical implication for the Treasury to treat the two states differentially. Reports sometimes waste space discussing statistically significant but meaninglessly small differences, or trivially uninformative results ("The male executives in our survey gave birth to significantly fewer children than did the females," for example).

Nonrandom Sampling

Purists who reserve the word "sample" for truly random samples regard

(continued)

the above heading as a contradiction in terms, since the logic upon which statistical inference is based applies only to data in which every member of the population had an equal likelihood of being selected. This is usually difficult to implement. United States law, for example, prohibits federal funding of research that randomly excludes people from potentially beneficial programs. For this reason, taxes spent on mandated evaluations of federal social-action programs of the 1960s and 1970s mostly produced anecdotal journalism (what statisticians call hand waving) rather than scientific results. Rigorous studies would have compared communities, people, or families who were program participants with similar nonparticipants who had been *randomly* excluded from the program. Assessment studies that compare beneficiaries with rejected applicants, for example, make the questionable assumption that grant-award or program-admission criteria are uncorrelated with program impact (see reference 3).

THE WRONG SAMPLE

In 1936 *The Literary Digest*, comparable in prestige to *The New Yorker* today, sponsored a $500,000 mail preference survey on that year's presidential election, based on 2,375,000 returned questionnaires. The startling prediction of an Alf Landon victory was confounded when President Roosevelt obtained 20 percent more votes than the survey projected, soundly defeating Landon and demolishing the credibility (and ultimately the circulation) of *The Literary Digest*.

What had gone wrong? Well, respondents were drawn from automobile registration lists and telephone directories; people who could afford cars or phones in the depths of the Depression were wealthier than most; and Roosevelt was less popular among the rich than among the majority of voters (see reference 4). Sampling bias is usually easier to see in retrospect, but your data and your model had better agree on what population it is that you are talking about.

AN ANALYSIS OF ANALYSES

The availability of software packages that allow statistically naive users to produce analyses and graphic displays is a democratic blow against elitism, but a few caveats are in order. Your data manipulation must reflect the logic of your conceptual model rather than the options on a program menu, since inappropriate analyses can produce either harmless or seriously misleading nonsense. One statistical package for microcomputers documented a significance test of the difference between two dependent variables. The programmer who coded the package was unaware that a t-test compares different samples measured on the same variable. But brisk sales of that software suggest that some unusual research issues are being modeled by this novel feature—for example, "Is the annual family income in dollars significantly different from the average number of children?"

More common are subtler deviations from rational practice, like fishing multivariate data for interpretable results in ways that exploit correlated error, or applying to data methods of analysis that only fit a different model. Normal statistical tests are inappropriate for data actually drawn from a non-Gaussian population, since a valid analysis must reflect the underlying distribution of variables. Statistical courses warn about this and caution students against blunders like substituting multiple t-tests for an F-test, using the wrong error term in the analysis of variance (ANOVA), or letting the number of variables approach the number of ob-

(continued)

servational units in regression studies.

Easy-to-use software packages, however, enable marginally trained or untrained users to perform analyses unencumbered by logical restraints. If important decisions will be based on your results, you should develop your analysis plan *prior* to collecting or simulating your data. And if you do not have a background in research methods and statistics, you should show your research plan and analysis model to someone who does, *before* you carry out your study. Self-delusion and wasted effort are the ordinary results of bad methodology.

BAD GRAPHICS

Computer graphics that display the results of data analyses can misrepresent what are otherwise perfectly good results. In figure 1, the line chart does not clearly indicate (by broken or jagged vertical lines, for example) that only an upper portion of the scale is shown. As is, the chart visually suggests a much greater proportional difference between the things compared than the data indicated, a misleading display. In figure 2, categories on the extreme right and left of this frequency polygon represent larger intervals on the horizontal axis than the middle categories, but no adjustment is made on the vertical axis. The effect is to exaggerate the area of the distribution that is in the tails. You should either use equal intervals or reduce the height in proportion to the increased width.

MEASUREMENT PROBLEMS

Many of you who persist in reading an article like this probably have some formal training in statistics or have taken the trouble to read statistical texts that were relevant to some practical problem. But even if you are statistically literate, you may not be aware of measurement, an allied discipline that plays an important role in the social sciences. Major hazards in using models arise from measurement error and from logical errors in designing and manipulating measurements, as distinct from the sampling and statistical problems already outlined.

Measurement has been called the science of discarding information. Those who work in fields based on the physical sciences are accustomed to relatively precise instruments that, when properly used, yield reliable data with fairly high ratios of signal to noise. Workers in the social and behavioral sciences (where measurement theory was developed) routinely deal with unreliable data, where noise swamps the signal, and with respondents who lie about such details as their income or alcohol intake because they think (perhaps correctly) that you are working for the government. Yet scientists have developed methods to extract valid inferences from variables of low reliability by using models that take into account errors of measurement.

MEASUREMENT ERROR

Statistical error reflects real but random differences between your sample and the population from which it was drawn. Measurement error is a consequence of fallible procedures for collecting data and of the necessity of using observable variables that are imperfectly correlated with the unobservable characteristics that you hypothesize as critical in social phenomena. If you are trying to survey social attitudes, for example, the data that you collect will be less reliable than carefully obtained data on blood type or on sex, in the sense that you cannot expect to get identical results by repeating your attitude-measurement procedures on the same people.

Attitudinal data will inevitably contain some measurement errors because some respondents may misunderstand your questions, or you may misunderstand their answers, or they may seek to please, impress, or deceive you, or response categories may lump together people with different attitudes, or (worst of all)

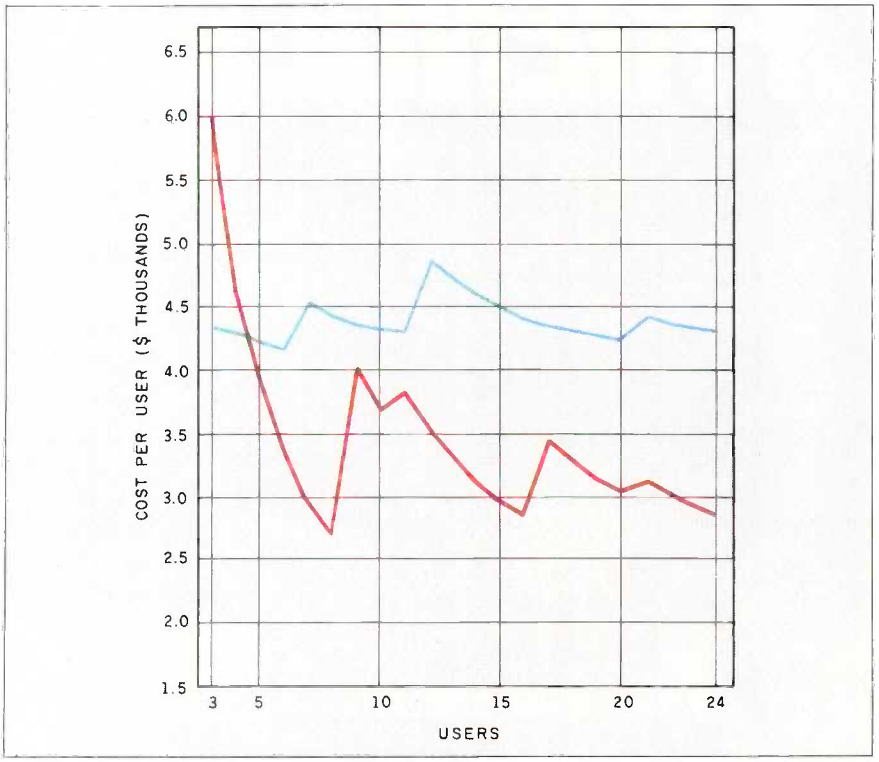

Figure 1: *Combined hardware and software cost per user in U.S. dollars of local-area networks of 3 to 24 workstations, for networked personal computers (blue) versus networked multiuser microcomputers with serial terminals (red).*

because attitudes may actually change after your interview. In another presidential fiasco, in September of 1948 the Roper poll projected Dewey's election over Truman, 52 percent to 37 percent, with Dixiecrat Thurmond strong in the South. Roper biased his sample by incorrectly weighting regional turnout, but most of his underestimate of Truman's winning plurality (49 percent) reflected political events that occurred after September, including a collapse in farm prices and vigorous Democratic campaigning. As in 1948, using the present to model the future can be risky.

Situations like Dewey's predicted victory, where the quantity or quality that you measured actually changes while you are writing your report, require a model that takes historic change into account or a report with a disclaimer. But even if the phenomena that you are trying to measure are stable over time, your data will combine true information with measurement error because of imperfect measurement procedures. Models that treat real data as infallible can produce amusing, paradoxical, or even calamitous results.

One fallacy based on measurement error involves regression toward the mean. Suppose you wanted to test a proposed way to prevent juvenile delinquency, smoking, or something else worth preventing. Further suppose that you identified a group of teenagers, families, or street gangs that were known to be at high risk of your target problem. If you apply your prevention method to this group and compare the incidence of whatever you were preventing both before and after your intervention, measurement theory predicts that you will observe improvement, regardless of whether intervention had any effect. Even stranger, despite this vindication of your method, if you applied the same intervention to subjects demonstrably at low risk, you would be disappointed to see that their antisocial behavior tended to increase! What is going on?

To select a group as at high risk, you must identify them by measures that distinguish them from average teenagers, families, or street gangs. Scores on your classifying measure reflect a combination of both the true degree of risk and error (meaningless noise) from defects in your measurement procedures. Although these errors are uncorrelated with anything, observations that include large positive errors are more likely to rank near the top of a distribution, while those with large negative errors are more likely to end up near the bottom. Thus, groups that are selected for extreme values tend to have measurement errors that are skewed in the same direction.

But since measurement errors are random, when you collect new measures on the same group, errors in the new scores will not be correlated with anything, eliminating any positive or negative skewness. In the absence of the biased error that helped put them in one tail of the original distribution, extreme groups will tend to "regress" toward the population mean when you retest them. Variations on this spurious effect plague models that use samples chosen from the top or bottom of any population.

A class of problems combining both

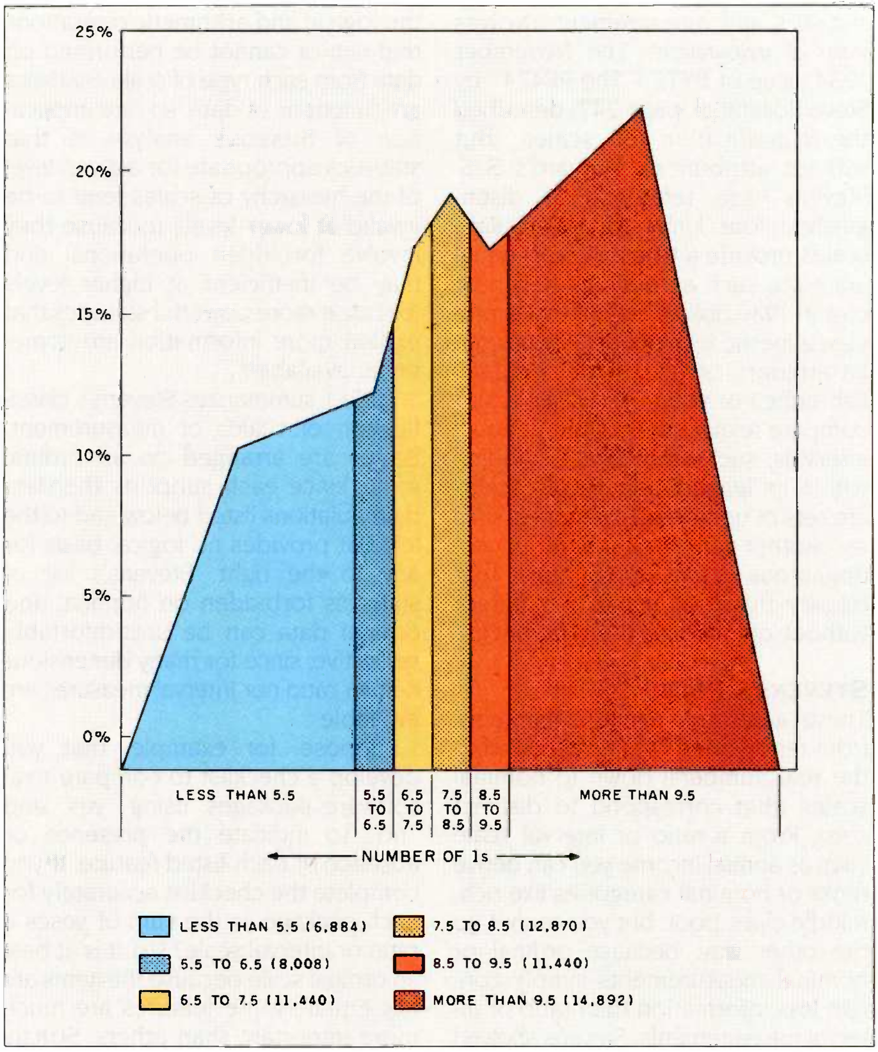

Figure 2: *Frequency distribution of the first 64K nonnegative binary integers* (0 *through* 1111111111111111), *according to the number of* 1s.

(continued)

statistics and measurement involves *scales of measurement*. The November 1984 issue of BYTE ("The PF474" by Steve Rosenthal, page 247) described the classification of scales (but without attribution). Harvard's S. S. Stevens (see reference 5) distinguished four kinds of scales: *Ratio* scales provide a true zero and equal intervals, such as degrees Kelvin or cost in 1980 dollars; *interval* scales provide a metric with equal intervals but an arbitrary origin, such as degrees Fahrenheit or year A.D.; *ordinal* scales compare relative ranks without equal intervals, such as a team's standing within its league; and *nominal* scales are sets of unordered categories, such as mother's maiden name or endogamous versus exogamous, that classify things as same or different without quantifying the differences.

STEVENS'S RULES

These scales form a natural hierarchy, from ratio scales (that correspond to the real numbers) down to nominal scales (that correspond to disjunct sets). From a ratio or interval scale such as annual income you can derive ranks or nominal categories like rich, middle class, poor, but you cannot go the other way, because ordinal or nominal measurements simply contain less information than ratio or interval measurements. Stevens showed that in terms of mathematical group theory the four types of scales have different structures, which determine the logical and arithmetic operations that can or cannot be performed on data from each type of scale. Statistics are functions of data, so one implication of Stevens's analysis is that statistics appropriate for a given level of the hierarchy of scales tend to be invalid at lower levels (because they involve forbidden operations) and may be inefficient at higher levels (because more powerful statistics that exploit more information are sometimes available).

Table 1 summarizes Stevens's classification of scales of measurement. Scales are arranged on an ordinal scale, since each supports the data manipulations listed below and to the left but provides no logical basis for any to the right. Stevens's list of statistics forbidden on nominal and ordinal data can be uncomfortably restrictive, since for many dimensions neither ratio nor interval measures are available.

Suppose, for example, that you develop a checklist to compare rival software packages, using "yes" and "no" to indicate the presence or absence of each listed feature. If you complete the checklist accurately for each package, is the sum of yeses a ratio or interval scale? No, it is at best an ordinal scale because the items are not equal—some features are much more important than others. Strictly interpreting Stevens, you cannot justify calculating sums nor averages of ordinal data.

Table 1: *Classification of scales of measurement, according to* S. S. *Stevens (see reference* 5).

	TYPE Nominal	Ordinal	Interval	Ratio
Examples	sex, zip code, nationality	military rank, bond rating, USDA grades	date, balance of payments, latitude	age, weight, gross sales
Group Structure	permutation group	isotonic group	general linear group	similarity group
Permissible Operations and Functions of Data	$x = y$, $x \neq y$, one-to-one substitutions	$x > y$, $x < y$, increasing monotonic transformations	$x = ay + b$, linear transformations	$x = ay$, unrestricted
Examples of Permissible Statistics	mode, contingency coefficient	median, tau, rho, percentiles	mean, variance, Pearson's r, ANOVA	geometric mean, coefficient of variation

In practical work, most research imperfectly matches some methodological assumptions, and many social scientists treat sums of more or less homogeneous items as approximately interval scales, subjecting such data to statistical analyses appropriate for interval scales. That undermines, however, the purpose of statistical inference, namely, to quantify the likelihood that your conclusions are incorrect, since the consequences of playing a little fast and loose with Stevens's rules are unknown for most data sets. (The consequences are clearer, however, for more extreme violations: Your analysis will be meaningless, and you may expose yourself to the criticism and ridicule of your peers.)

CAUSE AND EFFECT

Why do people love models and analyses that postulate cause-and-effect relationships? Causal models satisfy the human need to understand, and as a practical matter, isolating the causes may enable you to predict or control outcomes. Rigorously proving causality is hard when randomized experiments are impossible (see reference 6), but it may be easy for your own hypotheses to elude your scientific skepticism. Once you convince yourself that A causes B, that belief influences the design of your model or simulation and your analysis and interpretation of real data.

From antiquity logicians have cautioned against falsely inferring causality. For example, every year the Nile overflowed its banks after the star Sirius rose at dawn. Attributing the flood to Sirius is called *post hoc, ergo propter hoc* ("after this, therefore because of this"), a causal fallacy. Shading your garden from starlight or praying to Osiris to delay the rising of Sirius are ineffective strategies for flood control because the inundation is actually caused by a different star, the sun, in interaction with earth's tilted axis and with meteorological processes too complex to summarize here.

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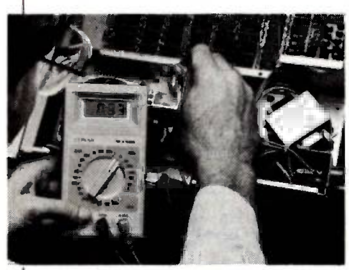

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Even those who put no faith in astrology or in the gods of Egypt sometimes blithely construct models that uncritically treat antecedent variables as the causes of outcomes that happen to be correlated. Yet these supposed causes and observed outcomes may both be effects of underlying determinants that are ignored by the model. You can sometimes "validate" these spurious causal models across different data sets, but their predictions will blow up when the unexamined factors change.

Rather than single causes, real social phenomena typically have multiple determinants, and complex feedback relationships may operate among the elements of a social system, rather than simple one-way causality. Models should seek to simplify, generalize, and explain the messy specificity of social processes, but models and analyses that oversimplify can also be a serious cause of confusion.

Did You Forget Anything?

A profound problem faced by makers of models is that of completeness. A scientist hypothesizes a conceptual model of social processes that specifies various relationships. To apply the model, procedures are followed to obtain measurements of the various dimensions identified in the conceptual model. Statistical analyses are performed on the data to validate the model, predict outcomes, or simulate options, or for some other purpose.

What if a conceptual model fails to include an important input or outcome dimension? Welcome to the real world! Unforeseen and unrecognized factors have been dominant forces in human history, and models that neglect these reveal our fragmentary understanding of nature. If an important independent (input) variable is left out, the model's predictions will seem to include a lot of random error. If dependent (outcome) variables are left out, you may not notice anything at all—the statistical analysis can go smoothly, the observed results can match your predictions, and yet you may have ignored outcomes more important than those that you included. For example, Victorian social policy permitted the use of powdered chalk as a flour extender, helping the poor by increasing the supply and reducing the cost of bread. Unfortunately, the kidney stones caused by this nonnutritive mineral increased the morbidity among the poor (and others on a high-flour diet), thereby reducing the British workforce and needlessly burdening health-care providers. These unforeseen social costs probably outweighed the value of the wheat that was saved.

A seriously incomplete model is defective. Is there any logical procedure to test for the completeness of a model? If your model accounts for a only small proportion of variance in the outcome measures, even though your measures are fairly reliable, then your model is dealing from a short deck. In general, however, there is no positive test for completeness of an independent variable set, since even if your predictions seem perfect, you may not have sampled the parts of the population where additional factors operate, or you may be using correlates unwittingly as proxies of the actual causal factors. In the case of the Sirius-Nile correlation, for example, both the rising of the river and the rising of the star are joint effects of the geometry of the solar system, for which no adequate models existed in the time of the Pharaohs.

There is no way at all to tell if a model includes a complete dependent-variable set. If there were, computers could become scientists, and social scientists could spend more time watching television. If you are modeling an unfamiliar process, you might ask someone closer to the subject whether your model seems to tap all the relevant dimensions. Unfortunately, this precaution only gives you the conventional wisdom, as mediated by economic, political, and other cultural and personal biases—should you ask a network executive about the probable impact of pro-

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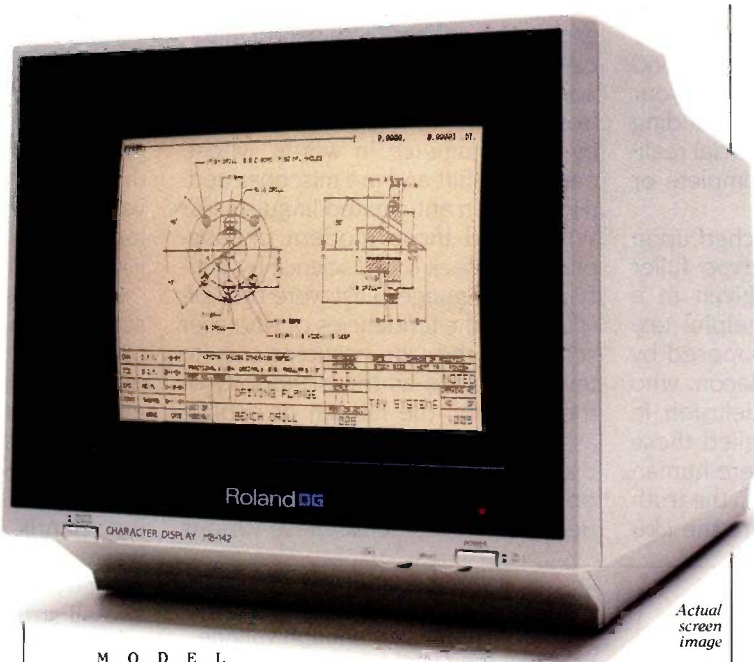

Actual screen image

MODEL
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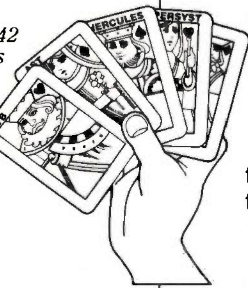

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BACON'S TAXONOMY OF FALLACIES

By now you may feel disheartened. If even models, simulations, and analyses that are statistically beyond reproach can be no better than your conceptual craftmanship in including the critical dimensions of social reality, how do you avoid incomplete or defective concepts?

Here again we have touched upon a rich subject that deserves fuller treatment than can be given in a single paragraph, but a helpful taxonomy of fallacies was proposed by the philosopher Francis Bacon, who identified four sources of delusion. In a Biblical metaphor he called these sources *idols*, since they were human artifacts that competed with the truth for our attention. First were the *idols of the tribe*, errors that we share with the human race, unexamined habits of thought and perception imposed on our consciousness by our humanity. Next were the *idols of the cave*, the personal, idiosyncratic tendencies of each mind isolated from nature in the cave of self. Third were the *idols of the marketplace*, misconceptions that arise from how our thoughts are mediated by our commerce in words, whose meanings shift and are misconstrued. (Here Bacon anticipated linguists like Whorf, and those modern philosophers who seek to aid science by purifying its language.) Last were the *idols of the stage*, the tendencies of whatever school of thought occupies the intellectual stage as the orthodoxy of the day, with the hidden or explicit assumptions and methods that philosophical fashions impose on our opinions, models, and theories. Because we internalize these various idols, only in rare moments like this do we even think about their possible fallacies.

THE INFINITE SWAMP OF ERROR

This is quite a pantheon of errors, but if you can shun all of these, and the blunders that were listed earlier, then the screen of your computer console can become a mirror of society as you perfect your simulations. On second thought, it might be safer to hope that your work will only suffer from modeling and analysis problems that were *not* included in this article.

Sir Isaac Newton once modestly described himself as gathering "a few bright pebbles" (a pun on the Latin *calculus*) from along the shore of the great Ocean of Truth. Our less sublime essay has wandered through the infinite Swamp of Error, pointing out flotsam, jetsam, bugs, crocodiles, quicksands, pestilence, and toxic wastes to avoid. Like chaos or comedy, the domain of fallacy has no overall structure, so here is as good a place as any to end this dismal tour. Besides vigilance, your only protections against these and undiscovered hazards are sensitivity to critical features of the processes that you are simulating and care in applying the principles of logic, statistics, measurement, and common sense in constructing and applying social science models. ■

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THE PROBLEM OF OVERFITTING DATA

BY WALLACE E. LARIMORE AND RAMAN K. MEHRA

A mathematical model for balancing the number of parameters and the degree of fit

ONE OF THE MOST common and difficult problems facing an empirical modeler is the question of when to stop adding terms to a model. It is well known that for any set of finite data, the fit error is decreased by simply increasing the number of free parameters in the model. In the extreme, the data set itself can be thought of as a model, albeit a highly unparsimonious one. The purpose of modeling is to obtain a model of the predictable behavior of the process but to avoid incorporating the random characteristics of the particular data set.

The usual advice given in statistical texts is to develop parsimonious models, though the exact meaning of parsimony is left undefined. Our purpose here is to give precise meaning to the concept of parsimony in a specific but important context such as forecasting of time-series data. We will show empirically and mathematically how overfitting in time-series analysis leads to an increase in forecast errors. The concepts presented here can be applied to other statistical modeling situations, such as regression analysis, as well as time series.

The method presented is based on statistical concepts of predictive inference and information theory as opposed to classical hypothesis-testing theory. The problem with classical hypothesis-testing theory is that it regards a model as either true or false. In practice, most models are neither true nor false. They are simply approximations to reality developed for a specific purpose. It is essential to keep in mind the objective of modeling while evaluating models. As developed below, these objectives are model approximation for the purpose of prediction—of later observations on a time series or of a related experiment in a regression problem.

The notion that a single model can be developed for all purposes led in the 1960s and 1970s to the development of huge multiequation econometric and energy models. It was then realized that the validation of these models is an arduous, perhaps impossible, task. Furthermore, the forecasts produced by these models have been beaten by very simple single-equation models. What went wrong in these modeling exercises was the emphasis on modeling everything and fitting the model by brute force to the available data. Heuristically, one might say that modelers attempted to extract too much from the data. Beyond a certain complexity, the model ends up fitting to the noise in the data trying to explain every wiggle in the time series.

In physical and engineering sciences, where the art of mathematical modeling is well developed, specific models are constructed for specific applications. Numerous models are available for systems such as aircraft and spacecraft that address different issues. For example, a model to study the structural deformations of a spacecraft is very different from a model to study its trajectory motions. In socioeconomic modeling, unfortunately, our phenomenological

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understanding is not accurate enough to isolate all the effects in the observed data. The purpose of modeling, therefore, becomes crucially important in determining the complexity of the model. The key issue is: How complex should a model be for a given final use of the model? As one might imagine, concepts from theories of complexity have also been applied to answering this question. In fact, there is a close relationship between the concepts of complexity, information, and entropy, which we will explain later on.

First, we will review curve fitting and show that overfitting lessens the predictive value of the model.

Steps in Model Building

The process of model building from empirical data involves a number of steps, as illustrated in figure 1. These steps are discussed in a number of books on statistical model building, such as reference 1. While all of these steps are important, in this article we focus on the problem of deciding between various alternative models of different structures or involving different numbers of parameters.

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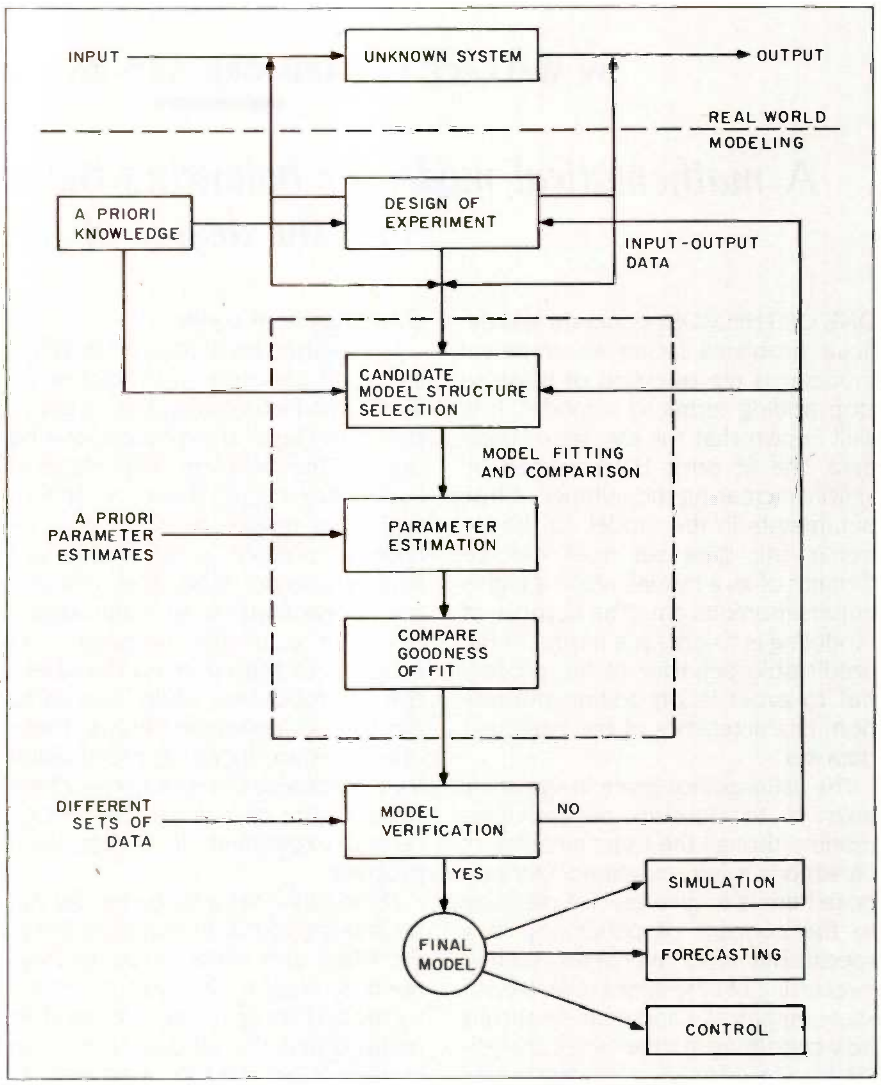

Figure 1: *Steps in system modeling and identification. Those steps discussed in this article are shown within the dotted-line box.*

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While the other areas of model building have received significant attention and have a developed theory for guiding their application, the determination of model order or structure from empirical data was largely neglected until 15 years ago. The order-determination problem is most easily discussed by viewing the example in the next section.

An Example of Model Overfitting

This simple example contains most of the concepts used in solving the model-overfitting problem. More elaborate examples involving time-series forecasting are discussed later.

Consider the case of a simple polynomial regression model where the observations are considered to have come from a model of the form $y(t) = a_0 + a_1t^1 + \ldots + a_6t^6 + n(t)$, where the coefficients $a_0, \ldots, a_6$ are to be determined from the observed data over some interval, say $t = 1, \ldots, 20$, and where the observations include Gaussian noise $n(t)$ with zero mean and known variance σ^2.

A typical ambiguity in the literature is the use of the term *model* to mean both a particular model with a particular set of parameters as well as a class of models such as the class of order-4 models. We will try to avoid this confusion by differentiating between a particular model and a model class where there is possible confusion. To discuss the fitting of different model orders, let $M(i)$ denote the class of models where all of the coefficients with indexes larger than i are set to zero; for example, $M(4)$ has $a_5 = a_6 = 0$ and the coefficients $a_0, \ldots, a_4$ are free variables to be fitted from the data. More precisely, $M(4)$ is the class of particular models of order 4.

As an experiment to investigate the effect of choosing different model orders, consider a repeated sampling experiment depicted in figure 2, where a particular order model is fitted on the fit-set data $t = 1, \ldots, 20$, and then this model is used to predict the observations for the prediction set $t = 21, \ldots, 40$. The usual notion of model-fit error is the average error of fit between the model and observations on the fit set. The average squared error on the prediction set will be used as a measure of the error in prediction. If the experiment is performed repeatedly for a large number of trials, the average squared fit error and the average squared prediction error will approach constant values that are easily calculated from simple regression theory.

Consider the true process to be a polynomial of order 4 with coefficients $A_0 = 0.5$, $A_1 = 1.0$, $A_2 = 0.5$, $A_3 = 0.05$, $A_4 = 0.025$, and $A_5 = 0$, $A_6 = 0$, and suppose the noise variance is $\sigma^2 = 3$. In table 1 the average fit error and prediction error are given for each of the possible model orders from 0 to 6, involving from 1 to 7 parameters. What is of great interest is that while the fit error is uniformly decreasing as the model order increases, the prediction error reaches a minimum and actually increases with further increases in model order beyond order 2. Note that the best order model for the purpose of prediction in this case is less than the true order of 4. Even though the true order is 4, more error is incurred in the prediction by estimating a_3 and a_4 than by setting them to zero in the model. In the regression case, the difference between the two curves is $2\sigma^2$ times the number of parameters varied in the fit, which represents a penalty term.

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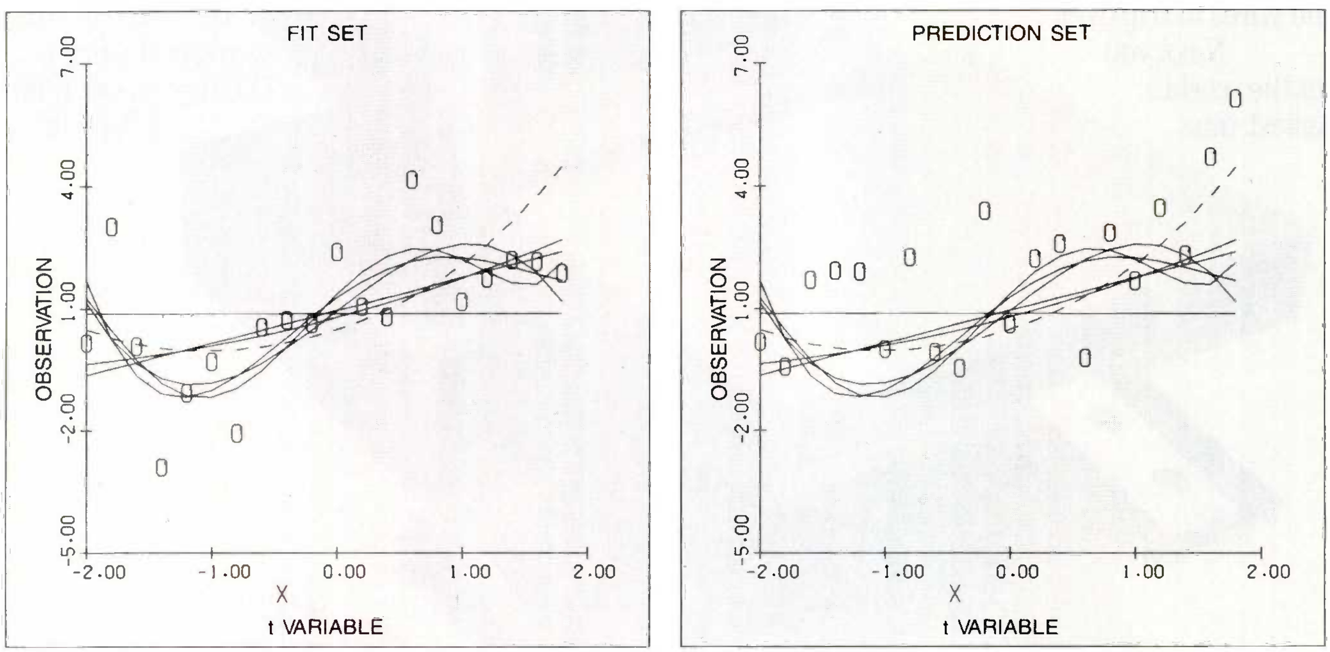
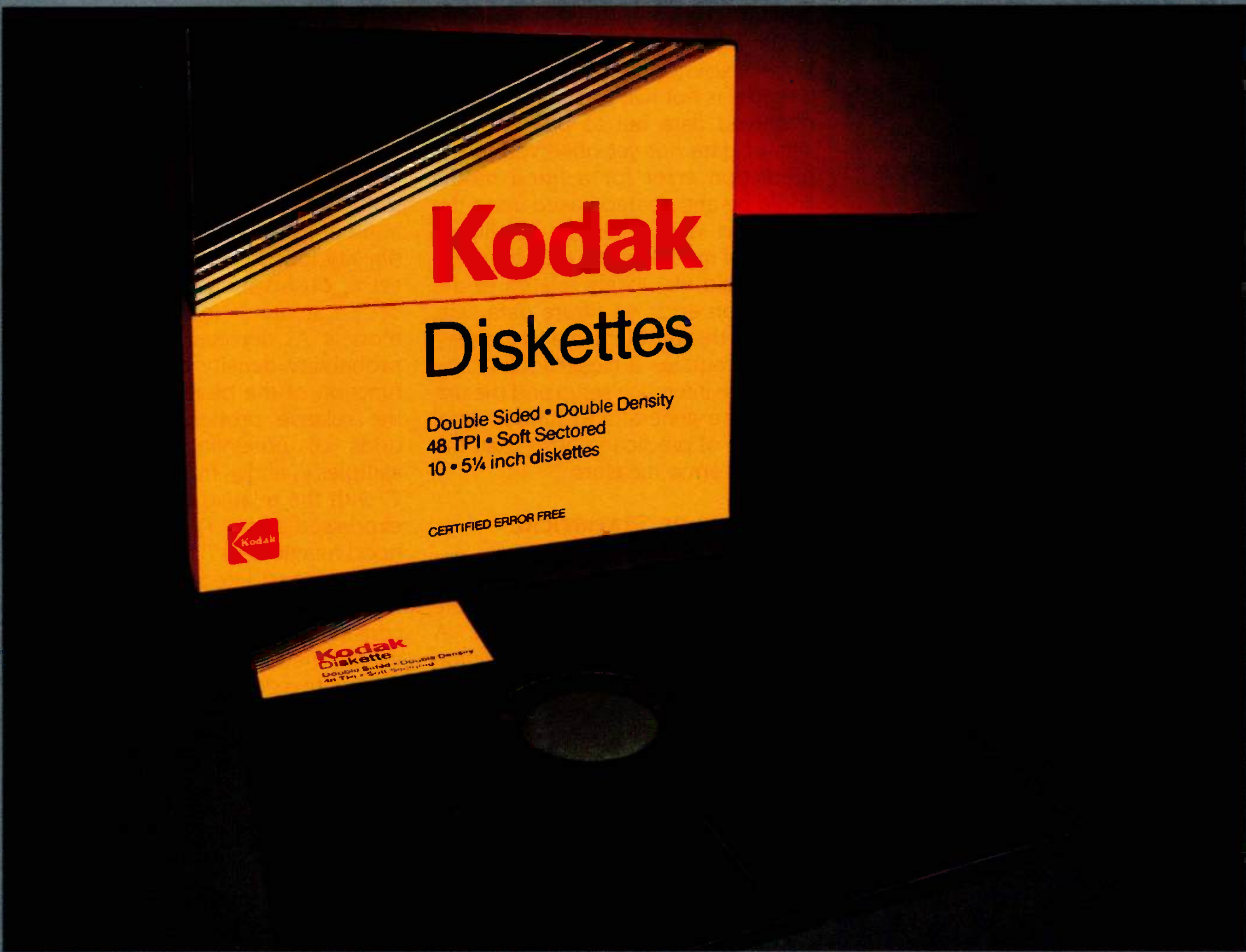


Figure 2: *Fit set and prediction set showing observations* (0), *true model* (– – – –), *and fitted models* (——) *for orders* 0 *through* 5.



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The key concept in arriving at a measure of prediction error is the concept of a sufficient statistic.

The difficulty in using error on the fit set as a measure for model order selection has been known from early statistical writings. The uniform decrease in fit error is a simple consequence of minimizing a function of several variables—if an additional variable is included in the minimization, then the resulting minimum is always less than if it is not included. One attempt to cure the problem is the use of hypothesis testing to determine when a "significant" reduction in fit error is achieved that justifies the use of a higher-order model. This cure casts the problem in the context of hypothesis testing that was developed primarily for use in quality-control problems and true/false decision problems, and it does not address the predictive issues that are central to the problem of choosing a good approximating model from among a multitude of potential models.

The regression example illustrates the basic concepts involved in the problem of selecting model order. The concept of a predictive sample to evaluate the accuracy of using a particular model order is very appealing since in science the purpose of fitting a model is not just to summarize the observed data but to predict other sets of data not yet observed. If the prediction error for a fitted model could be anticipated based upon the observed data, then an intelligent choice of model order could be made that would be closely related to the prediction error on future data sets. To solve this problem in a fundamental way requires a closer look at the predictive inference setup and the use of a more general and fundamental measure of prediction error than the squared error measure.

CONCEPTS OF STATISTICAL MODEL BUILDING

The key concept in arriving at a measure of prediction error is the concept of a sufficient statistic. A *statistic* is a quantity that is a function of a set of observed data and possibly other variables. The sample mean and sample variance are examples of statistics. A statistic is sufficient for a class of models if all inferences that are possible based upon the observations can be made using the statistic in place of the observations. In other words, there is no loss of information in using the sufficient statistic in place of the data for inference about the particular class of models. In the regression example, a class of models of interest is the class of models of some particular order, e.g., order 4. The principle of using a sufficient statistic in place of the data for inference concerning the associated class of models is one of the few principles that is universally accepted among statisticians.

Another fundamental concept in statistical inference is the likelihood of a model. Consider the probability density function $p(y,T)$ where y is the set of observations and T is the set of parameters indexing different models. As depicted in figure 3, the probability density considered as a function of the observations y gives the relative probability or relative odds of observing two different samples y_1 and y_2 from a given model T, with the relative odds specifically expressed as $p(y_1,T)/p(y_2,T)$. The likelihood function $p(y,T)$ is the probability density considered as a function of the parameters T with the sample considered as fixed at the observed value. The likelihood function gives the relative odds of a given sample y having come from two different models T_1 and T_2, expressed as $p(y,T_1)/p(y,T_2)$. Thus the two concepts are exactly complementary in describing relative odds of either the various samples for a given model or the various models for a given sample. Statistical inference about alternative models based upon an observed sample thus is primarily concerned with likelihood.

A fundamental yet simple result in statistical inference is that the likelihood function is a sufficient statistic; any inference concerning a class of parameterized models can be done by consideration of the likelihood function in place of the observations. The entire range of possible values for the parameters T must be considered for this last statement to be true. For making any inferences concerning two particular models, say T_1 and T_2, it is easily shown that the likelihood ratio $p(y,T_1)/p(y,T_2)$ is a sufficient statistic so that it contains all information in the sample relevant to making

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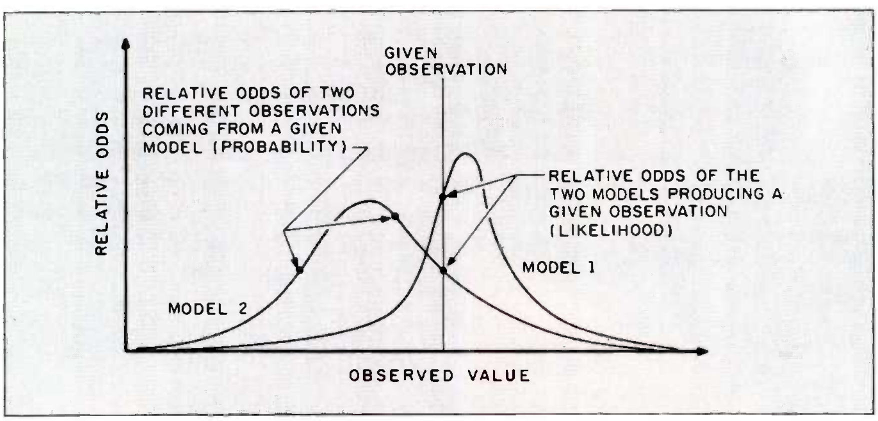

Figure 3: *Probability density and likelihood as relative odds.*

(4a)

$$\Lambda_N = \frac{p_2(y_1|x_1)\times\ldots\times p_2(y_N|x_N)}{p_4(y_1|x_1)\times\ldots\times p_4(y_N|x_N)}$$

Figure 4a: *Likelihood ratio Λ_N for comparing a particular order-2 model with a particular order-4 model.*

(4b)

$$\frac{1}{N}\log\Lambda_N = \frac{1}{N}\sum_{j=1}^{N}\log\frac{p_2(y_j|x_j)}{p_4(y_j|x_j)} \approx \int p(y,x)\log\frac{p_2(y|x)}{p_4(y|x)}\,dy$$

$$= \int p(y|x)\log\frac{p(y|x)}{p_4(y|x)}\,dyp(x)dx - \int p(y|x)\log\frac{p(y|x)}{p_2(y|x)}\,dyp(x)dx$$

$$= E_xI(p(y|x),p_4(y|x)) - E_xI(p(y|x),p_2(y|x))$$

Figure 4b: *Derivation of the negative-entropy expression from the likelihood ratio.*

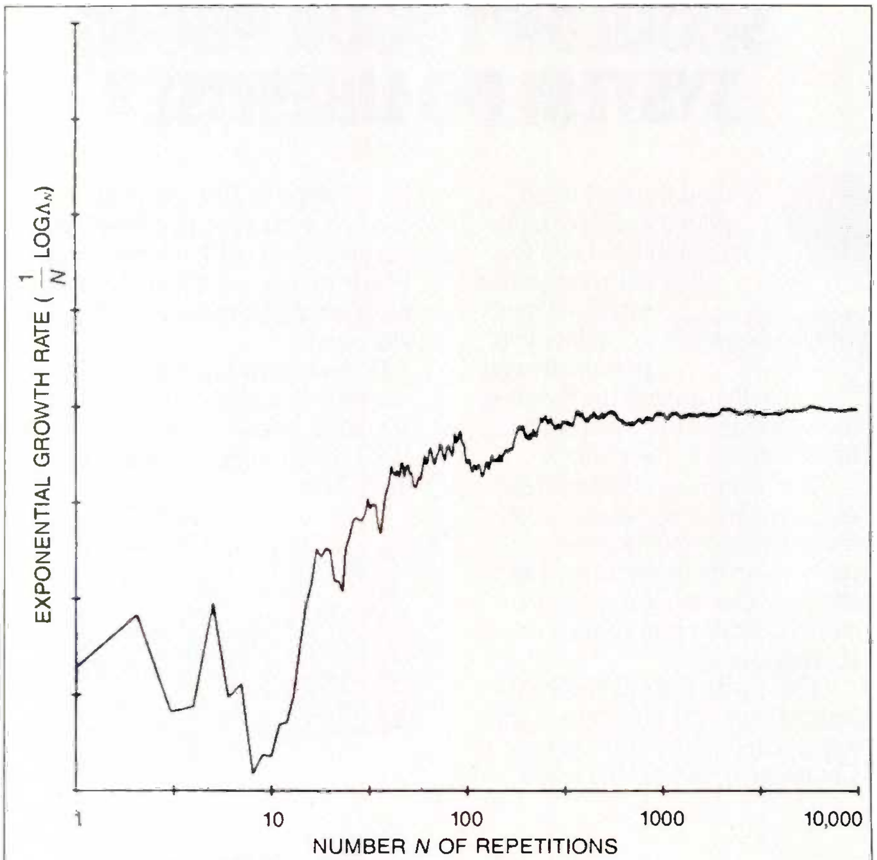

Figure 5: *Observed exponential growth rate of the likelihood ratio Λ_N for N predictive samples.*

any inference on these two models. A simple derivation of this result along with an elementary yet illuminating discussion of the concepts of sufficiency and likelihood is given in reference 2.

Entropy Measure of Model-Approximation Error

The concept of sufficiency and likelihood can be developed very generally to allow the comparison of different model-selection procedures in terms of the prediction error. In particular, consider the case of selecting a model for predicting the future sample based upon using the observed fit-set data x and an order-2 regression model. To this end we consider the predictive density $p(y|x)$ describing a probability density for the predictive sample y based upon a particular observed value x of the fit set. For a particular order-2 model T_2, the simplified notation $p_2(y|x)$ is used in place of $p(y|x,T_2)$ since only the two particular models T_2 and T_4 will be compared. Here we focus attention on the predictive samples y and consider x as simply an additional variable that plays a minor role in the immediate discussion. Similarly, let $p_4(y|x)$ correspond to the case of using an order-4 model.

Now recall the conceptual repeated sampling experiment above where on the ith repetition the fit sample x_i is used to fit the order-2 model $p_2(y_i|x_i)$ for predicting y_i and similarly for the order-4 model. Denote the joint fit sample and prediction sample over N repetitions as $(X,Y)=(x_1,\ldots,x_N,y_1,\ldots,y_N)$. Then from the sufficiency and likelihood principles above, all of the information in the predictive sample Y for comparing model order 2 versus model order 4 is given in the likelihood ratio shown in figure 4a. The equation in figure 4a expresses the relative odds of the observed repeated sample Y having come from the order-2 model versus the order-4 model. As the number N of repeated samples (X,Y) becomes large, this odds ratio approaches a constant exponential function of N as illustrated

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In regression problems, negentropy reduces to average squared error.

in figure 5. More precisely, as N increases, $1/N$ times the logarithm of the likelihood ratio approaches the value shown in figure 4b.

The quantity

$$I(p(y|x), p_i(y|x)) = \int p(y|x) \log \frac{p(y|x)}{p_i(y|x)}\, dy$$

in figure 4b is known as the Kullback-Leibler conditional discrimination information (reference 3) between the true density $p(y|x)$ and the model $p_i(y|x)$ for a fixed-fit data set x. E_x means the average over all possible fit sets x. This average of the Kullback-Leibler information is called the negative entropy, or *negentropy* for brevity. In the case of a normal distribution with an unknown mean function as in the regression problem, the negentropy reduces to the average squared error. It can be considerably different in other cases. In addition to the sufficiency principle, we have used what is known as the repeated sampling principle, which states that statistical procedures are to be judged by their behavior in hypothetical repeated sampling experiments.

The negentropy has considerable appeal as a result of the above simple derivation. In terms of the conceptual repeated sampling experiment for evaluating the prediction accuracy of a modeling procedure, the odds ratio of two models having produced the predictive sample will diverge with increasing numbers of repetitions at an exponential rate equal to the difference of the negentropies of the two models relative to the true.

The above simple reasoning can be made very general (reference 4) and applies to very complex modeling problems. The negentropy also has a natural interpretation as a measure of model-approximation error in approximating the true density $p(y|x)$ by the model-selection procedures $p_2(y|x)$ or $p_4(y|x)$. Since the negentropy is a measure between the true and any approximating model, the comparison of many different models is no difficulty. Even more complex situations can be considered where the model-selection procedure includes the choice of model order and structure.

ESTIMATING ENTROPY

The results above describe how to determine or compute the model-approximation error between the true process and a model-approximation procedure in the case of perfect knowledge about the random statistical behavior of the true process. In the model-fitting problem at hand, the true process is completely unknown. The entropy measure follows as the natural measure of model-approximation error in a hypothetical repeated sampling experiment if such an experiment were actually to be performed. In any case, we would like our model-selection procedure to come close to minimizing the negentropy in such an experiment.

There are two approaches to estimating the negentropy from the sample. One approach is to empirically compute the prediction error by dividing the sample into two data sets—the fit set and the check or prediction set. Obviously, full use is not made of the data for model fitting since some of it is saved as a prediction set for computing the negentropy measure. A more sophisticated variation on the same theme is the cross-validation approach (reference 5), where each individual observation is deleted and the resulting data is used to predict the deleted point. The prediction error is then averaged over all possible points. This is applicable only in the case of models with independent errors and not for the time-series forecasting problem. Stone (reference 6) shows that for a large fit-set sample the cross-validation procedure is equivalent to the AIC procedure described below.

A second approach is to determine the correction to the fit-set error that will give an unbiased estimate of the error on the prediction set. In this approach the prediction set is not actually available, but an estimate is obtained by studying the statistical theory relating the fit-set error and the prediction-set error.

Using such an approach, Akaike (references 7 and 8) first proposed an estimate of the negentropy for comparing different model orders using the fit data. Consider again the case of comparing an order-2 regression model and an order-4 model. Suppose that for the order-2 model, the parameters are estimated using an efficient parameter-estimation procedure so that it is essentially a maximum likelihood procedure. We wish to compare the order-2 model to the order-4 model. The negative log likelihood function for each of these models is an estimate of the negentropy. This gives a biased estimate of the negentropy for two reasons. First the fit data are used instead of the prediction data, and the optimism of overfitting the data on the fit set has been thoroughly illustrated above. Secondly, the same fit data is used to estimate both models, and thus there is a strong correlation between the two estimates, which results in a bias. A detailed inspection of the situation reveals that correction of the bias requires adding the number of parameters used in the model-fitting procedure to the negative log likelihood function.

Akaike originally worked with two times the negative entropy and gave the Akaike information criterion (AIC) as $AIC(j) = -2 \log p(x, \hat{T}_j) + 2K(j)$, where $p(x, \hat{T}_j)$ is the likelihood function on the fit data for the maximum likelihood estimate $\hat{T}_j$ of the jth order model $M(j)$ and $K(j)$ is the number of parameters adjusted in fitting the model $M(j)$. In the regression case the negentropy reduces to the average squared error and the average AIC to the prediction-set error. As shown in figure 6, the AIC is large for low model order but also increases for high order due to the term proportional to the number of parameters adjusted in the fitting. By comparison, the fit error on the fit set continues to decrease for higher-order models.

TIME-SERIES FORECASTING WITH AIC

The pioneering work of Akaike was originally developed for time-series analysis to determine an appropriate order to use for the time-series model. If an inappropriate model order is used in fitting the time series, then the error in using the model for prediction will be increased. Here we illustrate this phenomena with two examples, the first with simulated data where the true process generating the synthetic data is known, and the second with real data where only the data are available for judging the model-fitting procedures.

In fitting models to time series, most

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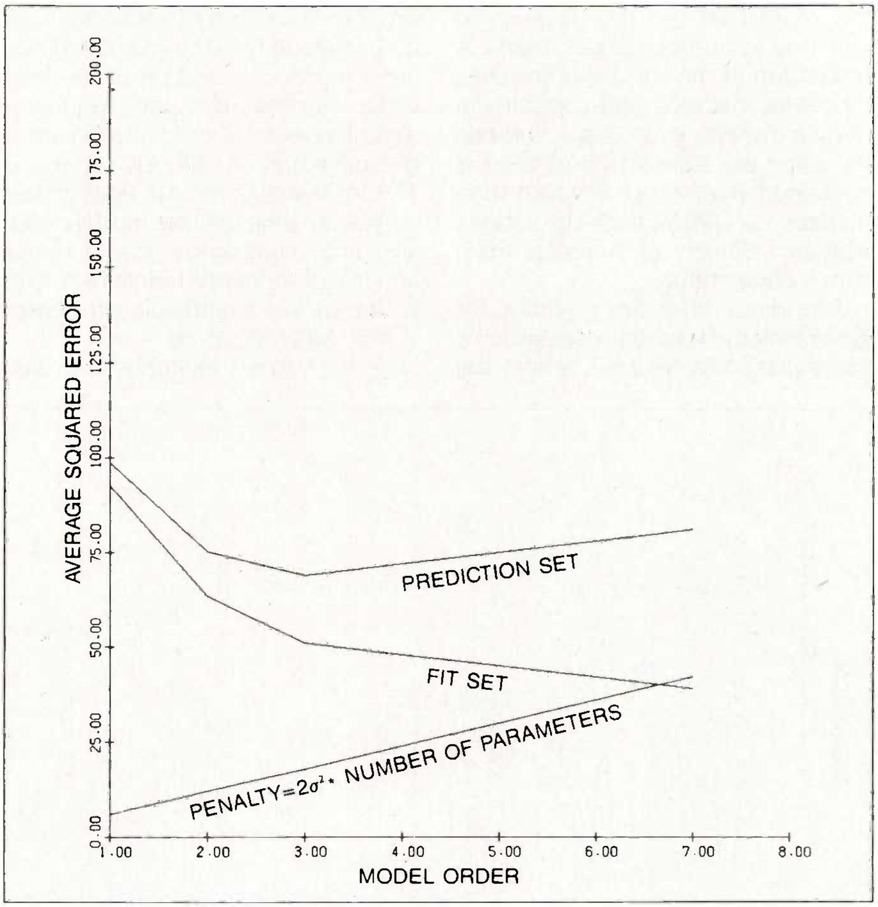

Figure 6: *Relationship between fit-set error, prediction-set error, and number of parameters.*

$$y(t) = 1.3136y(t-1) - 1.4401y(t-2) + 1.0919y(t-3) - 0.83527y(t-4) + n(t) + 0.17921n(t-1) + 0.82020n(t-2) + 0.26764n(t-3)$$

Figure 7: *Difference equation used to generate the data for table 1.*

of the available software does not consider a quantitative measure of the predictive model-fit error such as the AIC measure. In the examples, the Forecast Master software from Scientific Systems Inc. was used to automatically determine a best model order using an approximate AIC, which permits refined comparison of the various model orders. Several types of models are used to parameterize time-series models. At present, the parameterization that most easily and directly deals with the comparison and choice of the model order is the state space structure. For this reason we use the state space structure to fit time-series models. A discussion of the various time-series modeling methods and comparison of their respective forecast accuracies including the state space method is contained in reference 9, which summarizes an ORSA/TIMS (Operations Research Society of America) time-series competition.

Consider a difference equation for generating the synthetic data given by the equation in figure 7, where the observations are $y(t)$ at time t and the random white noise $n(t)$ excites the difference equation. Suppose that 200 observations are generated by the difference equation and that a model is fitted using the first 100. This model is then used to predict the observation at time 101 through 200 and the prediction error computed as depicted in figure 8.

This simulation is then repeated 100 times to obtain statistics given in table 1 on the behavior of the AIC as well as the use of a fixed model order in model fitting. The AIC and fit-set error computations do not exhibit the usual properties for orders above the best fit. In spite of this, the calculated AIC gives a proper selection of the best order as seen from the frequency-weighted average prediction error of the minimum of the AIC, which is 125.26. Note that the AIC does almost as well as using the true model order, which has a prediction error of 124.64 and in real situations is unknown. This is one of the remarkable properties of the AIC procedure.

In the second example, the data consists of 300 viscosity readings from a chemical process, Series D times series in reference 1. As in the simulation example, a model is fitted based upon an interval of 30 observations, and the prediction set is the next 30 observations. This is repeated for five such intervals of data to evaluate the prediction error with the results shown in table 2. In this case there is no "true" process model or true order, and most likely the "true" order is not finite. Here again the AIC procedure chooses a model that is as good as the best fixed-order model in terms of its ability to forecast the future of the time series.

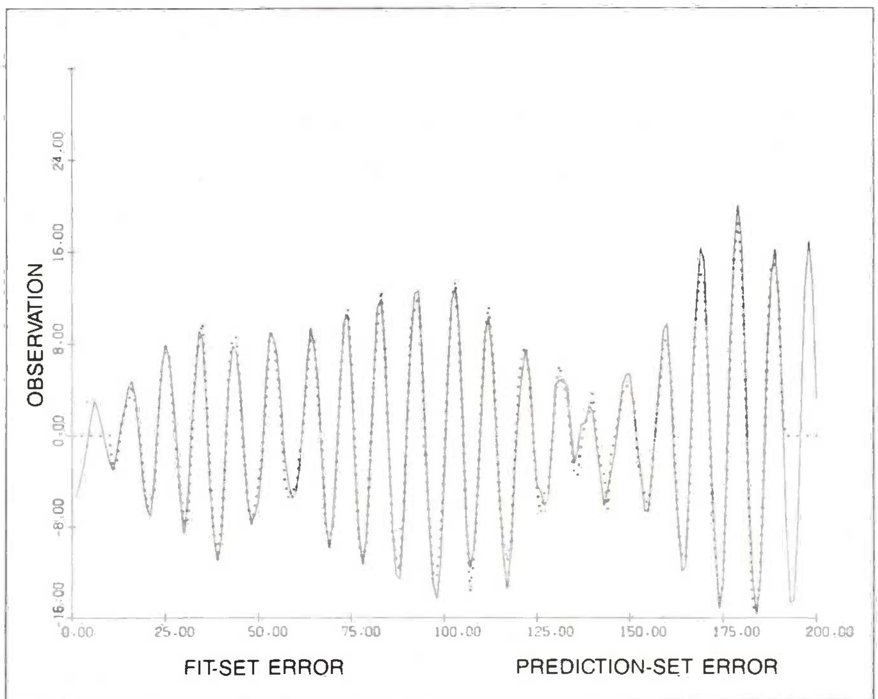

Figure 8: *Observed time series (—) and one step ahead prediction (. . . .) for one data set generated by the equation in figure 7.*

Current Research

The area of model order and structure determination from empirical data is of great current interest. The approach taken here involves the fundamental statistical concepts of sufficiency and likelihood in the context of predictive inference. The minimum description length approach of Rissanen (reference 10) involves the use of information coding and complexity concepts. A Bayesian approach to the order-determination problem is taken by Schwarz (reference 11). Both of these approaches lead to an order-determination criterion similar to AIC except that the additional term that adjusts for the number of parameters is proportional to the logarithm of the number of parameters rather than just the number of parameters. Such a procedure is shown to be *order consistent*—the "true" model order is chosen with probability 1 as the sample size of the fit set grows without bound.

At first sight, order consistency is an attractive property of an order-determination procedure. Shibata (reference 12) has studied this issue in depth and found that AIC actually achieves the implicit goal that motivated Akaike—it does the best that any order-determination procedure can do in minimizing negentropy, at least for a large fit-set sample. Such a procedure we will call *entropy efficient*. Further, it was shown that

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order-consistent procedures cannot be entropy efficient and vice versa so that a choice is necessary as to the basic purpose of the modeling. If the model is for the purpose of information storage with a restricted number of bits, then the criterion of Rissanen may be more appropriate, whereas if prediction or forecasting of future observations is the main objective, then AIC may be preferred. The concept of a "true" order is suspect in the case of real data. Besides, within any small neighborhood of the "true" model there are higher-order models of all orders so that there is a lack of separation between the "true" model and higher-order models. The entropy concept appears to be founded upon much more basic principles of statistical inference.

Current research is focused on the derivation and use of order and structure determination procedures in a variety of random processes where classical statistical methods are difficult to apply. In time-series analysis of time-varying processes, entropy concepts are being used to determine the best length of data to use for adapting to process changes. For the detection of failures or abrupt changes in a process or system, the comparison of the predicted versus actual response based on the entropy measure results in a sound statistical basis for decision.

The innovations of adaptive model order selection and structure determination are currently being applied to such diverse problems as adaptive identification and control of aircraft wing vibration, failure detection and adaptive identification of large space structures, identification of injection molding processes and machines, and adaptive control of electric arc furnaces. Among the numerous potential applications are nuclear power plants, paper mills, and petrochemical plants. In robotics, the mass and inertia of an object must be determined before it can be safely moved.

Empirical model-fitting methods are thus at the center of truly adaptive methods of constructing models of observed process data. This is a necessary step in the application of many scientific and engineering technologies to particular real-world problems. The powerful technology of automatic control is of little use until the particular dynamics of a process are determined. The continued development and application of empirical model fitting is an important step in the continued automation of data processing and process control using the rapidly expanding availability of computational resources. ■

Table 1: *Error measures for various order models on simulated data.*

Model Order	1	2	3	4	5	6	7
Error Measure							
Fit Set	184.58	117.61	117.26	113.58	113.24	113.10	113.04
Prediction Set	194.73	126.08	125.61	124.64	124.42	124.29	124.20
AIC	187.58	122.62	124.27	122.58	124.24	126.10	128.40
Min. AIC		126.22		123.63	128.58		
(Frequency)	(0)	(0.61)	(0)	(0.38)	(0.01)	(0)	(0)

Table 2: *Error measures for various order models on real data.*

Model Order	1	2	3	4	5
Error Measure					
Fit Set	−2.43	−2.83	−3.03	−3.07	−3.08
Prediction Set	22.91	24.33	24.31	23.60	23.90
AIC	0.58	2.16	3.96	5.92	7.91
Min. AIC	22.91				
(Frequency)	(5)	(0)	(0)	(0)	(0)

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TESTING LARGE-SCALE SIMULATIONS

BY OTIS F. BRYAN JR. AND MICHAEL C. NATRELLA

Using a discrete simulation language to develop large programs

TESTING IS A RESPONSE to the practicalities of programming. Theoretically, you can write a correct program of any size and mathematically prove it is correct. But few people know *how* to do the proofs, let alone do them.

Even when people are very careful, they make mistakes. People work on different parts of the program and do not coordinate their efforts completely. They forget what they have been told, or it does not make an impression on them.

Time is limited. At some point you have to deliver working code to the user. Normally, time does not permit all of the logical checks everyone would like.

Still, someone who has paid for a program will want to know that the program will do several things: It will work as it is supposed to under normal conditions, it will work properly under a wide range of conditions, and if it does bizarre things, they will be readily apparent.

VALIDITY AND VERIFICATION

It's helpful to keep these two concepts separate, especially in simulations. Writing a simulation program is a two-step process. The first step is to convert reality to a model. The simulation is valid if the model is an adequate representation of reality.

The second step is to convert the model to a program. The simulation has been verified if the code does what the model requires. If you want distance, you multiply velocity by time and do not add them.

The reason it's important to keep problems of validity and verification separate is that they require different solutions. In the case of validity, you have to redesign the model and occasionally rip out large chunks of code. In the case of verification, you normally have to rewrite a routine or two.

VALIDITY TESTING NEVER ENDS

Testing a large simulation is somewhat different than testing an operational program because the simulation is never really complete. The purpose of simulation is to make you smarter about your world. It's here to help you learn. You create a situation, try some things, review the results, change a few things, and go again.

An example. TAC THUNDER is the Air Force's premier theater-level combat simulation. It simulates both the NATO and Soviet sides of a conventional war in Europe, including the air and ground wars and resupply. It is a discrete-event simulation, written in about 40,000 lines of SIMSCRIPT II.5, which is roughly equal to 100,000 lines of FORTRAN.

In running THUNDER, we found the air defense aircraft seldom scrambled. "Something's wrong with THUNDER." A few quick calculations showed that THUNDER was doing what it was supposed to do.

The problem was one of validation, not verification. The decision rule did not reflect reality. The rule said, "Scramble only if you can reach the Soviet aircraft before they reach their target." Since Soviet fighters attacking

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In debugging, find the simple errors first, then work on the big ones.

the front line would not be detected until they were very near the target. THUNDER calculated that the NATO fighters could not reach them in time and did not scramble.

There followed a four-hour discussion of air defense rules, combat air patrols, and the value of being able to delay making irrevocable commitments until the last minute. As a result, the air defense strategy was redesigned.

Verification Testing: A Bottom-up Activity

If design starts at the top, testing starts at the bottom. Errors come in many types. Some are simple, such as dividing by 2 instead of 3. Others are complex, such as two widely separated parts of the program interacting with each other.

You can throw a full database at a full program, but it will take you a long time to catch each error. It's better to find the simple errors first, then work on the complex interactions.

We recently added a theater airlift module to THUNDER. When it was first run, the C-130s took off but hadn't landed 10 days later when the simulation ended. It took an hour or so to find out that to calculate the landing time, distance in meters had been divided by air speed in knots.

Database design, rather than the model, caused the trouble. THUNDER works in meters, kilograms, and days. The analysts use nautical miles, tons, and hours. In putting a test database together, we asked the airlift people for characteristics of a C-130, and we received knots and tons.

Once you find a mistake, don't forget to test the fixes. After getting the C-130s to land in three and a half hours rather than two weeks, we took the results to a navigator with a master's degree in operations research. We wanted someone who had flown the missions to tell us if the results made sense. That is, were they valid?

After a few minutes, he asked, "Why does it take a C-130 three and a half hours to go 600 miles? Even with 25 minutes thrown in for descent and landing, it shouldn't take a 300-knot airplane that long." In rushing to fix things, we upgraded the previous bug from meters divided by knots to kilometers divided by knots.

Fixing this bug did not require recoding. We created data-input worksheets with three columns for the user. The first column had dimensions the user was familiar with, the second column had a conversion factor, and the third had dimensions appropriate to THUNDER. Sometimes solutions involve more than rewriting code.

The best way to debug a simulation is to start with small test cases and databases to catch the simple errors that do not involve large interactions.

In the THUNDER airlift module, we started with 100 tons of cargo and the case where no aircraft were available. The cargo went by ground transport and arrived in a reasonable time. We then made one C-130 available and ran the simulation again. The cargo left a supply depot by ground and went to an airbase. There, part of it was loaded on the C-130 and flown to another airbase, where it was unloaded and sent to its destination by ground. The C-130 made several more flights until all the cargo was delivered. Nothing particularly difficult, but it uncovered several problems.

TAC THUNDER has a journal. Every time a status change occurs, the key values are written in the journal along with the time of occurrence. We were able to trace the scheduling and actual movement of the cargo event by event. This involved some work with a pocket calculator, but that was simple.

Then we substituted a C-17 for the C-130. The C-17 will carry four times as much cargo. We encountered and solved different sets of problems.

Then we tried 15 C-17s, and THUNDER did the right thing: It scheduled two aircraft and kept the rest on the ground. Then we tried air drop at the destination rather than air land at an airbase. By that time, things were working smoothly.

This illustrates the usefulness of zero, one, and many as a debugging tool. Notice also that after we solved the basic problem, getting cargo from airbase to airbase, we tried the options, again one at a time. They worked as expected.

These were very simple tests, but they uncovered verification and validity problems in a short time. They were not confounded by interactions with other sets of cargo and other aircraft. Conversely, the big interaction problems were seen to be big ones because the small ones had been solved earlier.

Developing the test plan was simple. We set up cases to test each routine as it would normally be used. Then we laid out the key variables (aircraft type, cargo type, arrival time, etc.) and tested each in an orderly way. We tracked flights in the journal to make sure they made sense.

As time went on and we gained confidence in our results, we skipped over several of the redundant ones. In fact, we got to be pretty good at predicting results—a sure indicator that we understood the model.

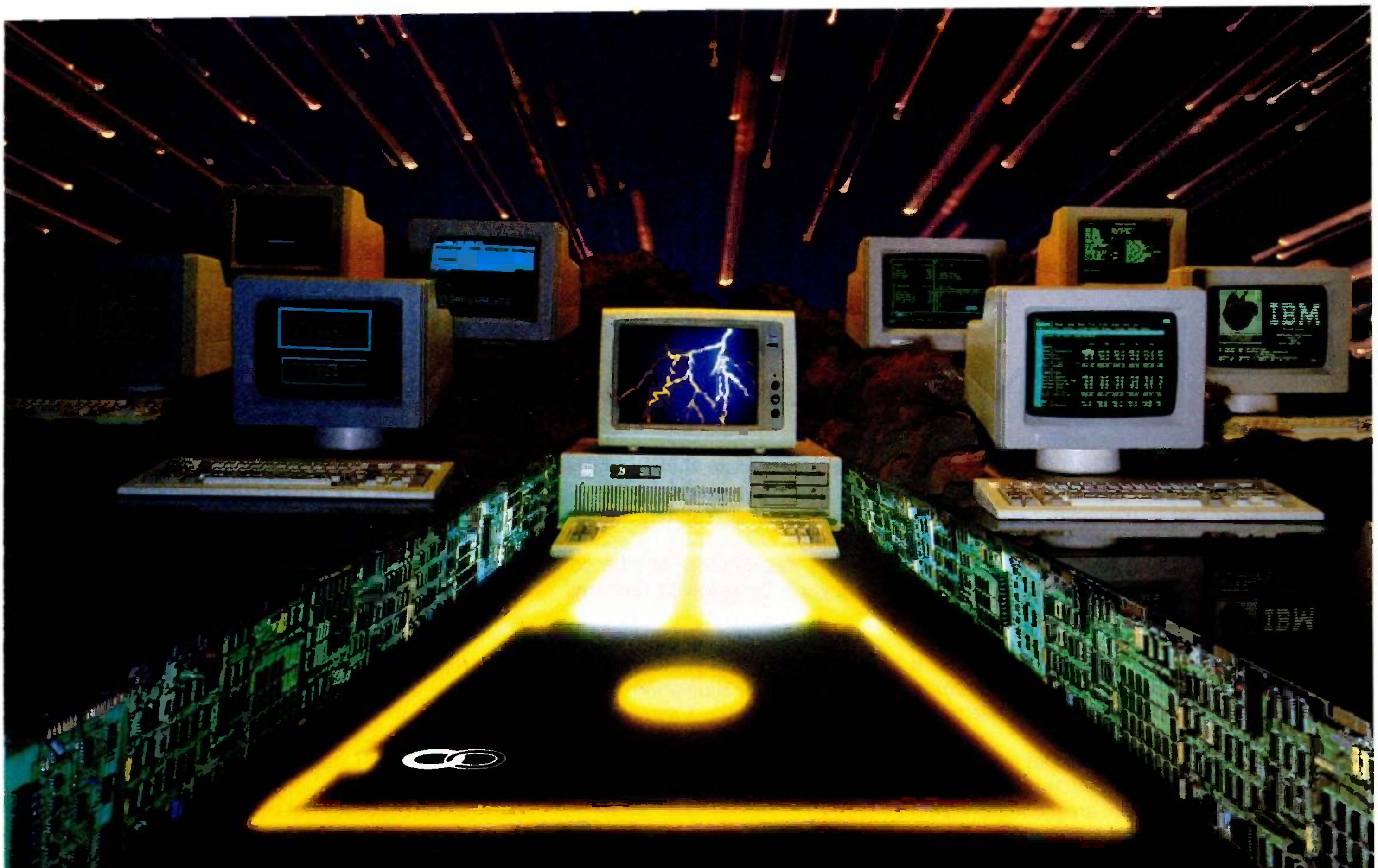
Develop a Testing Strategy

Even though testing is mundane, it can be done efficiently if you have a strategy. The testing strategy for the airlift module in THUNDER had three parts:

- Reduce the chances for errors to a reasonable level.
- Make it easy to find the errors that do occur.
- Make it easy to correct the errors you have found.

Reduce the chances for errors to a reasonable level. A large simulation will have many events and processes happening at arbitrary times. Uncovering undesir-

(continued)



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THE WASHINGTON NATIONAL AIRPORT MODEL

Listing A is a fairly simple program that will illustrate the concepts described in the main text. It is written in SIMSCRIPT II.5, CACI's proprietary language.

The federal government currently owns and operates Washington National Airport. There is a move afoot to transfer it to regional ownership. If that happens, action should be taken quickly to solve the automobile traffic problem at National.

Any automobile model will have to take into account aircraft arrivals and departures. These are the reasons people come to and leave the airport. As these arrivals and departures vary, so will the traffic demand at National vary. We need some way of generating estimates of traffic loads. Thus the Washington National Airport Model.

The situation to be modeled is this: An aircraft arrives at the edge of the Washington Terminal Area. It is directed to a point about 10 miles north of the airport called the Cabin John Bridge. It flies down the Potomac River, lands, taxis in, and unloads its passengers.

We will model this and call it ARRIVAL, APPROACH, and LANDING. Later we will need to add general aviation traffic. Once the model operates correctly for airliners, general aviation will be a straightforward modification.

Aircraft departures are somewhat simpler. People arrive at the airport 30 minutes prior to departure and go on board. The airliner leaves the gate, taxis to the end of the runway, takes off, and disappears from the system. This is modeled in DEPARTURE and AIRLINER.DEPARTURE.

Because this is a simple model, data is contained in a routine called CONSTANTS. If it were a working model, a database manager would be used, and the model would have no data in it.

For all intents and purposes, there is only one runway at National for airliners. We'll assume that a takeoff takes 1 minute and a landing takes 2 minutes. We want the runway clear for at least 1 minute before the landing airliner touches down so that it doesn't have to go around. Landing airliners get priority.

This means there will be conflicts. They will be resolved this way:

- Arrivals at the Approach Control will take 7 minutes to get to the Cabin John Bridge. In our simulation, once an aircraft crosses the Cabin John Bridge, another cannot cross for 4 minutes. In reality, air traffic control varies flight paths and speeds to control separation.
- Once the aircraft arrives at the Cabin John Bridge, it will schedule use of the runway in 3 minutes and hold it for 2 minutes. Because of landing separation, there will be no interference from other landing aircraft.
- An aircraft taking off will ask for the runway now. If the runway is being used by a landing aircraft, it will have to wait. Because of loading separation, it can get off before the next landing aircraft seizes the runway.
- The taxi areas will be holding areas for the planes on the ground, which is the way things normally operate.

The model will be somewhat artificial. All times will be deterministic. They should be random variables. Not everyone shows up exactly 30 minutes ahead of time. This is a strategy for validity testing: Start simply, make it work, and add complexity later.

General aviation aircraft are excluded, although they often account for twice as many takeoffs and landings as airliners. This will lead to artificial answers about aircraft congestion and delays. That can be added later.

Arrival and departure times will be chosen from random distributions. With a little time, we can get the actual times from the Official Airline Guide to add more validity to the data. These would be read from a file.

In listing A, three features may not be obvious. A process is a set of events, ordered by time, with intervening periods of operation. If the LANDING process is read as a time sequence, it will make more sense.

There can be several concurrent processes. In fact, in the Washington National Airport Model there were a maximum of 18 approaches going on simultaneously. Because only one approach can be made at a time, the other processes were suspended until it was clear to start the next approach.

The WAIT statement causes the passage of time. While this is going on, control passes out of the process and to the next process, the event list. Thus, other things can happen. When the waiting period is over, control passes back to the process at the next statement.

If the process asks for a resource, such as the runway, and it is not available, the process will wait. That is, control will pass out of the routine and come back to the next statement when the resource is available.

The program itself is functionally organized. The PREAMBLE contains all global data declarations and statistical data collections. Note that only one statement is necessary to collect data and calculate a statistic, and that statement is in the preamble.

The MAIN routine schedules the first arrival and departure, then starts the simulation. The processes ARRIVAL and DEPARTURE schedule the rest of the arrivals and departures.

After the simulation is over, MAIN calls the report generator, REPORT.

The CONSTANTS routine puts all the data in one place. If random variables or external events, such as actual airline schedules, are used, the data can be modified easily.

The APPROACH process ties up the Cabin John Bridge, and the LANDING process ties up the runway. SIMSCRIPT permits you to schedule a process in advance, but it does not let you seize a resource in advance. Thus, while a statement something like

(continued)

Listing A: A SIMSCRIPT II.5 *implementation of the Washington National Airport Model.*

```
PREAMBLE

  Normally mode is integer

  Processes include

    approach,
    arrival,
    landing,
    departure,
    airliner.departure,
    hourly.report.writer

  Resources include

    cabin.john.bridge,
    runway

  Define
    airport.arrivals,
    seats.per.aircraft,
    people.in.airport
      as integer variables

  Define
    airport.departure.time,
    arrival.separation,
    check.in.time,
    departure.interval,
    descent.time,
    end.time,
    final.approach.time,
    landing.time,
    load.factor,
    peak.load.factor,
    separation.time,
    take.off.time, and
    taxi.time
      as real variables

  Define ..minutes to mean units

  Define ..on to mean 1
  Define ..off to mean 2

  The system has
    a test.switch " if test.switch = ..on, write the
                  " journal

  " Statistics

  Tally average.number.of.people as average and
        maximum.number.of.people as maximum of
        people.in.airport

  Tally average.at.bridge as the average and
        maximum.at.bridge as the maximum
              of n.q.cabin.john.bridge
  " n.q.cabin.john.bridge is the number of aircraft
        waiting to start an approach.
  " SIMSCRIPT automatically tracks that number


  Tally hourly.arrivals as the hourly sum.
        total.arrivals as the sum of airport.arrivals

  End
```

```
Main

  Call Constants

" Set up first events and run simulation

  Activate an arrival now " first arrival

  Activate a departure now " first departure

  Activate an hourly.report.writer now " start printing
        the arrival report

  Start simulation " run simulation

" When last scheduled event is completed,
  goes to next statement

  Call Report " print reports

End
```

```
Process Departure

  " Creates airliner departures until simulation ends

  While time.v < end.time " time.v is the current time

    Do

    Wait exponential.f(departure.interval,1) ..minutes

    If test.switch = ..on

      Print 1 line with time.v thus
****  Departure

    Always " entry written to journal

    Activate an airliner.departure now

  Loop

End
```

(continued)

TESTING PROGRAMS

```
Process Arrival

'' Creates airliner arrivals until simulation ends

   While time.v < end.time

      Do

      Wait exponential.f(arrival.separation,2) ..minutes

      If test.switch = ..on
         Print 1 line with time.v thus
****     Arrival
      Always '' entry written to journal

      Activate an approach now '' next aircraft

   Loop

End
```

```
Routine Constants

'' Values of constants; set in one place
'' All times are in minutes

   Let airport.departure.time = 20.0 '' time to
   go through airport

   Let arrival.separation = 4.0

   Let check.in.time = 30.0 '' before departure

   Let departure.interval = 4.0

   Let descent.time = 7.0

   Let end.time = 480.0 '' 8 hours of simulation

   Let final.approach.time = 3.0

   Let landing.time = 2.0

   Let load.factor = .5 '' avg number of seats filled

   Let peak.load.factor = .85

   Let seats.per.aircraft = 150

   Let separation.time = 4.0

   Let take.off.time = 1.0

   Let taxi.time = 5.0

   Create every cabin.john.bridge(1)
   Let u.cabin.john.bridge = 1 '' just one bridge

   Create every runway(1)
```

```
     Let u.runway = 1 '' just one runway

     Let test.switch = ..off

   End

   Routine Report

     Print 7 lines with average.number.of.people
        and maximum.number.of.people thus

      Number of people at Washington National Airport
                     Average         Maximum
                       *****           *****


     Print 7 lines with average.at.bridge
        and maximum.at.bridge thus

      Number of aircraft waiting to land
        at Washington National Airport
              Average     Maximum
                *****       *****


   End

   Process Hourly.report.writer

   '' Print titles and hourly statistics
   '' Also changes load factor at 4 p.m.

     Print 7 lines thus

        Washington National Airport Model
              Hourly Passenger Arrivals
                  HOUR    NUMBER

     While time.v < end.time
        Do
        Wait 60 ..minutes '' print reports every 60 minutes

        Print 1 line with time.v/minutes.v, hourly.arrivals thus
     ****      ****

        Reset hourly totals of airport.arrivals

   '' Reset the load factor at 4 p.m.

     If time.v >= 240.0

        Let load.factor = peak.load.factor

     Always

   Loop

   End
```

(continued)

```
Process Approach

   '' Approach to Washington National

   Wait descent.time ..minutes '' travel to bridge

   Request 1 cabin.john.bridge '' start approach

   Activate a landing in final.approach.time ..minutes

   Wait separation.time ..minutes '' maintain
   aircraft separation

   Relinquish 1 cabin.john.bridge '' next aircraft can
                                  '' start approach

End
```

```
Process Airliner.departure

   Let airport.arrivals = seats.per.aircraft * load.factor

   Add airport.arrivals to people.in.airport

   Wait check.in.time ..minutes

   Subtract airport.arrivals from people.in.airport

   '' Airplane taxis and takes off

   Wait taxi.time ..minutes '' taxi to end of runway

   Request 1 runway

   Wait take.off.time ..minutes '' take off

   Relinquish 1 runway '' departed

End
```

```
Process Landing

   '' Maintains separation on runway

   Request 1 runway

   Wait landing.time ..minutes '' complete landing

   Relinquish 1 runway

   Wait taxi.time ..minutes '' taxi time

   Let airport.arrivals = seats.per.aircraft * load.factor

   Add airport.arrivals to people.in.airport

   Wait airport.departure.time ..minutes '' going
   through airport

   Subtract airport.arrivals from people.in.airport


End
```

Request the CABIN.JOHN.BRIDGE
in 7 minutes

would allow the arrival to be contained in one process, it is illegal in SIMSCRIPT. While it may appear that permitting seizing resources in advance would simplify programming some simulations, in reality it would generate very hard-to-spot errors. In complex simulations, it would be possible to create a kind of simulation gridlock in which each process needs to seize a resource that has been seized in advance by another.

Where to go from here? This program has been verified; it does what the model calls for it to do. The next step is to add more "realism," in particular, to use actual arrival and departure times and to add general aviation as a random event.

Just for fun, close the airport for an hour with a bad storm at 4:30 p.m. on the Sunday after Thanksgiving—the airlines' busiest day of the year—and watch gridlock occur.

able interactions is inevitable during testing. By giving some thought to the total design, you can avoid a large number of such interactions.

All of the modern software design tools come into play here: top-down, structured, modular programs; prologues; structured, English commentary; and so forth. They control the interactions and make sure the routines do what they are supposed to do. They solve most of the verification problems.

By observing the concepts of structured programming, this strategy is easy to accommodate. Subroutines are designed to perform one well-defined task.

Initially, a subroutine can be "stubbed" to return a value without concern for the internal process of getting the value. By designing the interface to the routine early, with input and output explicitly stated as parameters (as opposed to global variables), sophistication can be added to the routine with less chance of causing undesirable interactions with other parts of the simulation.

TAC THUNDER was carefully designed. It took nine months of structured programming before the coding was started. During this time there were frequent discussions of the design with the technically knowledgeable people in the Air Force.

There were very few verification problems, but we rewrote the model considerably to improve it.

During the design phase, we recognized that not all problems could be

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Let the program keep track of conventions for you.

solved immediately. Some programs were designed in an elementary way with the understanding that the algorithms would be revisited later.

One sensible strategy for beginning simply is to start by assigning a constant to a variable. For example, you can make maintenance turnaround time equal to four hours.

```
Let MAINTENANCE.TURN.
  AROUND.TIME = 4.0
```

Next you can add variability to that by changing from a constant to a random variable.

```
Let MAINTENANCE.TURN.
  AROUND.TIME = exponen-
tial.f(4.,1))
```

This will give you a value from an exponential random variable with a mean of four hours based on a random number drawn from random-number stream 1.

Alternatively, you can model the maintenance function, either in low resolution with a few basic functions or in gory detail with each person doing his or her job on a minute-by-minute basis.

Start simply; get it right. Then add complexity.

Make it easy to find the errors. Readability is the key to validation and verification. Readability is measured by how long it takes you to understand code you have never seen.

The longer it takes to understand a program, the more difficult and frustrating it is to find errors—particularly errors of interaction. Conversely, the easier a program is to understand, the more likely it will work correctly; errors will be easier to detect.

There are several things you can do to improve readability. First, select the correct language. You can write a discrete-event simulation in any language. But if you pick a language that is arcane, it is going to be difficult to read.

Every language is good at solving a certain class of problems and tolerable to bad at solving others. FORTRAN is good for repetitious numerical calculations. C is good for operating systems. SIMSCRIPT II.5 is good for discrete-event simulations. Pick the tool that fits your problem.

Set some style conventions and stick to them. The rule is an old one: Keep it simple. TAC THUNDER has a style and conventions manual, and the coding follows it. Here are a few naming rules that we used in that simulation to improve readability:

- Begin global names with a word or acronym: AIRLINER.ARRIVAL.
- Begin local variables with a single period: .MY.APPROACH.TIME.
- Begin "define-to-mean" variables with two periods.

THUNDER's mode is normally integer. That is, everything is done in integer arithmetic unless declared to be something else. Rather than keep a code book of things like "Yes" means 1 and "No" means 2, let the program do the bookkeeping for you:

```
define ..YES to mean 1
define ..NO to mean 2
```

The code is then written using the term rather than the number:

```
Let AIRDROP.CAPABILITY = ..NO
```

You will notice that ..NO is not defined to mean 0. Another convention. SIMSCRIPT II.5 initializes all variables at 0 or blank depending on their type. By defining Yes and No as 1 and 2, you can differentiate between a variable that was never changed and one that was.

- Begin an entity's attributes with an acronym identifying the entity and list them alphabetically in a column.

Every AIRCRAFT.NOT.AVAILABLE has
an AC.NA.DATE
an AC.NA.NAME,
an AC.NA.NUMBER, and
an AC.NA.STATUS

Good names are signposts; they

(continued)

point to other related things. If you see AC.NA.STATUS in a subroutine, you can go back to the preamble and find something with AIRCRAFT in it. Note the spacing and indentation. This makes for readability.

Even programmers who have written code and set it aside for several months are delighted to be able to read and understand a program the first time they pick it up again. A project manager will make a lot of money if he establishes conventions early and enforces them.

In keeping with the separation of validation and verification, make the commentary a verification tool. Write the comments in structured English, but don't use the programming language. The code will be written right beneath it. Then you have a good check on the translation of the model to code. It does not do much good to say the same thing twice in exactly the same words.

Use good debugging tools. Here are a few we used while developing TAC THUNDER:

As mentioned above, THUNDER has a journal or transaction file. Every time a key status change occurs, a record is written to a file with the important values and the time of occurrence. We were able to find the kilometers/knots bug while tracing a flight using the journal.

By the way, all of the journal entries for testing are still in the code. But they are preceded by an IF statement:

```
if TEST = .ON
     write TIME.V (etc.)
```

If you want an operational run rather than a debug run, you set TEST = .OFF and the records are kept out of the journal. You don't change the code.

TAC THUNDER has no data in the program. All data for THUNDER, including run parameters, must come through the database, another separation of function.

In addition, SIMSCRIPT II.5 provides some useful debugging tools, including trace and snapshot routines—at any point the user can call for a listing of key variables and their values—and a cross-reference dictionary at the end of every subroutine. This lists each variable, the line number of the line it is used in, and whether it is set or read at that point. Combined with the style notation, it becomes very easy to find variable locations and what they mean.

Make it easy to correct the errors. Verification errors are generally easy to handle if the modularity rules are followed—each routine is intended to do one thing and do it correctly. Validation problems are tougher because they frequently require major redesign. Still, if you adhere to the functionality rules, the troubles can be kept within reasonable bounds. ■

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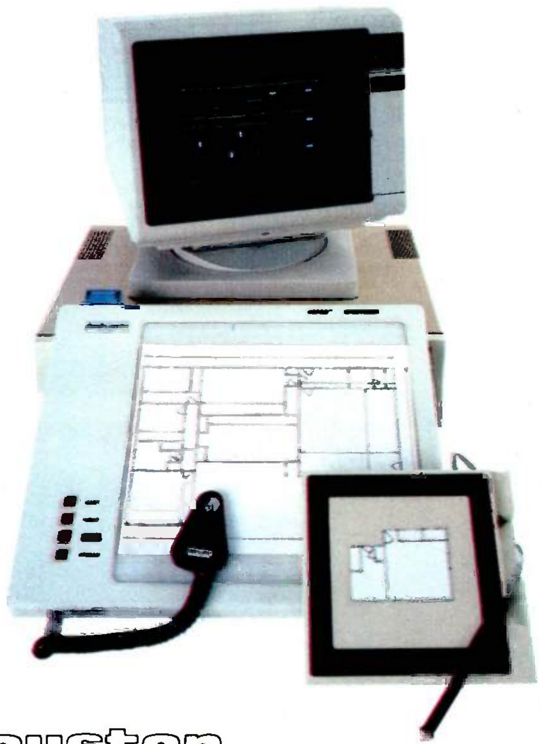

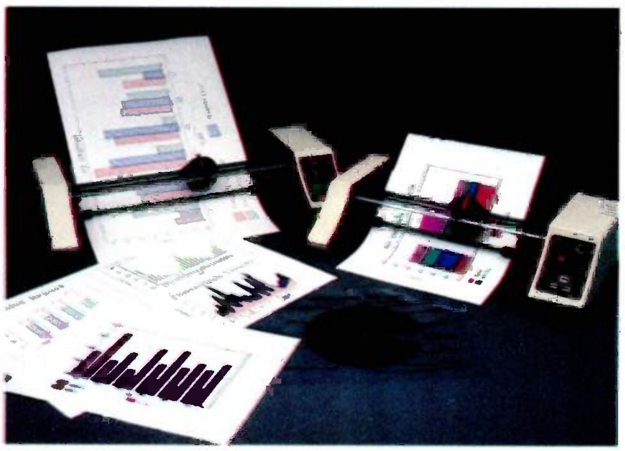

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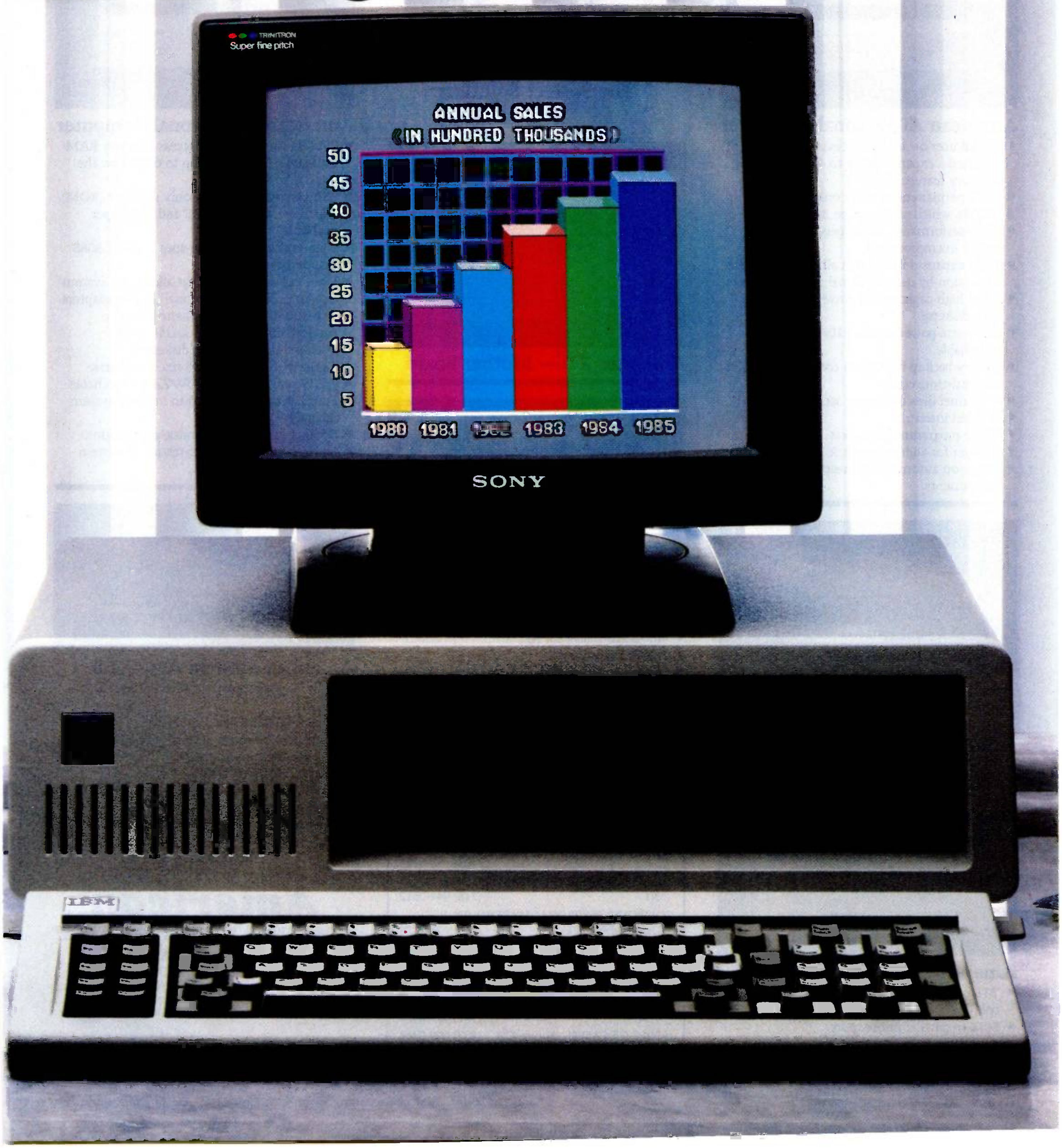

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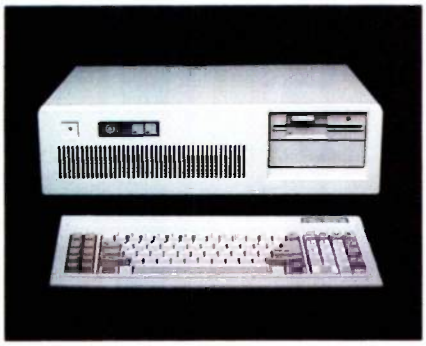

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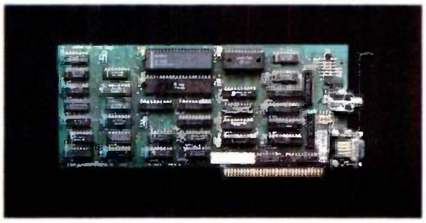

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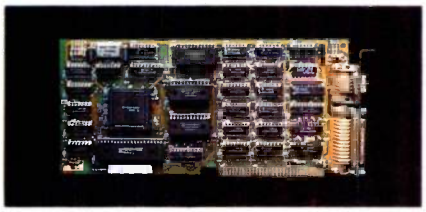

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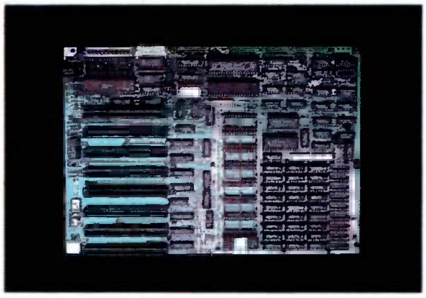

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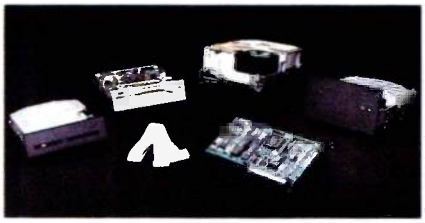

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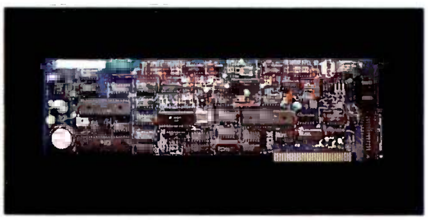

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ANALYZING GOVERNMENT POLICIES

BY ROSS M. MILLER AND ALEXANDER S. KELSO JR.

Economic modeling with Lotus 1-2-3

THIS ARTICLE DEMONSTRATES how a computer spreadsheet program can be used to assess the impact of a major government policy decision and illustrates some general microcomputer policy-modeling techniques in the process. The question we examine is the proposed funding of the environmental "Superfund." In response to the public outcry resulting from the contamination of Love Canal and the discovery of other abandoned toxic-waste dumps, Congress established a $1.6 billion Superfund in 1980 to clean up hazardous waste from sites where it was impossible to identify liable parties and assess them for clean-up costs. The taxes that finance Superfund expire on October 1, 1985, unless Congress reauthorizes them.

In the course of analyzing hazardous-waste sites, the Environmental Protection Agency discovered that the problem is considerably larger than originally thought. As a result, in 1984 Congressional committees considered a number of bills reauthorizing the Superfund taxes and increasing them substantially.

We analyzed the proposed tax increases as part of a study funded by Atlantic Richfield Company (ARCO) and conducted under the direction of Yale professor William D. Nordhaus and Management Analysis Center Inc. (see reference 1). The goal was to compare the tax in question with other taxes that would meet the same revenue targets. We simulated the effects of the tax by modeling the markets in which the tax is levied and the related markets where spillover effects occur.

The Superfund taxes are levied principally on the production of bulk chemical feedstocks that are the upstream predecessors of many toxic wastes. One of the taxed chemicals is propylene, which is not as hazardous as some of its downstream derivatives, such as phenol (carbolic acid), the chemical that binds plywood (figure 1). Other derivatives of propylene, such as polypropylene (a plastic film that is used in packaging), are safe enough for household use.

Although a tax on propylene raises revenues, it does so by raising the price of propylene and, indirectly, the prices of all products made from propylene, whether they are hazardous or not. ARCO asked us to analyze the economic effects of the Superfund tax on the petrochemicals markets and to compare the feedstocks tax with taxes on the hazardous downstream derivatives.

In this article we present two models that we developed using Lotus 1-2-3: The tax-incidence model considers taxes and spillover effects in a number of related domestic markets; the international-trade model takes the petrochemicals markets in the rest of the world into account. The models presented here are essentially the same models that

(continued)

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formed the analytic centerpiece of the study we wrote for ARCO.

ECONOMIC MODELS

In general, modeling is a means of taking a complex situation and capturing its essence formally. Often the nature of the model that is produced depends on the questions one wishes to explore with the model. Because the effects of a new tax on upstream or downstream markets can be separated from its effects on international trade, we develop separate models to examine these two issues.

The complexity of economic models used for policy simulation can be controlled in two ways. First, the range of economic activity that the model comprises can be limited to those activities on which the impact of the policy is significant. Second, the interactions among the activities that are included in the model can be restricted. Although every economic activity depends directly or indirectly on every other activity, the art of designing an effective economic model consists of finding the important activities and determining the critical links between them.

The validity of an economic model depends on how well it fits economic reality. Naturally, a model that oversimplifies a situation will not be able to present a valid reflection of that situation.

Complexity alone, however, does not ensure the validity of the model. Validity also depends on the degree to which the model has a behavioral basis. The types of behavior that economic models can most easily capture are optimization and competition. Models that rely simply on the extrapolation of past actions into the future without concern for the behavior that influenced those actions are likely to be invalid representations of the economic situation.

The methods of economic modeling that we employ are analogous to the classical methods of the physical sciences. (Beginning in the late nineteenth century, mathematical economists adapted physical models—particularly those from mechanics, fluid dynamics, and thermodynamics—to economic life. The idea of resource "flows" is so closely modeled on the flow of a fluid that some economists have designed hydraulic devices that simulate the flows of goods and money in an economic system.) The behavior of sellers generates an economic force—supply—that is opposed by an economic force exerted by buyers—demand. Equilibrium in a market is analogous to equilibrium in a physical system; it occurs when all forces are in balance.

The models developed in this article all examine how the imposition of a new tax is spread through connecting markets. The connections between markets are similar to connections between the members of a bridge (figure 2). The downward gravitational force of the person on the bridge is not borne entirely by the member directly below; rather, it is distributed through the adjoining members. The structure of the bridge determines exactly how the weight of the person exerts stress on each member of the bridge.

A tax may be viewed as an economic force exerted on an economic structure. The tax is not borne solely by the product on which it is levied but spreads to markets related to it. The bridge analogy is imperfect, however, because the links between markets may imply a far more complex structure than the simple linear structure of an idealized truss. Nonetheless, the equilibrium conditions—that supply and demand be equal in each market—lead to a sys-

(continued)

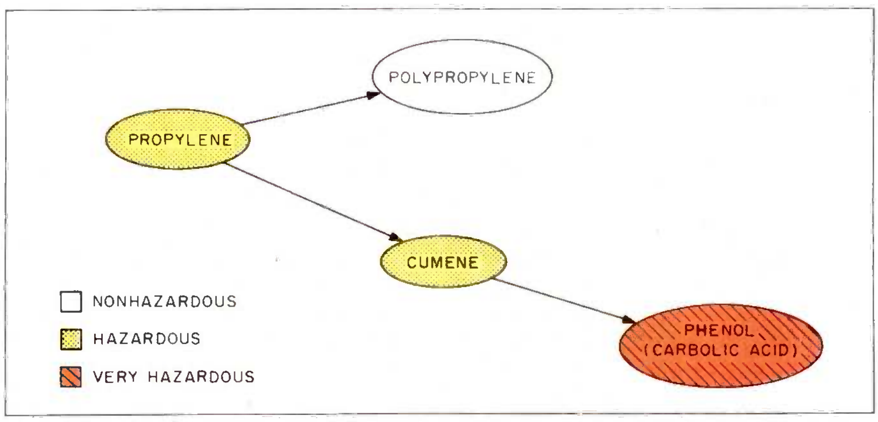

Figure 1: *The propylene-phenol production chain.*

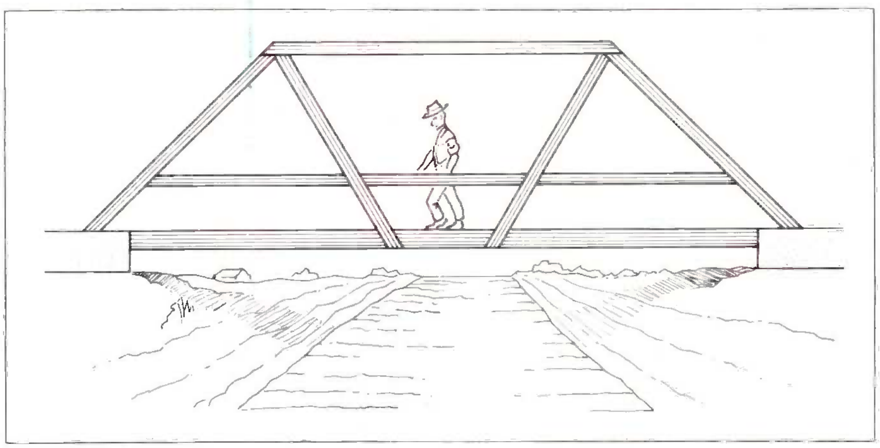

Figure 2: *The bridge analogy for economic interactions.*

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tem of equations whose solution indicates how the tax will be borne.

SPREADSHEET SOLUTION METHODS

Spreadsheets are particularly well suited to economic modeling. Unlike most procedural languages, such as FORTRAN, a spreadsheet enables you to build a model one piece at a time because you can see the calculated results from each step automatically. It is less work to verify the model output because you can see your intermediate calculations. It is also less bother to generate reports because you can easily change the report format. Input forms are also easier to generate. Naturally, spreadsheets are more specialized computational tools than procedural languages and so are not suited for models that do not fit into the spreadsheet mold. Models that cannot avoid extensive use of matrix algebra, for example, are generally not suited to spreadsheets.

Before examining the tax incidence models, it is worth spending some time with a model of a single market. Table 1 gives a spreadsheet that examines the direct effects of the propylene tax on the propylene market alone. This spreadsheet, developed in Lotus 1-2-3, will run with little or no modification with most spreadsheet software. Computed answers may differ slightly on some spreadsheets because of differences in rounding. [*Editor's note: All spreadsheet templates discussed in this article are available for downloading from* BYTEnet Listings *at* (617) 861-9774 *in* Lotus .WKS *file format and in* ASCII *format for porting to other spreadsheet software.*]

The equation that gives the supply of propylene is

$$P_{prop} = a + b \times Q_{prop} + T_{prop}$$

where P is the price of propylene, Q is the quantity produced, and T is the tax. This supply curve, like the others discussed in this article, is derived directly from the cost structure of existing propylene-producing facilities in the U.S. To simplify the computations, we use a linear approximation to this cost-based supply curve.

For the propylene market in isolation, the demand for propylene is given by the equation:

$$P_{prop} = c + d \times Q_{prop}$$

where P is the price of propylene, Q is the quantity purchased, and c and d are parameters. To illustrate spreadsheet solution methods, we can rearrange this demand equation as follows:

$$Q_{prop} = (P_{prop} - c) / d.$$

This equation is a linear approximation to the demand curve around the current price.

At the bottom of table 1 are three ways to solve for the equilibrium price and quantity of propylene, given the parameters of supply and demand. The solutions in the table are the actual 1983 price (in dollars per metric ton) and quantity (in thousands of metric tons). Although table 1 shows equilibrium with a tax of 0, changing the entry in the tax rate cell will, in turn, change the resulting price and quantity for propylene.

The first method is algebraic. We obtain this solution by solving the supply and demand equations algebraically for their two unknowns—price and quantity. While this method is probably the fastest way to solve two equations with two unknowns, it quickly becomes impractical as the number of unknowns grows beyond two.

The second method is iterative. Price is found by calculating the supply equation given above, using the most recent iteration of quantity as an input. Quantity is found by calculating the rearranged demand equation given above, using the most recent iteration of price as an input. To find the solution, we must repeatedly recalculate these two equations until price and quantity converge. (In Lotus 1-2-3, you simply press the Calc function key to recalculate the spreadsheet.) The iterative solution is another example of the Gauss-Seidel method that Jan-Henrik Johansson used to solve macroeconomic models (see reference 2). Unfortunately, this method exhibits problems converging that generally preclude its use in models like ours.

The third method is adaptive, which is iteration with lagged adjustment. It converges in instances when the iterative method does not. The disadvantage to using this method is that it converges more slowly than the iterative method, when both con-

(continued)

Table 1: A *model of the effects of the propylene tax on the propylene market alone.*

	A	B	C	D	E
1		INCIDENCE OF PROPYLENE TAX			
2			Cell	Contents	
3	Supply Intercept	283.6640	B3	283.6640	
4	Supply Slope	0.03634	B4	0.03634	
5	Demand Intercept	1188.56	B5	1188.56	
6	Demand Slope	−0.12	B6	−0.12	
7					
8	New Tax	0	B8	0	
9					
10		Algebraic			
11	Price	494	B11	(B3 + B8-B4*B5/B6)/(1-B4/B6)	
12	Quantity	5788	B12	(B11-B5)/B6	
13		Iterative			
14	Price	494	B15	+ B3 + B16*B4 + B8	
15	Quantity	5788	B16	(B15-B5)/B6	
16		Adaptive			
17	Price	494	B19	(B3 + B20*B4 + B19 + B8)/2	
18	Quantity	5788	B20	((B19-B5)/B6 + B20)/2	
19					
20					

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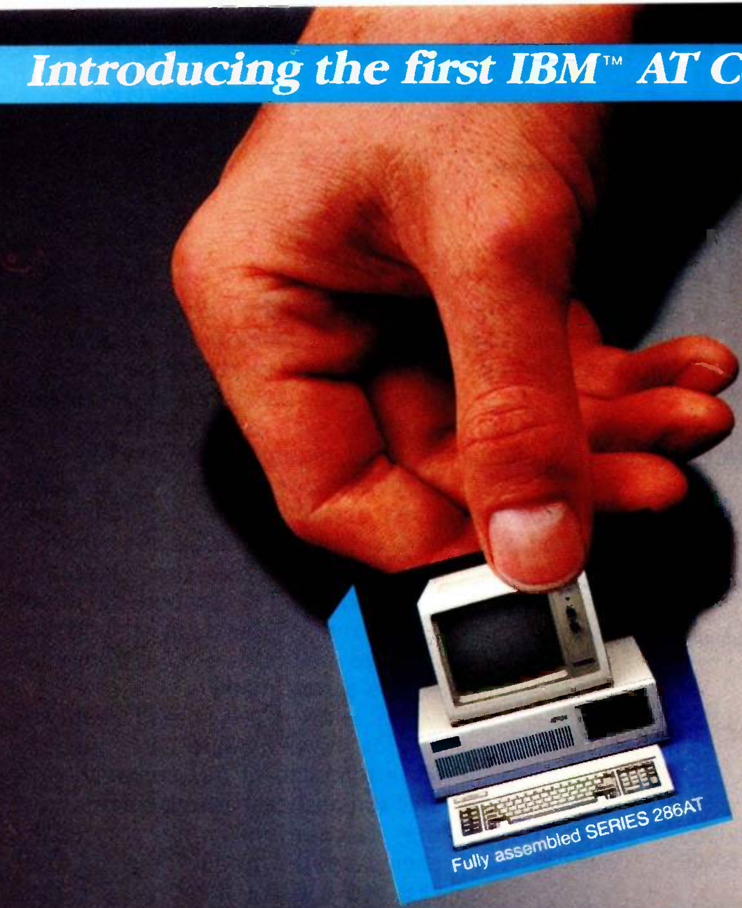

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verge. The iterative method uses only the current price to recalculate quantity, and vice versa. The lack of dumping in the recursive method is what sometimes causes it to diverge. The adaptive method reduces oscillations by averaging the newly computed value for price or quantity with the old one. More complex ways of ensuring convergence are also possible, but they all have in common that old values are used to moderate the updating process.

Tax Incidence Across Markets

The model of a single market provides some insight into how a tax on propylene affects the propylene market, but it is not suitable for comparing the effects of a tax on propylene to those of a tax on hazardous downstream products, such as phenol. Doing this requires modeling the markets for propylene's derivatives. The spreadsheet described in this section uses a hybrid of the algebraic and iterative solution methods. The algebraic method is used to compute the price and quantity within a market, and the iterative method is used to compute effects across markets.

The Lotus 1-2-3 spreadsheet we used is shown in table 2 (see table 3 for a template of this spreadsheet). This spreadsheet has four columns for the calculations, one for each chemical in the production chain. The first two rows of numbers give the 1983 quantities (in thousands of metric tons) and prices (in dollars per metric ton). The next block of four rows gives supply and demand parameters. The absence of demand parameters for propylene and cumene is an important aspect of this model and is discussed below. The supply and demand intercepts are unknown, computed by the spreadsheet from the 1983 prices and quan-

(continued)

Table 2: *A model of the across-market effects of the propylene tax, ignoring international trade.*

	A	B	C	D	E
1		FOUR SECTOR MODEL OF TAX INCIDENCE			
2					
3		Propylene	Polypropylene	Cumene	Phenol
4					
5	1983 Quantity	5788.00	1577.33	1215.00	969.00
6	1983 Price	494.00	803.00	507.06	573.20
7					
8	Supply Intercept	283.66	197.38	480.94	300.23
9	Supply Slope	0.0363	0.0510	0.0215	0.0370
10	Demand Intercept		991.94		1063.12
11	Demand Slope		-0.12		-0.51
12					
13	Tax Rate	13.82	0.00	0.00	0.00
14	New Tax in $/MT	9.87	0.00	0.00	0.00
15					
16	After-tax Quantity	5677.47	1540.92	1208.51	963.83
17	% Change	−1.91%	−2.31%	−0.53%	−0.53%
18	After-tax Price	499.85	807.36	509.26	575.82
19	% Change	1.18%	0.54%	0.43%	0.46%
20					

Table 3: *The spreadsheet cell definitions used to create the table 2 model.*

B5: 5788	B6: 494
B8: +B6 − B9*B5	B9: 0.03634
B13: 4.87	B14: (B13 − 4.87)/(2000/2204.623)
B16: (1.0631*C16 + 0.4*D16)*(B5/(1.0631*C5 + 0.4*D5))	B17: (B16 − B5)/B5
B18: +B8 + B9*B16 + B14	B19: (B18 − B6)/B6
C5: 1577.33	C6: 803
C8: +C6 − C9*C5 − 1.0631*B6	C9: 0.051
C10: +C6 − C11*C5	C11: −0.1197854453
C13: 0	C14: +C13/(2000/2204.623)
C16: (C10 − C8 − C14 − 1.0631*B18)/(C9 − C11)	C17: (C16 − C5)/C5
C18: +C10 + C11*C16	C19: (C18 − C6)/C6
D5: 1215	D6: 507.06329
D8: +D6 − D9*D5	D9: 0.0215
D13: 0	D14: +D13/(2000/2204.623)
D16: (E16/E5)*D5	D17: (D16 − D5)/D5
D18: +D8 + D9*D16 + 0.4*(B18 − B6)	D19: (D18 − D6)/D6
E5: 969	E6: 573.20198
E8: +E6 − E9*E5 − 0.48*B6	E9: 0.037
E10: +E6 − E11*E5	E11: −0.5055894966
E13: 0	E14: +E13/(2000/2204.623)
E16: (E10 − E8 − E14 − 0.48*B18)/(E9 − E11)	E17: (E16 − E5)/E5
E18: +E10 + E11*E16	E19: (E18 − E6)/E6

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tities and the slope parameters.

Tax rates are entered in the next block of two rows. Congress sets tax rates in dollars per English ton rather than dollars per metric ton. The Congressional rates are entered in row 13 and the conversion to metric is performed automatically in row 14. Propylene is the only one of these chemicals that was taxed in 1983; the tax rate was $4.87/English ton. The tax rate entries in table 2 are those in a congressional bill discussed below.

The last rows give the computed quantities and prices and their changes relative to 1983. The directed graph in figure 3 shows how the major cells in the spreadsheet are linked together. An arrow from one variable to another, such as from the tax on propylene (T_{prop}) to the price of propylene (P_{prop}), indicates that the first variable is used to compute the second. This directed graph does not describe the actual process by which the markets arrive at an equilibrium but gives a way of computing the equilibrium through iteration. It is considerably more difficult to build a model that accurately simulates market dynamics than to build models, such as those discussed in this article, that compare equilibrium situations. Indeed, because chemical markets tend to adjust very rapidly, there is little value in modeling the adjustment process. For markets that adjust slowly, such as labor markets, an accurate description of the adjustment process is a critical part of the modeling procedure.

The simplest link in the production chain is between propylene and polypropylene. Based on industry data, our estimate of the demand for polypropylene in 1983 is

$$P_{poly} = 991.94 - 0.12 \times Q_{poly}$$

The structure of the spreadsheet reflects the structure of the production chain. Since propylene is a raw material used in polypropylene production, the price of propylene affects the cost of producing polypropylene and, therefore, the price at which polypropylene will be offered for sale. It takes about 1.06 tons of propylene to produce 1 ton of polypropylene, so in 1983 about $525 ($494 × 1.06) of the cost of producing polypropylene went to cover the cost of the prc pylene raw material. The link between the two chemicals is expressed in the equation for the supply of polypropylene:

$$P_{poly} = 197.38 + 0.051 \times Q_{poly} + 1.0631 \times P_{prop}$$

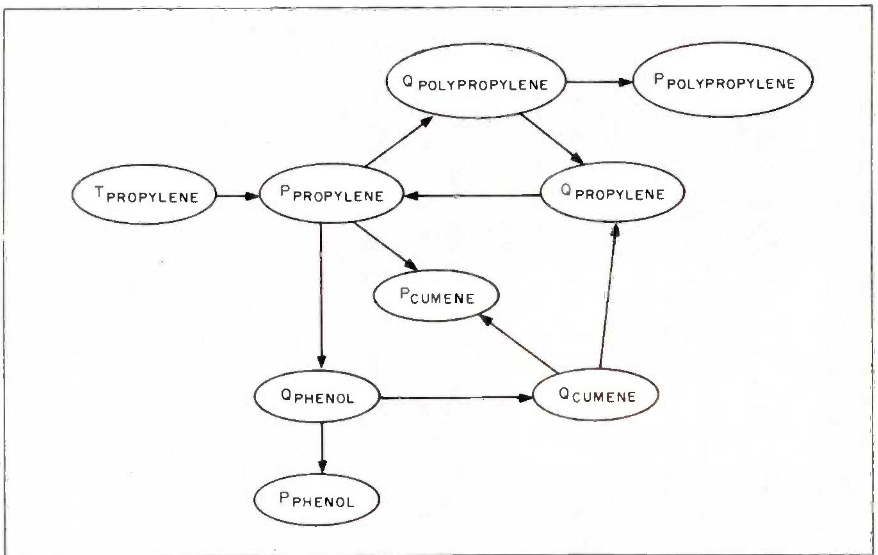

Figure 3: A *directed graph for the table 2 model of tax incidence, ignoring international trade.*

This supply equation for polypropylene was generated from the costs of all United States polypropylene production facilities in the same way that the supply of propylene was. These supply and demand equations can be solved algebraically for the quantity (cell C16) and price (cell C18) of polypropylene; these equilibrium values depend on the price of propylene, which is computed elsewhere in the model.

Now we turn to the market for propylene. The supply equation is

$$P_{prop} = 283.66 + 0.03634 \times Q_{prop} + T_{prop},$$

where the parameter values have now been entered (a = 283.66 and b = 0.03634).

Because propylene is a petroleum product, the price of oil affects the price at which it will be produced for sale, but we can abstract from that effect for two reasons. First, propylene production uses a very small portion of the total oil used in the United States, so the feedback from the propylene market to the crude oil market will be extremely small. Second, the policy question at issue is the difference between taxing upstream feedstock petrochemicals like propylene and taxing hazardous downstream products like phenol. Changes in the price of crude oil will change the prices of these chemicals but will have little effect on the difference between the two taxes.

Propylene is used to make polypropylene and cumene, and these products account for about 37 percent of all propylene use. We assume that the demand for the other 63 percent of the propylene produced changes proportionally to the demand from the polypropylene and cumene producers. As a result, we can write the equation for the quantity of propylene demanded as

$$Q_{prop} = (1.0631 \times Q_{poly} + 0.4 \times Q_{cum})/0.37$$

where 1.0631 is the conversion factor from propylene to polypropylene, and 0.4 is the conversion factor from pro-

(continued)

pylene to cumene.

The links between propylene and cumene and between cumene and phenol are analogous to those between propylene and polypropylene. Because 97 percent of cumene is used in the production of phenol, the cumene market is essentially a conduit between the propylene and phenol markets.

Now that we have set up the model, we can compare the effects of a propylene tax with a phenol tax. All that is necessary to make these comparisons is to substitute the proposed tax rates in row 13 of the spreadsheet and then recalculate the spreadsheet to find the new equilibrium. (Lotus 1-2-3 requires about 30 iterations for the spreadsheet to converge.) At the time of this study, the principal bill before Congress reauthorizing Superfund (HR 5640) proposed an increase in the tax on propylene from $4.87 per ton to $13.82 per ton. The proposed tax increase would raise $56 million in additional taxes for Superfund each year, based on 1983 figures. A tax on phenol that would raise an equal amount of new revenue would have to be set at $59.75 per ton.

Figure 4 shows our model's predictions for the proposed tax on propylene and the equivalent tax on phenol. Taking into account the feedback effects on downstream markets, we find that increasing the tax on propylene increases the price of propylene by 1.2 percent and reduces its production by 1.9 percent. It reduces the production of hazardous phenol by 0.5 percent. The phenol tax reduces production of phenol by more than 12 percent.

Figure 4 shows an interesting example of the feedback effects of the model. Because the tax on phenol reduces the production of phenol, it affects upstream markets, too, reducing the demand for the raw materials used to produce phenol. One of these is propylene. As a result of the reduction in the demand for propylene, its price falls, resulting in an increase in the production of other propylene derivatives, represented here by polypropylene. The phenol tax has stimulated the production of less hazardous substances at the expense of more hazardous ones.

TAX INCIDENCE WITH FOREIGN TRADE

Clearly, a tax increase puts U.S. chemical manufacturers at a distinct disadvantage in the world petrochemicals market relative to foreign producers who do not face the new tax. In an effort to minimize the trade effects of the proposed taxes on primary petrochemicals, the Superfund tax law includes a tariff on imported petrochemicals at the same rate as the tax.

To show the downstream effects of such taxes, we modeled international trade in benzene and its derivative, styrene. Styrene is used to produce a variety of plastics and synthetic rubbers including styrofoam; these materials are included in the model through the demand for styrene. The benzene-styrene model provides some features that help to demonstrate how introducing foreign trade into an economic model makes it far more complex.

Even if the world is divided into just two parts—the United States and all other countries—we must model two production sectors and two consumption sectors for each product. The smallest model that shows the effects of the taxes on foreign trade consists of eight sectors—four for the primary product and four for its downstream derivative.

The spreadsheet in table 4 gives the model of trade in benzene and styrene. The directed graph in figure 5 summarizes the model. In this spreadsheet, "Other" refers to non-U.S. production. The main part of this spreadsheet resembles the incidence model of the previous section; however, because of the complexity of this spreadsheet, it requires a number of auxiliary variables. The principal difference between the two spreadsheets is that each column in the international trade spreadsheet represents two market sectors. For example, the first column of numbers gives U.S. consumption of benzene at the top (row 5) and U.S. production of benzene at the bottom (row 20). (Note that, without trade, consumption and production are equal.)

This model calculates consumption in the United States and abroad similarly to the tax-incidence model above; then it uses the relative levels of U.S. and world prices to determine how consumption is split between domestic and foreign producers. (World prices in this model are weighted averages of the prices of

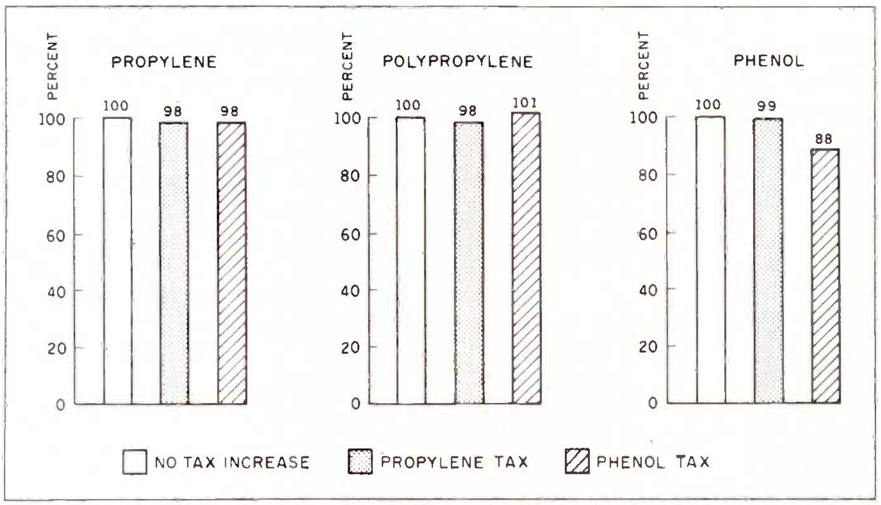

Figure 4: *The effects on production of propylene, polypropylene, and phenol from a $13.82-per-English-ton tax on propylene versus a tax on phenol that raises the same tax revenue.*

non-U.S. producers.)

The prices used include transportation costs from the producer country to the consumer country. The ability of a country to substitute the petrochemicals of one country for those of another is greatly limited by the high cost of transporting petrochemicals (over $100 per ton on some routes) relative to production cost. The statistical estimation of an equation for trade shares explicitly accounts for transportation costs and the existing pattern of petrochemical trade.

The first set of auxiliary variables gives the estimated coefficients for the trade share equations in row 19. Because the United States exports so little benzene, we used a logistic function to estimate the trade shares of non-U.S. petrochemicals. The logistic function captures an important element of the decision to import or export: When domestic and foreign prices are quite far apart, changes in prices have little effect on trade, but when they are close together, changes in prices can have a considerable effect on trade.

The complexities of this spreadsheet are such that simple iterative calculation, even with exact solutions for each consumption sector, does not always converge.

The spreadsheet, however, forces convergence in three ways. First, consumption quantities and prices are computed adaptively, as previously discussed. The adaptive nature of the model is reflected in the closed loop at each quantity and price in the directed graph in figure 5. Second, the ranges of these values are limited by one set of auxiliary variables. Third, another set of auxiliary variables was used to calculate the 1983 baseline values used in the spreadsheet separately.

Table 4: A *model of the across-market effects of the benzene tax, extended to incorporate international trade. Cell-content data is available from* BYTE*net Listings.*

	A	B	C	D	E
1		TAX INCIDENCE WITH FOREIGN TRADE			
2		Benz. US	Benz. Other	Styr. US	Styr. Other
3					
4	1983 Quantity Consumed	3991.00	11025.00	2440.00	5337.00
5	1983 Price	460.25	459.62	647.50	715.87
6					
7	Supply Intercept	412.07	426.70	163.25	231.96
8	Supply Slope	0.0119	0.0030	0.0004	0.0002
9	Demand Intercept			2960.00	3272.53
10	Demand Slope			−0.95	−0.48
11					
12	Tax Rate	11.03	0.00	0.00	0.00
13					
14	After-tax Quantity	3863.73	11186.49	2430.16	5335.34
15	% Change	−3.19%	1.46%	−0.40%	−0.03%
16	After-tax Price	469.17	460.36	656.83	716.66
17	% Change	1.94%	0.16%	1.44%	0.11%
18					
19	US Share of Sales	90.61%	0.18%	97.69%	4.40%
20	Production	3520.63	11529.58	2608.98	5156.52

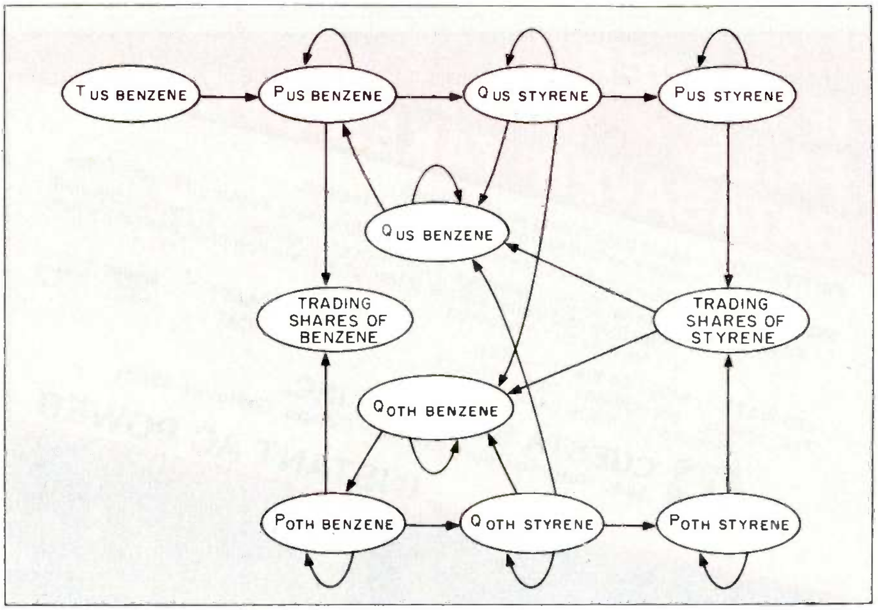

Figure 5: A *directed graph for the table 4 model, incorporating international trade.*

The spreadsheet in table 4 shows the effects of an $11.03 per metric ton tax on benzene that was proposed in Congress. The spreadsheet is designed to include automatically the tariff on U.S. imports of benzene. The direct effect of the proposed tax is to increase the price of U.S. benzene by almost 2 percent and decrease consumption by over 3 percent. Also, because much of U.S. benzene goes into production of U.S. styrene, the price of styrene increases and its consumption decreases. The magnitude of these changes is smaller for styrene than for benzene, reflecting their indirect nature.

The effects of the benzene tax on foreign markets are less obvious. We expect the price of both chemicals to rise in foreign markets because higher prices stimulate production of benzene and styrene to replace imports of the chemicals from the United States. The unexpected outcome is the increase in foreign con-

(continued)

Numerical predictions of economic models are not always accurate.

sumption of benzene in the face of the 1.5 percent increase in its price.

This increase is an important outcome of the benzene tax and one that is likely to be overlooked without the use of an equilibrium model. What happens is this: The tax on benzene raises the U.S. price of its derivative, styrene. Because there is no tariff on styrene, the price increase elicits increased imports of foreign styrene. As a result, the demand for foreign benzene increases to supply raw material for the production of styrene to export to the United States. This demand increase more than offsets the demand reduction that results from the price increase. (Incidentally, the model makes use of the fact that imports of benzene do not go into the production of styrene.)

MODEL VERIFICATION

The spreadsheets we have described in this article did not start out in their final form, but rather they evolved from a series of earlier models. To create these models we had to test them at each stage in their development. The ease with which spreadsheets enable you to vary parameters made testing a fairly quick and easy process. (The Data Table facility in the Lotus 1-2-3 package was especially useful in generating large numbers of test cases.)

Preliminary tests of a new version of a model almost always produce results that appear counterintuitive. You can often trace these anomalies to a simple bug in the spreadsheet, such as an incorrect sign in an algebraic expression. Drawing the directed graph for a spreadsheet based on the formulas in its cells is an effective way to root out deeper logical errors; the directed graph exposes the structure of the spreadsheet in a way that simply reading the cell formulas does not.

Even after a thorough audit of the spreadsheet, you may still find surprising results. At this point, assuming you have found all the bugs, you have to question the model itself. The detective work required to explain the results forces you, the model builder, to understand completely how the model works. When the model is valid, the reason for the unexpected results provides new insights, such as occurred when we discovered that both the price and quantity of foreign styrene increased in the trade model. Otherwise, the unexpected result points out the limitations of the model and indicates directions for further refinement.

Economic models are best at helping understand the net effects of a change when there are multiple interactions. In many cases, however, their numerical predictions are not very accurate. The numerical results of the models presented in this article are estimates.

A disturbing—but in the face of ignorance, necessary—habit that economists have developed over the years is to verify their models by comparing the results to those of similar models. After we developed our models of the effects of taxes in the petrochemicals markets, we found it at least a little reassuring that a study done by the Stanford Research Institute arrived at results of the same magnitude for a tax levied even further upstream—on crude oil itself. ■

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SIMULATING THE ARMS RACE

BY MICHAEL D. WARD

In this model, military competition is based on weapons stockpiles

SIMULATION OF international relations has provided a convenient laboratory for the study of world politics during the last 40 years. Long before the "increasing complexity" of the modern world became a catchword, many realized that the verbal methods of analysis that dominated the study of politics for the previous 2000 years needed to be augmented with sophisticated new approaches often employed in the so-called hard sciences.

Few people today will argue that politics and physics present identical problem sets, yet they do have a number of similarities, including both the difficulty of experimentation and the importance of relatively rare and difficult-to-observe phenomena. In both areas—as well as in many others—numerical analysis and computer simulations have become important methods of investigation.

Simulation is generally useful in the study of systems that are poorly understood, complex, and data-poor. It is also valuable in situations in which experimentation is costly or impossible.

HISTORICAL OVERVIEW

War games have a fairly long tradition, dating back in some form even beyond the war colleges established in the 1800s. Their major purpose has been to explore war scenarios that were too costly to pursue otherwise. The use of simulation in the study of world politics grew out of this tradition, coupled with the use of role playing and laboratory experimentation in social psychology.

In the 1950s, Harold Guetzkow engineered an "all-person" simulation known as Inter-Nation Simulation (INS), marketed by Science Research Associates, that was widely employed as a research and educational device to study world politics. One of the basic ideas of INS was to provide a laboratory in which to study world politics, with the aim of creating more general theories about the behavior of nation-states and their decision makers. Based on an initial scenario, small teams of decision makers were assigned to function as heads of state, economic advisors, and foreign diplomats in forming alliances, establishing trade agreements, spending money on economic development, purchasing armaments, and the like. All of this had to be done under fairly strict time constraints.

At the end of each decision-making period, the dice were rolled, the calculating machines were cranked, and the "results" of these decisions were produced and distributed at the beginning of the next period or year. Within a few hours, researchers could approximate several years of decision making. By introducing various conditional scenarios, it was possible to conduct thought experiments in a systematic way within a simulated world.

One famous study done in the 1960s examined the impact of nuclear proliferation on alliances. While it was possible to speculate about the behavior of decision makers in a world of proliferating nuclear weapons, prior to the development of simulations it was not possible to study the behavior of decision makers, even surrogate ones, under such conditions.

Such simulations were widely employed in teaching and research throughout the 1960s and 1970s, and they continue to be augmented and used within the policy and scholarly

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Michael D. Ward (Associate Professor, Institute of Behavioral Science, University of Colorado, Boulder, CO 80309) specializes in global modeling of world politics.

Applications of the Richardson model tended to suggest that the U.S. and the U.S.S.R. were not in an arms race.

communities. One reason for their popularity is the highly complex nature of world politics itself, which involves a large number of autonomous and semiautonomous actors. Reliable data on these relationships can best be characterized as either absent or of poor quality and questionable believability. These characteristics have combined to produce a vast amount of verbal theory that is relatively vague and nonrigorous, although interesting.

The advent of the computer provided new directions in the 1970s to both the educational and research avenues of simulation in international relations. A computerized version of INS, known as SIPER, was produced in the early 1970s. It was the first computer simulation model to focus specifically on the political and economic interactions among nations. Currently, some 20 or 25 "global models," or computer simulations, explore world politics in one form or another. Recently, the Joint Chiefs of Staff commissioned a million-dollar model to aid in their 20-year regional projections of political and economic stability. At the Science Center in Berlin, a team has been assembling a model, known as GLOBUS, aimed at exploring the political stresses and strains that industrialized countries will face in the next 25 years. In Geneva a small team of scientists has developed the SIMPEST model, which concentrates on the strategic interactions among superpowers. In Moscow several global models are being developed. Global modeling and the use of computer simulation has become a truly global activity.

Dynamic Arms-Race Models

One area that has been avoided by most of the large-scale global modeling efforts has been at the heart of the mathematical and quantitative investigations of international relations. Astonishing as it may seem in 1985, the global-doom model created at MIT in the early 1970s and discussed in Dennis and Donella Meadows's *Limits to Growth* (New American Library, 1972) did not even include arms races as a potential problem area. The brains behind the original model, Jay Forrester, is currently working on exactly this problem, however. As described in Philip A. Schrodt's BYTE article ("Microcomputers in the Study of Politics: Predicting Wars with the Richardson Arms-Race Model," July 1982, page 108), mathematical models of arms races were first developed by a Quaker mathematician and meteorologist, Lewis Frye Richardson. The seminal ideas from these early manuscripts have become well known as descriptions of "how nations would act if they did not stop to think." Working in differential-equation form, Richardson argued that decision makers in one nation will be threatened by increases in the armaments that are being accumulated by a potential enemy. Accordingly, they will begin to increase their stockpile of armaments, which in turn is perceived to be threatening to the other nation's decision makers. This is known as an action-reaction process and provides a relatively accurate description of the growth of military budgets in many nations of the contemporary world. Historically, it is a very accurate description of the buildup of weapons and military budgets prior to many wars.

Until recently, three problems plagued conceptualizations based on Richardson's notions. First, as with most social systems, intention is difficult if not impossible to ascertain from behavior. Does the U.S., for example, increase its military expenditures because it is "threatened" by similar increases in the Soviet budget, or does the incremental process of budgeting tend to produce marginal increases regardless of what the "enemy" is doing? As the budget is formulated, decision makers often tend to request and approve budgets that are equal to last year's expenditures "plus a little more." This incremental effect tends to make military expenditures go up in both the U.S. and U.S.S.R., for example. From the arms-race perspective, this would appear to be an action-reaction process when it could easily be solely the result of internal, bureaucratic politics. Working in the late 1970s, Charles Ostrom of Michigan State University produced an integrated model of defense budget making that took into account such decision-making practices.

Second, applications of the Richardson model (even with such modifications) tended to suggest that the U.S. and the U.S.S.R. were not in an arms race but that the two countries tended to ignore each other's military expenditures in deciding how much to spend on the military. In fact, one well-known and widely cited article concluded that "We have tried again and again to test for the presence of arms competition or arms racing, and we have failed to find anything each time." To even a casual observer of the international scene or anyone who has looked at the congressional testimony on defense expenditures in this country, such conclusions were startling and tended to be rejected out of hand.

Third, most arms-race models focused their empirical work on national defense budgets. Economists have been tremendously successful in convincing governments and other organizations to collect and produce data that is expressed in dollars or other currency terms. Despite his conceptualization of "Armaments and Insecurity," even Richardson was forced to rely on how much was spent on the military as the primary empirical indicator of defense effort. Everyone recognized the shortcomings of this approach (it seems clear that a $1000

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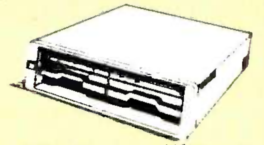

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With the use of better data, deeper conceptualizations, numerical analysis, and computer simulation, a small group of scholars began to remedy these three problems plaguing earlier work. In doing so, they developed dynamic models, which were nonlinear representations of the arms race that incorporated elements of domestic and international politics. Moreover, data not only on budgets but also on armaments was collected and used in these models. To do this it became necessary and desirable to use computer simulation.

BOMBS, BULLETS, AND BUDGETS: A STOCK-FLOW MODEL

One example that uses this strategy is a model I developed to analyze the U.S. and the Soviet Union. The basic idea of this model is that military, strategic competition is based on weapons stockpiles. Pentagon decision makers are mainly interested in what weapons systems the Soviet Union has at its disposal or coming on line and less concerned with how many rubles are being spent to acquire them. Thus, this model focuses on the action-reaction of weapons. The stocks are thought of as the actual armaments. At the same time, it costs money to produce these stocks, so the military budgets represent the flows of financial resources that are invested in producing the weapons stockpiles. Quite simply, the Soviet military decision maker, for example, might compare the level of U.S. and Soviet armaments. If it is determined that the U.S. has "more," this brings about an increase in the amount of money spent on weapons, which in turn would (in a few years) cause the Soviet weapons stockpiles to increase. This seems closer to the original ideas of Richardson vis-à-vis the arms race and a more realistic portrayal of actual decision making in the defense sector.

Expressed in differential equations, this augmentation of the Richardson process was originally suggested by Rein Taagepera of the University of California at Irvine. It has four equations (table 1a). The first two equations describe the changes in military expenditures of two nations as they monitor their enemy's military stockpiles in comparison to their own (plus some margin of "safety"). These equations are constrained by past levels of spending and fueled by hostility with the enemy. The last two equations describe the military stockpiles as they depreciate and are replenished by defense expenditures.

A slightly more complicated version of this has been implemented and estimated via the use of computer simulation (see reference 1 for a detailed discussion of this model). It is a nonlinear, continuous-time dynamic model that includes data on military expenditures and weapons stockpiles of the U.S. and U.S.S.R. during the post–World War II era. Most of the data has been taken from public sources such as the Stockholm Institute for Peace Research International's yearly data book, *World Armaments and Disarmament*, and the International Institute for Strategic Studies' annual *Military Balance*. Data on Soviet expenditures is notoriously problematic, and even data on the number of missiles and warheads is quite controversial. Unlike in some physical or biological sciences, direct observation and data collection is not really possible; however, considerable effort is undertaken to check the results of various models using a wide variety of different estimates of military expenditures and armament stocks (see reference 2 for one such study).

Table 1a: *The Rein Taagepera augmentation of the Richardson arms-race model.*

[1] $dx/dt = k((1.0 + u) * Y - X) - ax + g$
[2] $dy/dt = l((1.0 + v) * X - Y) - by + h$
where all variables are real-valued,
x and y are the defense expenditures of two nations
k and l are the reaction coefficients
u and v are the desired margins of safety
a and b are the budget constraints
g and h are the hostility coefficients
[3] $dX/dt = x - rX - f$
[4] $dY/dt = y - sY - j$
where X and Y are military stockpiles
r and s are depreciation rates
f and j are fixed costs

Table 1b: *The equations of table 1a, expressed in the* DAREP *simulation language.*

```
X. = K*((1.0 + U)*CY - CX) - A*X + G
Y. = L*((1.0 + V)*CX - CY) - B*Y + H
CX. = X - R*CX - F
CY. = Y - S*CY - J
```

THE SIMULATION MODEL

This model was implemented in a continuous-time simulation language known as DAREP, which was developed by Korn and Wait at the University of Arizona (reference 3). DAREP is a very flexible language permitting ordinary differential equations to be easily studied and analyzed. It consists of three major parts: a translator, a run-time library, and an output system. It is written in FORTRAN 66. The user specifies a set of equations, some of which may be first-order differential equations, which are flagged with a "period." Assuming real-valued variables, the equations in table 1a can be expressed easily in DAREP (table 1b). Note that *CX* and *CY* have been defined to distinguish uppercase from lowercase. The user would also specify the initial values of X, Y, CX, and *CY*, as well as all parameters and the number of periods for the simulation to run. DAREP would translate this into a FORTRAN program that was set up to use the run-time library, consisting primarily of a variety of numerical-analysis techniques for solving differential equations. With a user-specified integration rule, or in certain cases a rule the program decides is appropriate, the solution trajectories are provided for systems that effectively can be as large as desired. I ran a model with more than 400 ordinary differential equations. These solution trajectories are then available for display as tables or graphs.

One reason this language is so facile is the ease with which nonlinear differential equations can be expressed and numerically solved. Another is that DAREP is an open system in which other FORTRAN routines may be easily included. Even more important is that DAREP provides up-to-date and tested numerical algorithms for solving differential equations. Often simulation modelers assume that differential equations are just like difference equations and thereby rediscover the Euler first-order technique for integration (reference 4). This technique is well studied in numerical analysis and has two major flaws. First, the error introduced by discretization (i.e., choosing to set *dt* to 0.25, say) can grow rapidly, even though truncation error approaches zero at each step. Second, and more problematic, is round-off error. On a Control Data Corporation machine with single precision, the recommended step size is less than 6×10^{-8}. While Euler's method is simple and straightforward, it is avoided in practice—except in numerical-analysis classes.

DAREP provides more than 10 well-tested higher-order integration techniques, including several Runge-Kutta methods. These can be used to accurately provide the solutions. The major pitfall of DAREP for new or potential users is that no one at Arizona ever bothered to write an intelligible and informative manual. Other CSSLs (continuous system simulation languages) provide the same mechanisms but are more cumbersome to use, if easier to learn.

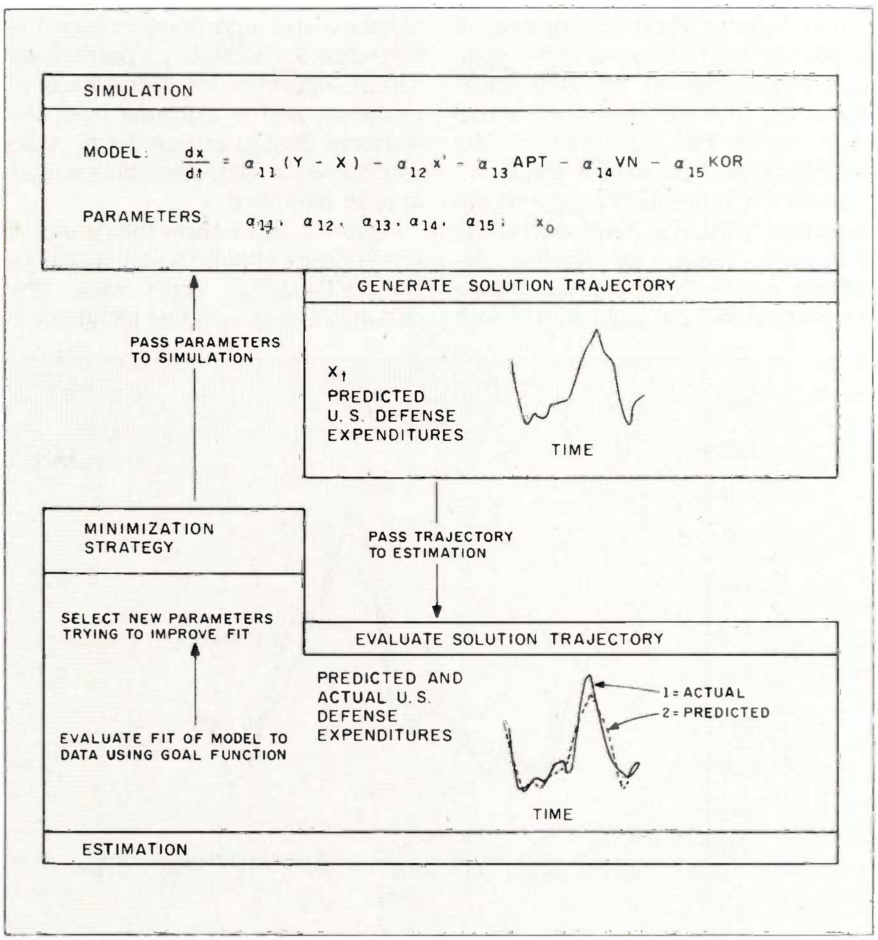

Figure 1: A *schematic representation of the author's optimization-of-fit strategy.*

Dynamic Trajectory Fitting

Once a model such as this is developed, one important task is to determine the estimated values of the coefficients and to determine the extent to which theoretical predictions match actual data. Typically, social scientists use some form of regression analysis based on least-squares minimization. The solution to the set of equations in table 1 is nonlinear, relatively complicated, and creates a number of problems for standard estimation strategies such as those found in widely available packages including SPSS and SAS.

My strategy for estimating these differential equations involves merging a flexible optimization (or minimization) package with the simulation. A goal function is defined: For example, you might minimize the sum of the squared errors between the simulation trajectories and the actual data. The minimization package perturbs the vector of parameters and evaluates whether the model fit is improving or deteriorating. It then passes the new vector of parameters back to the DAREP system, which once again simulates the trajectories. This iterative feedback process eventually converges to some local or hopefully global min-

(continued)

imum. Figure 1 shows this strategy in schematic form. Thus, it is the solution trajectories to the differential equations that are fitted to the actual data, within the constraints of the equations and parameter space.

Several minimization programs are available. MINUITS, developed at the European Center for Nuclear Research, is very flexible and compatible with DAREP. An evaluation of such software and algorithms is found in reference 5. NL2SOL is a particularly robust algorithm for these kinds of problems and is available from the National Bureau of Standards. A recent survey of such algorithms is available in reference 5.

Figures 2 and 3 show the results of this strategy applied to my model of the U.S.–U.S.S.R. arms race. The dynamic trajectory-fitting technique is relatively successful: 97 percent of the variance in the data series is "explained" by the model in a statistical sense. Substantively, it produces an empirically estimated model that shows the strong action and reaction in weapon stocks (here nuclear and conventional) that exists between the U.S. and the U.S.S.R.

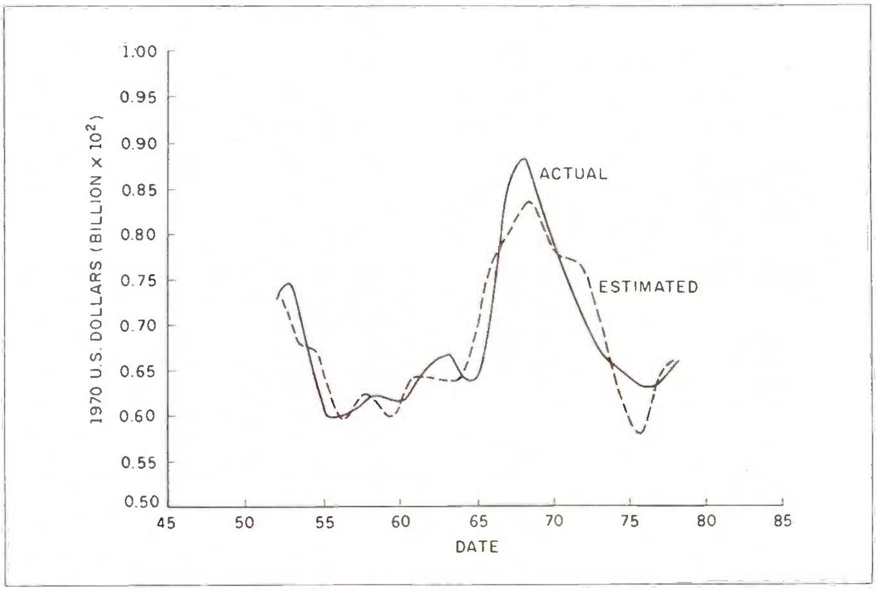

Figure 2a: *Actual and estimated U.S. military budget.*

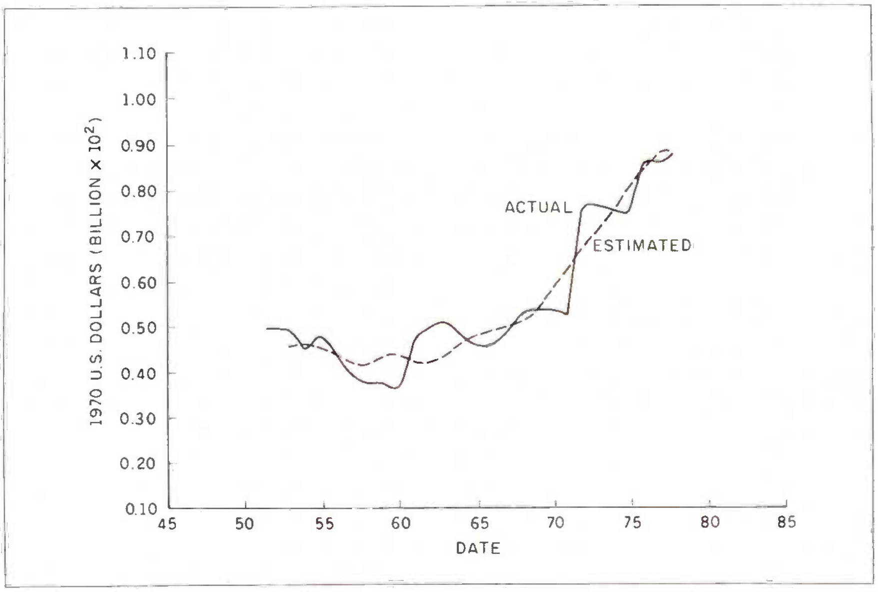

Figure 2b: *Actual and estimated Soviet military budget.*

ADVANTAGES AND DISADVANTAGES

The first and foremost advantage of this strategy for me was that it seemed to fit the problem. Not everything can be expressed in similar formulations; however, DAREP and other CSSLs provide for inclusion of discrete mechanisms such as switches. DAREP and its relatives are quite simple, substituting the number-crunching power of mainframe computers for the tiresome work of solving differential equations. The dynamic trajectory-fitting technique permits the development of statistical information about the fit of such simulation models with reality, as we measure it. This technique provides an easy interface to widely transportable code and subroutines.

When you are done with the model formulation and estimation, you have an operational simulation. Typically, a good deal of social-science research ends with the production of a table of coefficients and significance levels. A simulation permits one to probe the model more deeply in the experimental sense. And it permits the investigation of "what if" questions, important in and of themselves and as a check on the coherence of the model. What would happen to defense expenditures if U.S.–Soviet hostility doubled? Figure 4 shows my simulation of the impact of increased U.S.–Soviet rivalry coupled with a U.S. strategy of "catching-up" with Soviet armament levels (reference 6). The result is a doubling of armament levels by the end of the century.

With the simulation model it is also possible to conduct sensitivity analysis on the model. Typically, this is done on a variable-by-variable basis.

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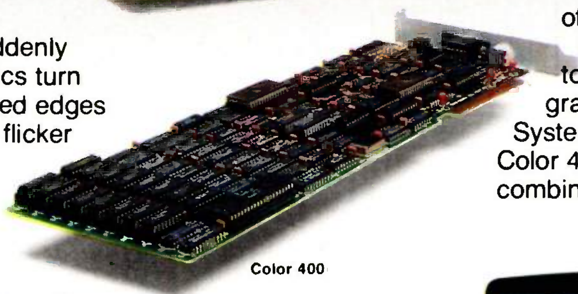

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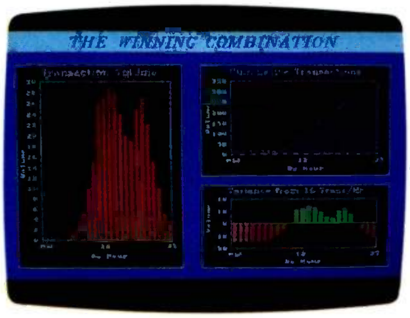

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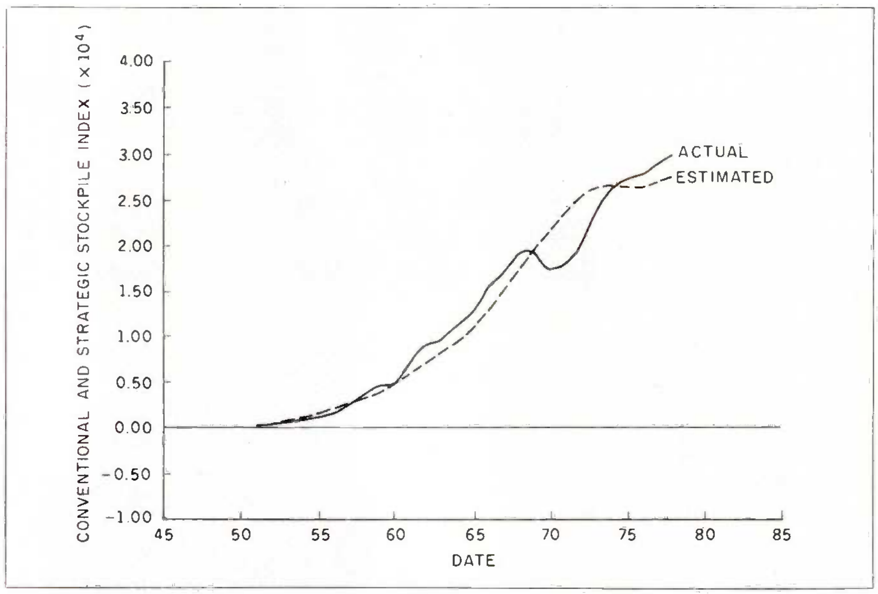

Figure 3a: *Actual and estimated U.S. military stocks.*

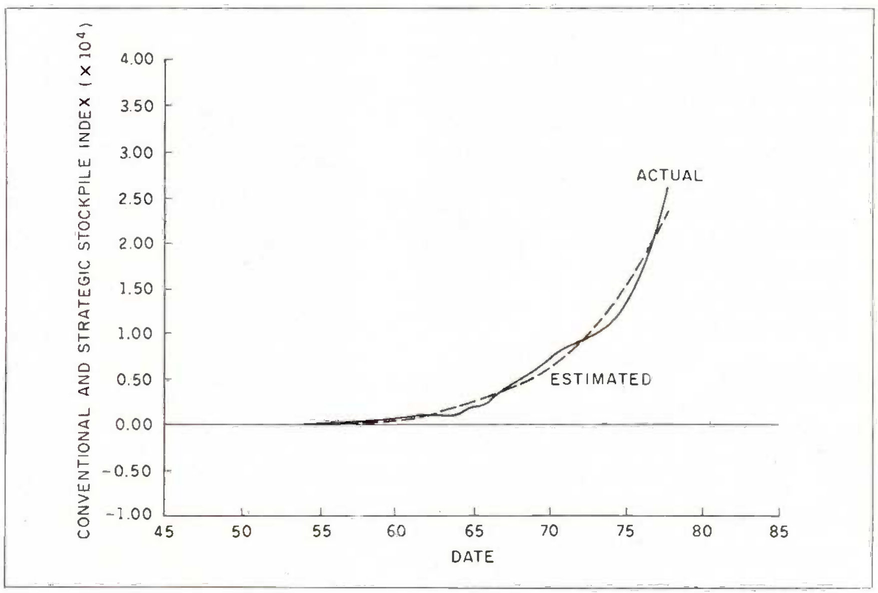

Figure 3b: *Actual and estimated Soviet military stocks.*

However, what one is able to minimize can also be maximized. I have taken the parameter-estimation strategy above and turned it on its head in order to probe the sensitivity of the simulation to the values of its parameters. This strategy constrains the optimization software to choose parameter values that are within the 95 percent confidence limits of those that were estimated. However, the goal function minimizes the fit of the simulation and the data within those constraints. What this does is to choose the worst-fitting model that would typically be accepted by a statistically cautious modeler.

Figure 5 illustrates a three-dimensional display of the worst-fit trajectories for a stock-flow arms-race model. The properties of error prop-

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agation in a dynamic model are shown by the expanding range of possible, acceptable trajectories. Another way of interpreting this high degree of sensitivity of the model is substantively; small modifications in the reaction of budgets to armament profiles may have future impacts that are quite dramatic.

Eigensystem analysis is also possible through the DAREP system. It suggests that the arms-race model explored above is marginally stable, but that once perturbed off its path it might require several centuries before it would return to some equilibrium path. Thus, even stable arms races, if such a term is not a contradiction, may be quite dangerous.

On the negative side, at present these techniques are not really available on microcomputers, and even on big mainframes (such as a Cyber or Cray) estimation of complicated models may require many cycles to complete. Thus, depending on the cost of access to such computing resources, it can be quite expensive. On the other hand, as computing power continues to distribute itself on desktops, I am relatively optimistic that such systems will become less expensive and more widely available in the near future (reference 7). Some CSSLs are now distributed for IBM PCs, though they are very expensive and have a way to go before they can serve the simulation needs of modelers with either large models or models that involve complicated estimations. ■

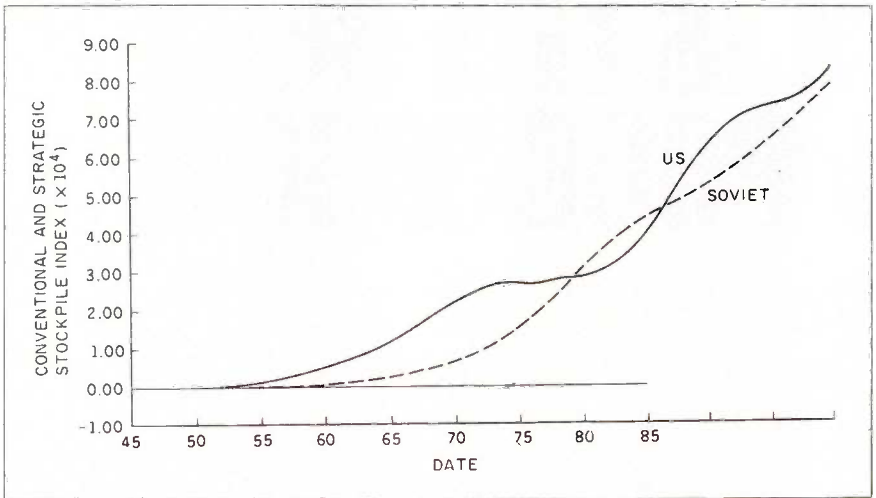

Figure 4: U.S. 1980 *catch-up and increased threat (stockpiles) simulation.*

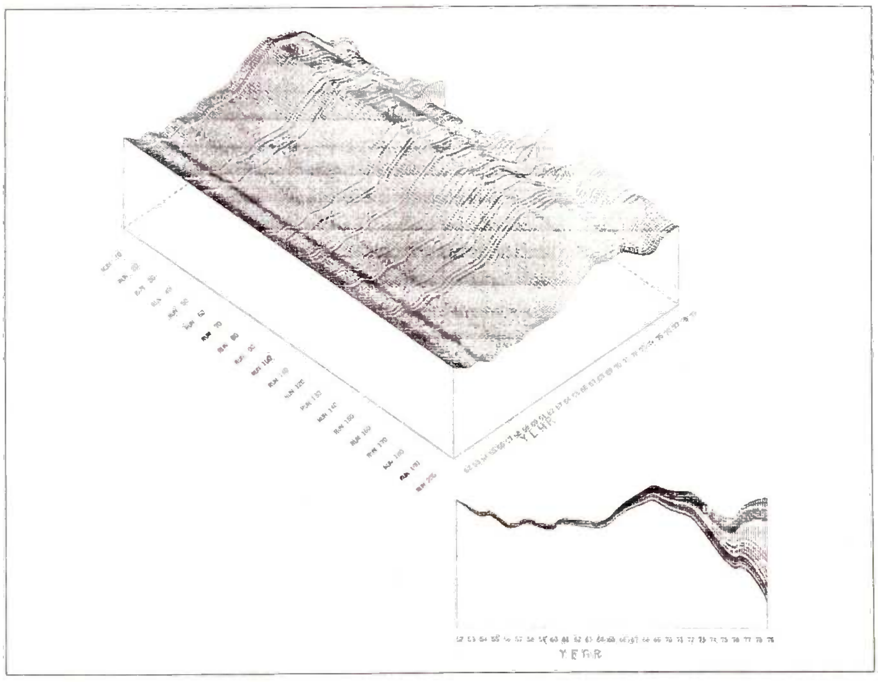

Figure 5: A *three-dimensional display of the worst-fit trajectories (sensitivity analysis) for a stock-flow arms-race model of U.S. defense expenditures from* 1952 *to* 1979. *The two-dimensional graph shows what you would see if you were standing on the Year axis of the three-dimensional display and dramatizes the effects of error propagation in a dynamic model.*

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EPIAID

BY ANDREW G. DEAN

This series of programs helps construct models of disease from real-world epidemics

EPIDEMIOLOGY, the study of disease and its determinants in a population, is the discipline underlying public-health disease control. Ideally, the epidemiologist, as portrayed in an exciting series of articles by Berton Roueche (see reference 1), flies into town from a distant point, calms the populace, and then, like Sherlock Holmes, unerringly gathers all the vital clues and a few spurious ones until the cause of the epidemic becomes clear. Although luck and skill can sometimes produce this result, the actual work of modern public-health epidemiology involves more person-to-person interviewing, paperwork, statistical processing, and library research than the popular image contains.

In technical terms, an epidemic is not necessarily an urgent, life-threatening, or even widespread threat to health, but it is "the occurrence in a community or region of cases of an illness, specific health-related behavior, or other health-related events clearly in excess of normal expectancy." (See reference 2.) By this definition, an epidemic can include any condition the epidemiologist regards as unusual and worthy of investigation—including cardiovascular disease over the past half-century, the consequences of smoking, the sinking of the Titanic, famine in Africa, family violence, snowmobile injuries, or warts seen by family physicians.

The process of epidemic investigation consists of entering a real-life setting, constructing a mental model of a disease and its hypothesized causes, gathering information from ill and well or exposed and unexposed persons, testing the model to see if it is "correct," and repeating this process until either the model is adequate or resources are exhausted. A slightly more detailed version of the process is shown in figure 1.

Figure 1 is also the main menu of EPIAID, the set of experimental microcomputer programs being developed at the Centers for Disease Control (CDC) in Atlanta, Georgia. The CDC, as the national center for public-health epidemiology, investigates major health problems and provides coordination for epidemiologists in states and counties and training for the more than 60 new epidemiologists who enter its Epidemic Intelligence Service (EIS) each year.

EPIAID was designed to provide better tools for field investigation by CDC's several hundred epidemiologists and their colleagues in state and local health departments. It is an experiment to see whether or not an expert system on a microcomputer is useful in epidemic investigation. Development of the system is also providing opportunities for examining how epidemiology is actually practiced. EPIAID offers a vehicle for storage, distribution, and refinement of commonly used epidemiologic tools such as questionnaires and case definitions for diseases. If field testing shows the system to be successful, it may be made available for both investigational and educational use to a wide variety of public-health agencies.

The partnership between the epidemiologist and the computer began with the availability of punch cards and mainframe computers. For research purposes, these resources and

(continued)

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later, more interactive systems have been invaluable, and most large epidemiologic research studies have been analyzed with the aid of computers. The tasks public-health disease control must accomplish, however, overlap only poorly with the services offered by mainframes. A typical acute-disease investigation occurs on short notice and requires travel to an unfamiliar site by an individual who will be busy with many tasks other than computer interaction.

As an epidemiologist, you often operate from makeshift headquarters and work long hours while being harassed by worried citizens, the press, and myriad details of the investigation. You must devise a unique questionnaire appropriate for the situation, choose samples of ill and well or exposed and unexposed individuals, perform interviews and/or supervise those who do, and tabulate the data from a few dozen or a few hundred interviews to reach conclusions. If all goes well, you identify the factors leading to the epidemic and use them to design control measures such as improved food handling or water chlorination, changes in personal or occupational behavior, isolation of patients, or immunization of susceptible persons.

Typically, the newly devised questionnaire is hurriedly typed on plain paper, photocopied or mimeographed, and administered as quickly as possible—while local interest, the supply of interviewers, and the memories of the subjects remain at their peak. Preliminary tabulation is usually done by hand, although some investigations enter a later phase at your home base, in which you do more careful tabulation with the aid of a spreadsheet, a database or statistics package, or a data-processing department. Until recently, most epidemic investigations were tabulated by hand because the number of interviews did not exceed a few hundred and the necessary preparation for computer entry was not worth the steps involved. Lately, spreadsheets have proved to be a useful tool for managing questionnaire data, but setup time is still significant in a field setting.

My own experience includes interviewing 25 victims of insecticide poisoning, scribbling the results on 3 by 5 cards, and inspecting an African tea shop in two hours before sundown because the airplane that brought us could not fly at night. One of my research investigations in the mid-1960s used 18,000 punch cards and a card sorter because the available computer was dedicated to financial work.

An expert system for field epidemiologists must therefore be portable, easy to use even under distracting conditions, and conducive to setting up new data forms easily and quickly. Since the number of interviews seldom exceeds a few hundred, speed in data entry is less important than accuracy.

Since epidemic investigation, unlike billing or word processing, is not an everyday activity, programs must be easy to use the first time. The type of program that requires days or weeks of practice is not helpful to an investigator under distracting conditions. These limitations have kept even the most computer-eager epidemiologists from using computers in field investigations. They pose severe problems in the implementation, if not the design, of an expert system for epidemiologic investigation. Menus and prompts on the screen must take precedence over documentation or conditioned reflexes as a guide to what to do next.

Three previous programs written specifically for epidemiologists stimulated our thinking about EPIAID. Two of these, Socrates by Richard Curtis and the Epidemiologic Analysis System by Anthony Burton, were developed at CDC. They ask for definition of data items in a questionnaire, allow entry of data, and perform tabulations such as frequencies and cross-tabulation, with simple statistical testing by chi-square or Fischer exact tests. The third, EPISTAT by Tracy Gustafson of the Texas State Department of Health, adds more statistical capabilities but focuses more on numbers than on textual information.

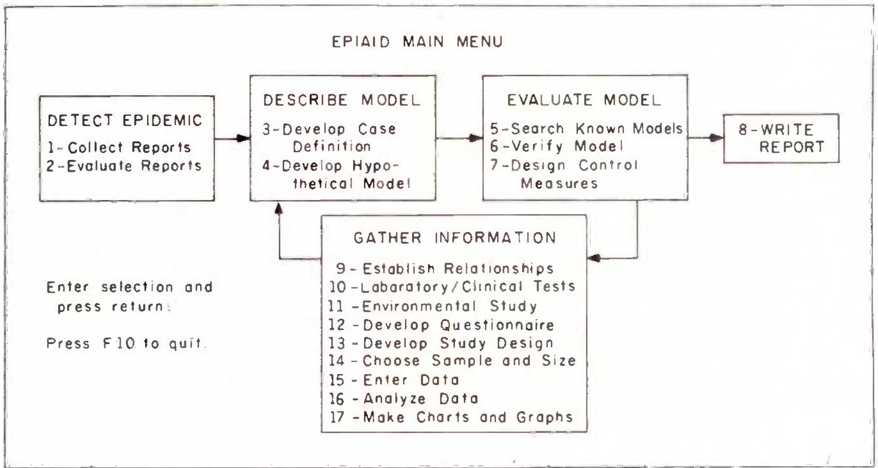

Figure 1: *The main menu of* EPIAID, *describing its programs and the usual sequence of events in an investigation. You usually need one or more information-gathering cycles before the hypothetical model is sufficiently precise and well confirmed to consider the investigation complete.*

WHAT KIND OF EXPERT SYSTEM?

The burgeoning literature on expert systems makes it tempting to emulate the expert epidemiologist in software. Further thought suggests, however, that the last thing an epidemiologist wants to take on in an investigation is a somewhat rigid, less intelligent clone of himself. The most useful ex-

(continued)

pert system would be an *expert team* consisting of the following:

- a skilled secretary who captures ideas, text, and data items collected by the epidemiologist and arranges them neatly on paper in labeled file folders for use later when things are less hectic
- a professor of epidemiology who coaches gently when needed and asks whether something has been left out at times but avoids imposing a straitjacket on the investigator
- a medical librarian to look up information on previous epidemics and other items from the literature of medicine and epidemiology
- a statistician to process data and help interpret the results
- a writer to do the preliminary and final reports
- an artist to produce the graphs and charts

EPIAID provides elements of each of these, linked together by a menu so that the novice user can follow the programs in order and be led through the process of investigation, and the expert can pick and choose among the various epidemiologic tools offered. The programs offer

- interactive protocols for epidemic investigation
- access to information from previous investigations and from the literature of epidemiology and medicine
- tools for storing, structuring, and processing data, preliminary thoughts, and elements of the final report

The Design of EPIAID

Compared to such other subjects for expert systems as spectrographic analysis, geologic exploration, or choosing an antibiotic for treatment of infectious disease, epidemiology operates in a broader, less-predictable environment. Decision making must incorporate elements of politics, personnel availability, ethics, and other parameters that are more easily handled by a human brain than by a computer. Even the more technical aspects of epidemiology are not easily distilled into rules. This element of fuzzy logic in EPIAID is handled by presenting options to the epidemiologist for refinement or even reversal at key points.

Epidemiology makes extensive use of information from medical literature, descriptions of previous epidemics, and tools from other investigations in the form of questionnaires. At present, the databases are scattered in both the filing cabinets and the brains of several thousand practicing epidemiologists in the United States, as well as in computerized bibliographic databases at the National Library of Medicine, CDC, and elsewhere. Even at CDC, the process of generating final reports about epidemic investigations has become slow and burdensome to the point that some reports are not completed before their authors leave for other employment.

EPIAID views the investigation as extracting information from the situation via systematic data-collection techniques, blending this information with data from past epidemiologic experience, and constructing an epidemic model that describes disease and its causes in the population being studied. During each round of data collection, EPIAID refines the model and then evaluates it to assess its suitability. The tests used are internal consistency, consistency with the medical and epidemiologic literature (matching known patterns), and the effectiveness of control measures designed from the model. When all three are judged satisfactory, the investigation is over, and the final report can be written.

Implementation

EPIAID operates under PC-DOS or MS-DOS. Although you can run it on a portable computer with 192K bytes of memory and two double-density 360K-byte floppy disks, a hard disk provides such advantages in convenience and speed as to be almost mandatory. EPIAID's programs are entirely menu-driven because they are intended for use under distracting conditions by occasional users who are interested in accuracy and organization rather than high-volume processing.

When you begin to run EPIAID, a banner is displayed while the program opens files; then you decide whether to continue with the current investigation or to begin a new one. The main menu (figure 1) appears, and you can select programs in the order suggested or you can pick and choose.

Since the specifics of the programs are mainly of interest to epidemiologists, the text box titled "EPIAID's Facilities" on page 230 looks at the kinds of facilities provided rather than dwelling on their contents.

Present Status

EPIAID is an experimental program and is still in development. As of May 1, 1985, about 80 percent of the programming was complete and the necessary databases of previous epidemic models, questionnaires, and laboratory test information consisted of only a few examples. Once we have completed the program and entered larger amounts of background data, we plan to evaluate EPIAID first through review by epidemiologic colleagues and then through field trials in epidemics.

One of the most difficult hurdles in developing a system for use by public-health epidemiologists is making the programs friendly enough for use in the field under distracting conditions. Field testing and the degree that epidemiologists adopt EPIAID will determine whether we have met this objective. Then we can proceed to the more theoretical problems of database content and program logic flow.

Unlike expert systems in the physical sciences where you can define rules for most situations, EPIAID and the epidemiologist together must preside over a dynamic and complex process using information and previously useful tools from databases to collect new information from individuals or records in a real community. The new information must first be defined from an essentially infinite set of collectible items about individuals, and the results

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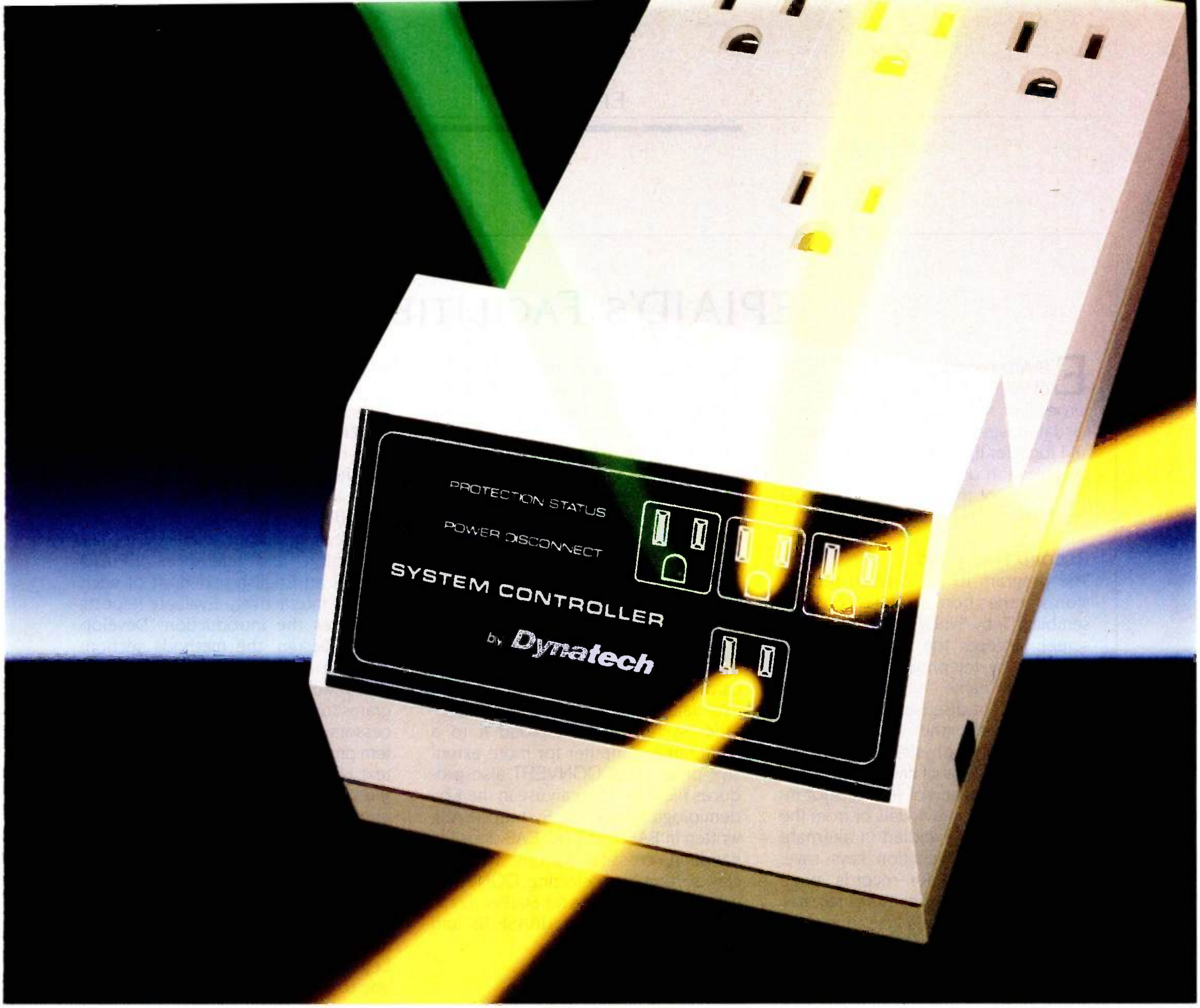
PROTECTION STATUS
POWER DISCONNECT
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EPIAID's Facilities

EPIAID provides three basic kinds of facilities: entry, storage, and retrieval of structured records; access to databases of previous epidemics and tools for investigation; and interactive creation of text (phrase processing). Some of the modules in EPIAID combine all three functions.

Record Handling

The program to log disease reports stores entries from screen records resembling 3- by 5-inch index cards. One screen accepts the entry of cases reported by telephone or mail with details on name, address, date of onset, type of disease, etc. A second screen records the source of the report, usually a physician or hospital. Reports of groups of cases without individual details and of requests for information from individuals or from the news media are handled in alternate record formats. Function keys save, delete, or search for records, page through the file, or print lists of records.

Most investigations use questionnaires to record data from interviews, clinical examinations, laboratory tests, or hospital records. The usual data-entry program requires a data specification for each new questionnaire specifying the data type, name, length, and other characteristics of each field—a questionnaire blank. To bypass this step, a program called ENTER *info* was written in Turbo Pascal. ENTER *info* uses the original questionnaire, created as a plain ASCII text file on a word processor, as the data-specification file. When you run the program, it scans the questionnaire for underline characters. A continuous underline defines an alphanumeric field. A series of number signs (###) of the desired length indicates a numeric field. Number signs with a decimal point (##.#) describe real numbers. You define date fields as <date> and uppercase fields as <A>. With these exceptions, the questionnaire looks like one designed for manual entry.

ENTER *info* reads a questionnaire containing up to 80 fields and displays it on the screen ready for data entry within 25 seconds. Paging up and down is handled automatically for any length of form; inserting, deleting, backspacing, and movement from field to field are accomplished with the appropriate keys on the IBM-style keyboard. The program saves each record after the last field is entered, and two Escapes provide exit. A utility program called CONVERT produces files for use in other database or statistics systems. CONVERT writes the data-specification statement for the Statistical Analysis Package (SAS), for example, and converts the data into 80-column "cards" with appropriate record and card numbers. You can send ENTER *info* data files over a network to another system and/or upload it to a mainframe computer for more extensive processing. CONVERT also produces files that you can use in the Epidemiologic Analysis System (EAS), written in BASIC at CDC. EAS does file handling, cross-tabulations, frequencies, sorting, and selecting. CONVERT will also produce files for StatPac, Lotus 1-2-3, SPSS, dBASE II, dBASE III, and other systems.

Access to Databases

EPIAID includes programs for creating and accessing databases of questionnaires from various investigations, case definitions of common or rare diseases (up to several pages long), information on laboratory tests available, and descriptions of past epidemics that the system can search for patterns that match the model of facts and hypotheses currently being used. Figure A contains a sample model, the screen for the program that searches a database of previous epidemics.

At present, all databases are contained on the same disk as the programs, but future plans include a program to create a search file for a remote on-line bibliographic retrieval system such as MEDLINE (maintained by the National Library of Medicine and available on a number of commercial database services). Medical librarians often perform such searches during an investigation, but our goal is to allow the epidemiologist to perform a search directly and download references and/or abstracts from the world literature into a disk file.

Interactive Text Creation

Reports of epidemic investigations, whether published or unpublished, have a reasonably well-defined structure. Biomedical papers contain sections for introduction, methods, results, discussion, and references. EPIAID creates an English text draft of each section interactively. Evaluate Reports produces the introduction; Develop Study Design, the methods section; Analyze Data, the conclusions; and Verify Model, the discussion. The programs function as intelligent word processors or phrase processors. The system presents a suggested outline of the text and/or fragments of sentences on the screen for you to respond to and amplify in normal English sentences.

In the introductory memo, for example, Evaluate Reports constructs a heading with the time, date, investigation number, and organizational information. It asks for the subject and author of the memo. The program begins the text with "On" and prompts you to enter the "Date of first report." It places the date you enter in the text and adds a comma. The prompt window then asks for "Person or organization who made first report." You might enter "Dr. Steven J. Smith, Health Officer of Jones County." Your response can be up to two lines of text, which is added to that already created and left-justified. After each entry, the program checks a table within it for any special procedures to be executed at that time. A procedure may analyze the entry for content, save it for later use, perform mathematics, branch if certain conditions are met, or do anything that can be written into Q-Pro 4 code.

The programs that perform these procedures are built around a common core of Q-Pro 4 routines driven by three tables containing lines of text to be incorporated into the document, instructions to be presented on the screen, and the names of special procedures to be called after you have made an entry. Each line has a number, and the program processes them in numerical order, somewhat like a program in BASIC. A procedure may center text, analyze its content, store a key word for later use, or jump to a subsequent line number if certain conditions are met. This rather simple facility can be used to create "intelligent" responses. Since the program displays the developing text and lets you edit as you create, you can provide responses in grammatical context. Therefore, the program does not need to try to adapt to the vagaries of English grammar and syntax. Figure B shows an example of the interaction that occurs. The final result is one or more pages of text in a dated and time-stamped sequential file, which can be incorporated into the final report and/or edited later.

Combined Programs

The program for developing questionnaires uses the interactive text-generating facility, providing headings and prompting you to enter questions and entry fields for ENTER *info* in sections such as "Introduction," "Informed Consent," "Identifying Information," "Disease Symptoms," "Factors Influencing Disease" (known to epidemiologists as exposures), etc. At appropriate times, or in response to a function key, the program displays the current epidemic model at the bottom of the screen for ready reference as questions are phrased to test each of the hypotheses in the model.

F1 (See Files) brings up a list of questionnaires available from a questionnaire resource file. Any questionnaire can be brought into a window that overlies the screen temporarily. You can examine it using the Page Up and Page Down keys. Pressing the F4 key (Get File) appends the questionnaire from the resource file, line by line, to the text being constructed. You can accept, discard, or edit each line, and you can terminate the process by a command or by reaching the end of the resource questionnaire block. The combination of word processing, artificial intelligence, database access, and prompted data entry produces a questionnaire as a sequential text file that can be fed into ENTER *info* to start data entry.

The program Develop Study Design uses the interactive text mode to produce a methods section for the final report. During the process, the epidemic model is available for reference, and the program creates blocks of text summarizing the facts and hypotheses developed so far. The previously developed case definition is brought in from an external file and included in the text. Intelligence is built into the program through the manipulation of key words such as "cases," "disease," "exposed persons," etc.

We usually design epidemiologic studies around persons known to be ill (cases) or exposed to some factor of interest (those involved with a chemical or a behavior like smoking or jogging). Epidemiologic studies may employ a comparison group (an analytic study) or merely describe the frequency of various factors in the study group (a descriptive study). A comparison study based on known cases is called a *case-control* study; one based on exposure is called a *cohort* study. Given this information, the tables can be set up so that the system can create the text in reasonably useful form through its interaction with the epidemiologist. The system can systematically address major questions, such as whether to use a comparison group, and record the answers in the text. It leaves major decisions to the epidemiologist to make after reviewing the considerations the program suggests as relevant to the decision. If the study is to be descriptive, the program automatically skips those sections of the interaction that deal with comparison groups and matching.

EPI # 1

Epidemiologic Model # 1

Location 1 TRENTON, PA	Disease Name 1 KAWASAKI DISEASE	Route of Entry 1 ORAL * 2 RESPIRATORY
Setting 1 DAYCARE CENTER *	Agent 1 VIRAL AGENT * 2 MERCURY	Vector or Vehicle 1 MITES
Number of Cases 1 13	Incubation Period 1 FEW DAYS 2 FEW WEEKS	Source 1 CARPET
Year(s) 1 1985	Control Measures 1 REMOVE AGENT	Risk Factors 1 JAPANESE ANCESTRY

KNOWN items are highlighted

1 SRCH 2 PREV 3 NEXT 4 MODEL 5 PRINT 6 CATEG 7 CITAT 8 CLEAR 9 HELP 10 DONE
PRESS SHIFT-F10 FOR OPTIONS

Figure A: *An epidemiologic model. The established facts about an epidemic are highlighted; hypotheses are in normal type.*

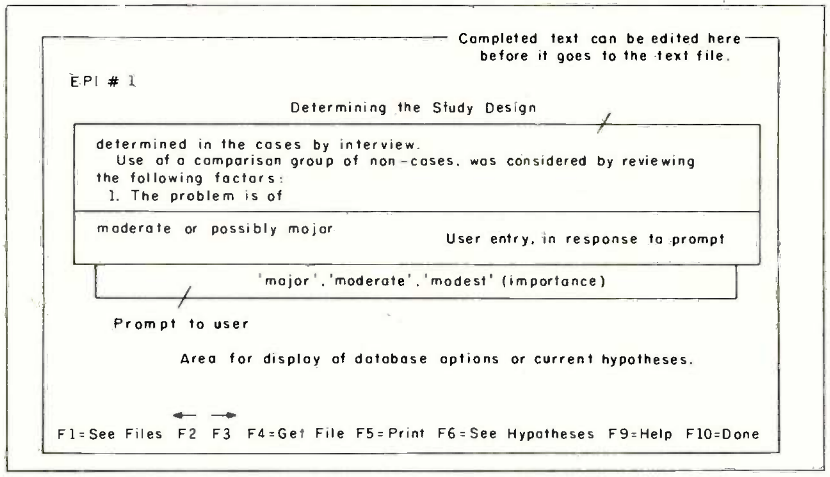

Figure B: EPIAID's *interactive text generation or phrase processing.*

must be interpreted with the complexities of the community situation in mind. The process is one of synthesizing a model of the current epidemic by merging data from the current situation with data from past epidemics and medical literature. The thinking process relies heavily on data from the collective experience of the discipline. Algorithms and computation, although important, are less prominent than in the physical sciences and are often simple (or complex but nonmathematical) enough to be supplied by the investigator in the field.

Many expert systems, particularly those available for microcomputers, seem to be either mechanical or limited to narrower domains than the task of epidemiologic investigation. EPIAID leaves more control to the investigator than most expert systems do and relies much less on rules and probabilities. Present-day epidemiology does not have the necessary probabilities or rules available for incorporation into an expert system. Hopefully, more progress in this direction will occur when systems like EPIAID become available.

One characteristic of an expert system is its ability to "learn." EPIAID learns by accumulating new and more useful tools in its databases and by improving its logic. The database approach lets EPIAID learn a new geographic location, since disease patterns differ radically in different parts of the world—a database suitable for Botswana, for example, is nearly useless in Colorado.

One distinctive feature of EPIAID is that it produces blocks of English text describing and evaluating the hypotheses, methods, results, and conclusions of the model-building process. This can improve epidemiologic record keeping and offer a common ground for discussion of various record-keeping methods. The process of keeping written records of investigations badly needs the same kind of attention given to that process in individual medical cases (see reference 3). EPIAID may focus the discussion by offering a format for criticism and revision of case definitions, questionnaires, and the flow of logic in designing investigations.

However, interactive text creation, if not carefully constructed, can churn out hundreds of reports containing similar words in the same order, having little impact because of monotony. The idea that a computer can "write reports" is likely to arouse considerable emotion. It will be interesting to evaluate investigators' reactions to interactive text generation as we try to achieve the right balance of guidance and freedom in the text-creation tables so that the program assists rather than constrains the writing process. One of EPIAID's major limitations is its dependence on the investigator's typing skill; this will remain a problem until the development of practical systems for voice-to-screen dictation.

Another limitation is the value of the databases that are incorporated into EPIAID. Access to questionnaires used in previous investigations is only useful if the questionnaires are well constructed and evaluated. Searching a database of previous outbreaks for similar patterns is not useful if the database is incomplete. Frequently, the fact that a particular combination of factors has *not* been reported in the literature is as important as the reverse, and you cannot determine this from a partial database. You would need considerable resources to create and maintain a credible database of previous outbreaks in the structured form proposed by EPIAID's current design or a later enhancement of it. The *epidemic model* composed of 12 items, shown in figure A in the text box, was developed for EPIAID and is therefore a proposal, not a component of routine epidemiology, although most introductory courses include related material.

Currently, the literature of epidemics, both at the National Library of Medicine and at CDC, is indexed by key words and topics; however, it was not designed with the parameters of an epidemic model in mind. Systematic coding of negative as well as positive results from an investigation would be a new development and would require extra resources and agreement on the format. It would offer as an extra benefit the possibility of systematically evaluating the *success* of investigations in terms of the number of elements from the general model that were known at the end of the investigation. We need an agreed-upon model to allow the "epidemiology of epidemics"—rather than of a particular epidemic—to develop to the point where we can include probabilistic thinking in an epidemiologist's expert system.

None of these problems is unique to computerized systems. If you're an epidemiologist relying on traditional resources, you probably either maintain a manila folder of favorite questionnaires or go down the hall to ask for a colleague's. You search previous outbreaks through several trial runs with a medical librarian or call another epidemiologist who specializes in a particular subject. All of these processes are still necessary with computer assistance, but EPIAID aims to make the manila folder very large and convenient and the questionnaires in it suitable for data entry immediately after editing. With EPIAID the epidemiologist is one step closer to bibliographic information and can edit and incorporate the reference citations in a report rather than retyping them.

THE FUTURE

The role of the expert epidemiologist in the future may be partially to see that other epidemiologists have access to well-constructed and complete database materials and effective tools that have been tested in the field. EPIAID, by providing a medium for storing and using such materials, may stimulate interesting questions about how epidemiology is or should be practiced and how the worldwide epidemiologic database can or should be maintained. ■

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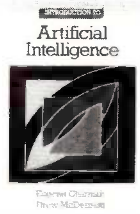

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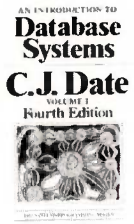

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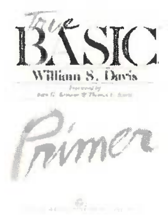

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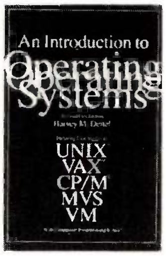

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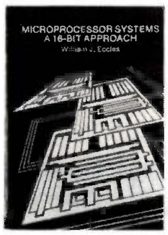

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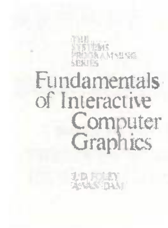

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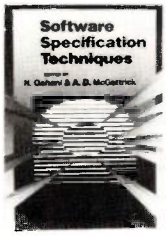

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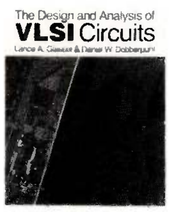

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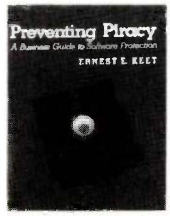

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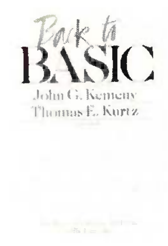

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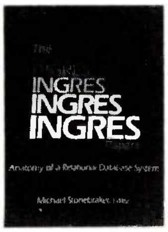

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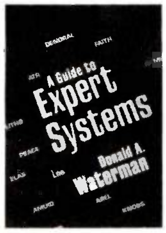

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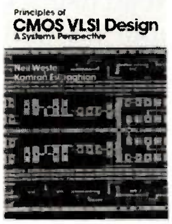

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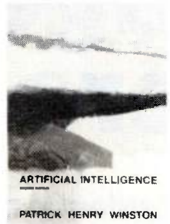

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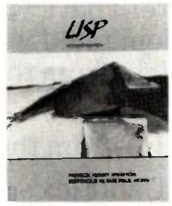

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PREDICTING ARSON

BY ROYER COOK

Micros become a new weapon in the fight against arson

ARSON IS A pernicious crime that strikes directly and dramatically at the physical and economic condition of a neighborhood. Although the scope and incidence of the problem are difficult to estimate precisely, available data indicates that arson accounts for billions of dollars in property losses, as well as thousands of deaths and injuries each year.

The tasks of local arson prevention and control were once restricted largely to municipal fire departments. Now, however, with the recognition that the roots of arson are embedded in the condition of the community—the quality of housing, trends toward disinvestment, general economic decline, and so on—community organizations have become increasingly active in efforts to combat arson.

Recently, a growing number of city agencies and community organizations have found that computer-based arson-prediction systems can be powerful weapons in the fight to prevent arson and halt the devastation and decline of their neighborhoods. By pinpointing the buildings where arson is most likely to strike, the computer models allow arson-prevention workers—community organizers, firefighters, and others—to focus their efforts more effectively.

At the Institute for Social Analysis, my colleagues and I have spent the past 2½ years evaluating these computer-based arson-prediction systems, concentrating on the system used by the Flatbush Development Corporation in Brooklyn, New York, probably the most advanced form of such systems. We found both considerable promise and numerous pitfalls in the use of computer-based arson-prediction systems.

PINPOINTING

Ironically, the main challenge in predicting arson stems from its relative rarity. Even in the most arson-ravaged neighborhoods, arson seldom occurs in more than 5 percent of all the buildings in a given year. If we know where arson is likely to strike, we can do several things to prevent it, from fire-marshall monitoring to tenant organizing. But even in a small community, there may be several thousand buildings; arson-prevention/control activities cannot be directed at each one. Fortunately, there are several characteristics of buildings that are associated with "arson-proneness," and if we can collect the pertinent information on each building, certain analytic techniques enable us to identify those characteristics. Computer-based arson-prediction systems permit us to store and analyze the large data sets necessary to pinpoint the buildings most likely to be torched.

THE BEGINNINGS

Computer-based arson-prediction systems were born in the late 1970s when a group of pioneering researchers at the New York City Arson Strike Force laid a foundation for "arson early warning systems," as they are now known. The Arson Strike Force staff examined the city records (housing, finances, fire, and so on) of 21,765 buildings in New York City, half of which had experienced arson during the previous six-month period. Through multiple regression analysis, the staff identified several building

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Royer Cook, Ph.D. (Institute for Social Analysis, 1625 K St., Suite 902, Washington, DC 20006), is president of the ISA, a private and federally funded organization that performs behavioral science research in the areas of crime and drugs.

characteristics that tended to distinguish between buildings with arson and those without arson. The end result was the Arson Risk Prediction Index (ARPI), a formula consisting of weighted variables such as building type, vacancy rate, and fire history. This formula could produce an ARPI for virtually any building in the city.

At the same time, Ron Hine of the Flatbush Development Corporation was developing an arson-prevention program to save the once-lovely neighborhood of North Flatbush in Brooklyn. Flatbush was the classic transition urban neighborhood in the 1960s and 1970s, suffering decline, disinvestment, and arson. Ron picked up the Arson Strike Force formula, built a data bank on neighborhood building characteristics—tax arrearages, vacancy rates, and so on—and generated an arson risk list, which ranked all buildings in the neighborhood according to arson-proneness. Buildings at the top of the list, the top 20 or 30 out of 1200, became the targets of Flatbush Development Corporation's arson-prevention activities. It was at this stage that we stepped into the picture.

The central question for us was: How well does the computer-based model predict arson? How many of the buildings at the top of the Flatbush risk list actually became targets of arson? By monitoring these arson-prone buildings for a year, we could get an answer to that question. But because people on the Flatbush staff were actively working on many of these buildings, their successes—the arson they prevented—would actually make their prediction system worse. So we built our own arson early warning system in the adjacent neighborhood of Crown Heights, where no arson-prevention work was being done. Basically, our work consisted of building the arson early warning system in Crown Heights, developing prediction formulas tailored to the neighborhood (such as running our own regression analysis on the buildings in the two neighborhoods), and measuring the predictive accuracy of the formulas in both neighborhoods.

No Small Task

The first step in building the arson early warning system in Crown Heights was to gather the relevant data on building characteristics. Data on tax arrearages, code violations, and descriptive building information (such as number of units, building type, and so on) was contained on computer tapes from the city's departments of finance and housing. We collected vacancy data from the local utility company and fire data from the Fire Department. All the data was entered manually, one category at a time, into our IBM PC with a 12-mega-

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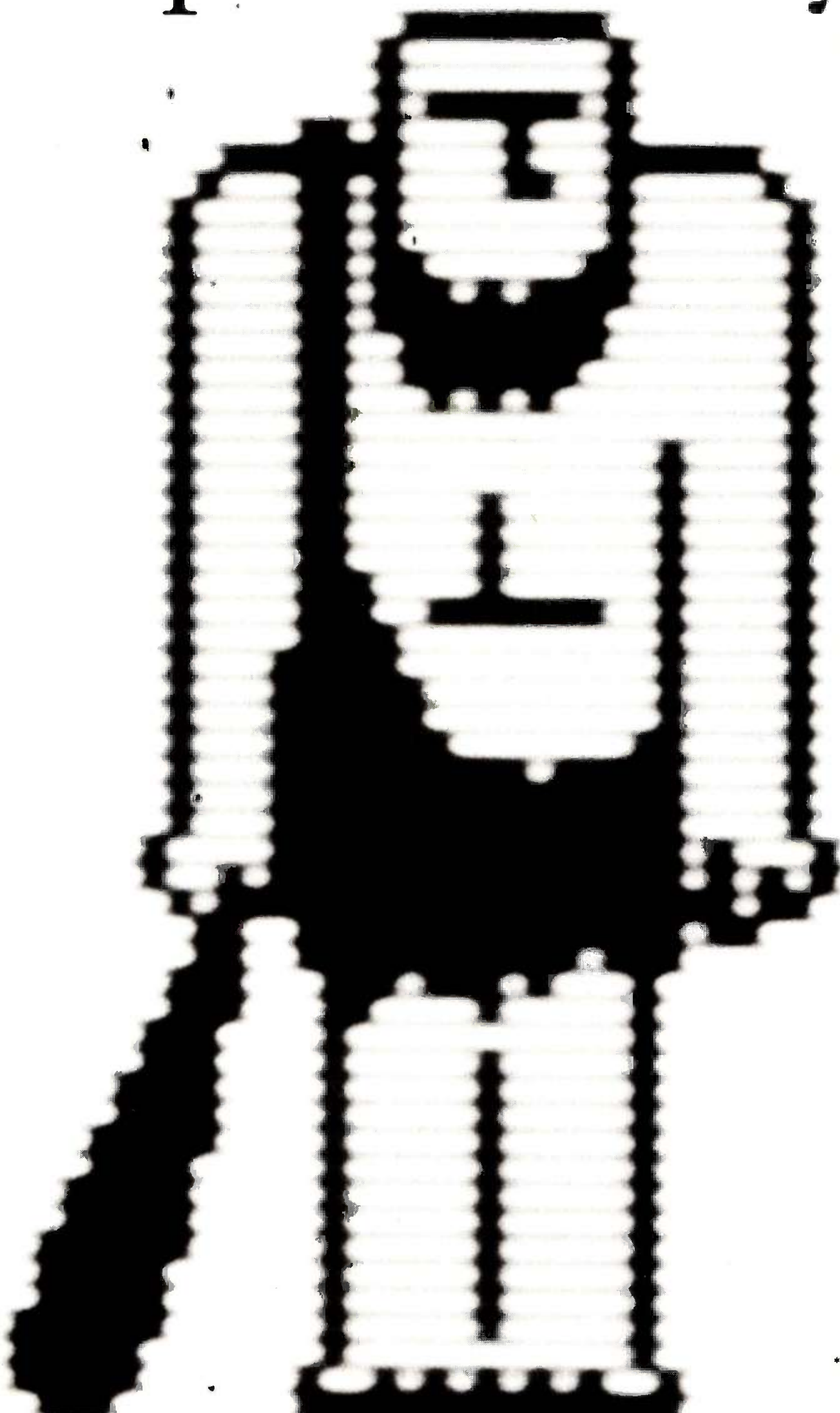

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byte hard disk. Our hardware and database-management system (dBASE II) purposely mirrored those of the Flatbush early warning system.

We constructed nine basic files to store all the information needed for arson-prediction and building information. These files contained fire data, building-code violations and liens, identification numbers and addresses, finance information (assessed value and tax data), alternative addresses, owner data, mortgage information, vacancy rates, and insurance information. Each of the nine files for an individual building contained a building identification number used to link the files together. Our staff updated the dBASE II files easily and frequently. Prior to applying the risk formula, a program written in dBASE II constructed a tenth file containing only the variables in the risk formula. dBASE II programs then calculated the arson risk score for each building and produced the building profiles used for information purposes. Other dBASE II programs conducted special analyses, such as identifying commercial properties with suspicious fires during a given time period and linking street addresses in fire records to the building identification numbers.

Sounds like a fairly straightforward procedure, doesn't it? It wasn't. One of the apparently simplest steps—matching the data to the appropriate buildings—turned out to be the biggest headache of constructing the early warning system. The main problem was that the agencies use different means of building identification—the Housing Department uses block and lot numbers to pinpoint each building, while the Fire Department uses addresses. The Housing Department attaches addresses only to multiple-family dwellings. We used a real estate directory to obtain addresses for other buildings whose block and lot numbers were known (and since the directory is organized by street, the search was cumbersome).

Even when we completed a data set full of building information with addresses, matching fires to buildings was not an easy task. Corner buildings may have two very disparate addresses (524 St. Johns Place and 807 Classon Avenue, for example, are the same building), and a fire may be recorded in an apartment within a building with an address "range" (e.g., 1151 Pacific Street is in the building known as 1147 Pacific Street).

Relying only on agency data, we could not match 11 percent of the fires to a building. So we sent a community organizer out into the neighborhood to clear up the discrepancies. The detective work was time-consuming but creative. Imagine discovering that the 30 fires listed as occurring at 555 Prospect Place were in the Brooklyn Jewish Hospital—listed in the building data set as on the corner of Classon and St. Mark's Avenues! This resulted in matching all but a few buildings to the data set. The problems of matching data would have been considerably lessened if the early warning system had been developed by staff members intimately familiar with the neighborhood or if the agency data had been recorded in similar ways.

A New Formula

Having constructed a full data set of potential arson predictors and arson indicators, we were now ready to develop our own prediction formula that, unlike the citywide ARPI formula, would be tailored to the particular neighborhood. Indeed, from the very beginning we were skeptical about the predictive accuracy of a citywide formula, given the wide variation in neighborhoods throughout New York City. We developed new formulas for both Flatbush and Crown Heights. In each case the procedure was the same. First, the bivariate relationships between each potential predictor variable (e.g., serious code violations) and arson were analyzed by Spearman's *rho* correlation coefficient. Those predictors with significant correlations to arson were taken to the next stage, multiple regression analyses.

At this point the analysis moved to a mainframe for application of the General Linear Model (GLM) of the SAS software package. This program tests all variables desired in every permutation, beginning with each variable on its own, then every combination of two variables, then three, etc. The best formula, in our eyes, was the one with the fewest variables (for ease of data collection), largest R^2 (to maximize predictive accuracy), and smallest Mallow's C (to reduce potential for biased estimates produced by correlated predictor variables).

The final formula for Flatbush contained four weighted predictor variables: serious code violations, number of units (apartments), vacancy percentage, and past fires of "unknown origin" (or not). In Crown Heights, the final prediction formula also had four variables, two of which were different from the Flatbush predictor set: number of quarters in tax arrears, serious fire (or not), number of units (apartments), and fires of "unknown origin" (or not). We applied these formulas along with the citywide formulas to the building data sets for Flatbush and Crown Heights, producing lists of all the buildings ranked according to their arson risk index.

Predictive Validity

How well do the formulas predict arsons? If the arson early warning systems are accurate, the buildings with the highest arson risk scores would tend to have arsons over the next year. Testing first the citywide ARPI score, we found this tendency, but in weak form: Only 14 of the 37 arsons that were set in 80 Flatbush buildings in the subsequent year were in the top 100 buildings of the ARPI list (an R^2 of only 0.045). Similarly, in Crown Heights only 13 arsons out of 39 were in the top 100 buildings (out

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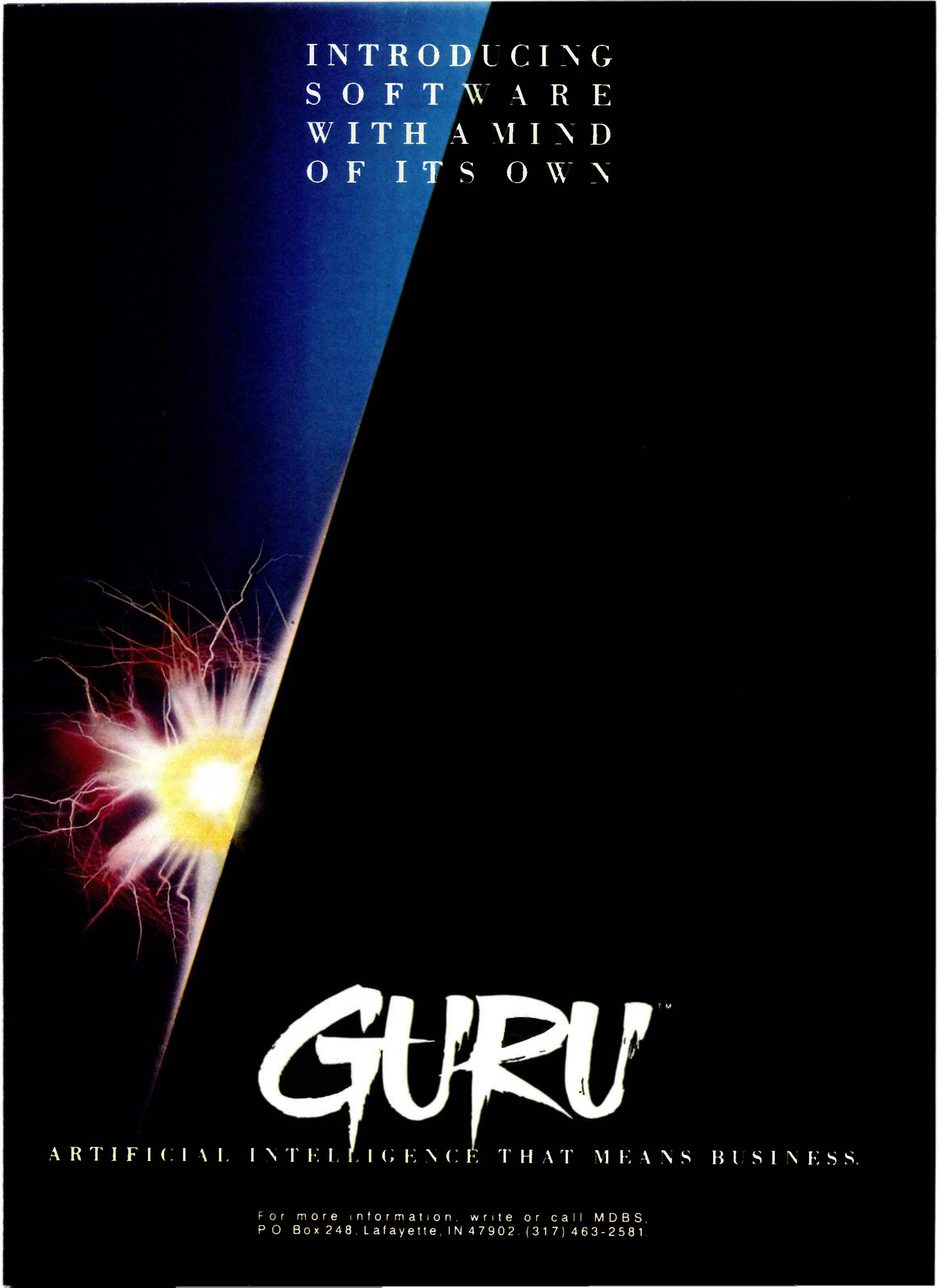
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Arson prediction is not precise; most high-risk buildings do not burn.

of 1105 scored) as predicted by the ARPI formula (an R^2 of 0.037). Clearly, this citywide formula was a crude predictor of limited practical use.

Would our neighborhood-specific formula perform better? It did, although the new formula was applied to a smaller set of buildings as a result of missing data on some new formula variables. In Flatbush, 11 arson fires (42 percent of all arsons in the 431 risk-scored buildings) were set in the top 48 buildings, and 22 arson fires (85 percent) were set in the top 146 buildings, yielding an R^2 of 0.129—nearly three times the predictive power of the citywide ARPI score. In Crown Heights, 23 arson fires (74 percent of all arsons in the 546 risk-scored buildings) occurred in the top 138 buildings, producing an even greater boost in the R^2, from 0.037 to 0.141.

Thus, if arson-prevention efforts are aimed at the top 50 buildings on a neighborhood-specific arson risk list, 30 to 40 percent of all potential arsons can be addressed. By widening the targets to the top 150 buildings, the large majority of all potential arsons will be targeted. (Our research also found that once an arson-prone building is identified, a variety of effective arson-prevention/control activities can be implemented—from fire-marshall scrutiny to organizing tenants—that generally improve the buildings and effectively reduce the frequency of fires in the buildings, both incendiary and accidental.)

Still, arson prediction is gross rather than precise; most buildings with high arson risk scores do not burn. So while computerized arson prediction helps to narrow the range of buildings, it is not accurate enough to permit a focus on only 20 or 30 buildings. Nor should the arson risk list be used as an unalterable guide for launching full-blown arson-prevention efforts toward 150 buildings. Arson fighters must use the risk list as a beginning, applying very-low-effort prevention methods (such as a warning notice to the landlord) toward all of the top 10 percent to 20 percent of the buildings, and more resource-consuming efforts toward smaller numbers of buildings.

High Tech, Grass Roots

The technology of computerized arson early warning systems is perhaps no longer in its infancy but in its toddler stage. Although the system at the Flatbush Development Corporation (where our new prediction formula has supplanted the old citywide ARPI) is one of only a small number of arson early warning systems, it has already proven its utility as an arson-prevention tool. No doubt these systems can be considerably improved in efficiency, accuracy, and scope.

We have really only begun to develop and test improved prediction systems; other predictor variables and models need to be tried out. For example, we are currently working on a program that will address the missing-data problem by substituting an alternative prediction equation when a building profile is missing one of the predictor variables. We are also exploring ways to simplify the prediction process so that organizations with less statistical sophistication can generate useful arson risk-prediction systems.

Once in place, these computerized systems have the potential to do more than predict where an arson will occur. In fact, at the Flatbush Development Corporation the system has already become a rather comprehensive housing information source. The system can produce, at the touch of a few keys, a comprehensive profile on any property in the neighborhood, showing real estate transactions, number of units, fire history, property value, and so forth. This kind of information has been helpful to other neighborhood revitalization activities at FDC, including a low-cost loan program for improving properties and a weatherization program. Some have called such systems "housing early warning systems" since they can serve as barometers of what is happening to the housing stock in the community. There is probably no better set of indicators of a neighborhood's socioeconomic health than the trends in housing stock.

CONCLUSION

With the recent expansion of storage capacity in microcomputers, a community organization can construct not only an arson early warning or housing information system but a neighborhood information system that stores and analyzes trends in crime data, employment, investment, and so on. The information itself, if organized properly, can be a valuable base for planning and allocating resources. Moreover, there is potential for the application of forecasting/prediction models to these other databases. The microcomputer has already begun to transform the work of a few community organizations. It seems likely that it will be used by many other organizations for arson prediction, housing information, and beyond. ■

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In case you're thinking that all this is an unnecessary duplication of what DOS does for you, let me explain the disk facts of life.

If DOS did what you may think it is supposed to do when you format the disk, DOS would map around these bad areas. Unfortunately, DOS doesn't do this.

DOS 2.0 and 2.1 can't enter the bad tracks. DOS 3.0 can, but only on the IBM AT. Unfortunately, as the press has so well documentated, the AT's hard disk develops bad tracks later on.

We do what DOS can't

We believe the problem is so bad, we use a software program that performs a powerful test of your disk drive on all of the IBM or IBM compatible computers—PCs, XTs, and ATs. Our format takes hours to analyze the disk. But when we finish, you know that the bad tracks are really mapped out so you won't write good data that will disappear into a black hole. We even send you a printed statement of our test results.

Our software allows you to type in the bad track locations from the list supplied by the manufacturers, so you'll never write good data to them—even if DOS didn't identify them as bad. The software even lets you save the location of these bad sections to a file, so that you can reformat your disk without spending hours retesting.

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

Average Access Time

As you might suspect, some hard disks are faster than others in their ability to move from one track of data to another. The time it takes the hard disk to move one-half way between the beginning of the disk to the end is called the "average access time."

The first generation of 10 megabyte hard disks had average access times of 80-85 milliseconds (msec). But computer users love speed, and guess what—the average access time for the new 20 megabyte hard disk in the IBM AT is only 40 msec. (We sell an AT equivalent with only 30 msec access time!)

There are some legitimate reasons for the shorter access time. It's particularly helpful when there are multiple users on the same hard disk. It's also important when running a compiler. But remember, before you get too wrapped up in the access speed, there's always that ST 506 interface which won't let data transfer from the hard disk to the computer any faster than 5 megabits/second. We've bypassed that choke hole, too. If you want the functional equivalent of a Ferrari with a turbocharger, order our 10 Mbit per second 100 megabyte hard disk with 18 mse[c] of average access speed.

Compatibility

To be sure that your hard disk i[s] 100 percent compatible with th[e] IBM XT you don't need to bu[y] the same hard disk that's in th[e] XT. You can't even be sure wha[t] brand hard disk it is becaus[e] IBM, like Express Systems, goe[s] into the marketplace and buy[s] hard disks from several vendors. However, they buy their X[T] hard disk controller from onl[y] one vendor—the same one w[e] do.

You can buy the IBM XT con[-]troller from IBM for $495 or yo[u] can buy from us, the functiona[l] equivalent, manufactured by th[e] same company that makes it fo[r] IBM for only $195. Is it the ex[-]actly identical IBM XT contro[l-]ler? No, it's better. First, it take[s] less power, and secondly, it ca[n] control from 5 to 32 mega[-]bytes—the IBM controller ca[n] work with only 10 megabytes. [It] is 100 percent IBM XT compat[i-]ble, and 100 percent is 100 pe[r-]cent. If you want to save a slo[t] we carry a version that lets yo[u] operate two hard disks and tw[o] floppy disk drives.

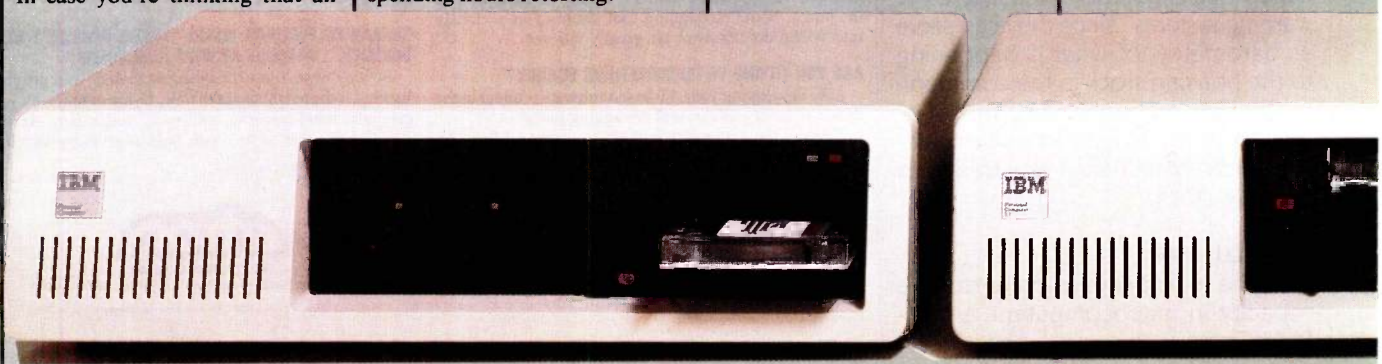
More than 32 Megabytes

You can operate with more tha[n] 32 megabytes (the limit of DOS[)] through the use of "device driv[-]ers." Express Systems can suppl[y] you with device drivers for ou[r] hard disks for over 32 megabyte[s] formatted. But, if you don't hav[e] individual files, or databases tha[t] are large, you might want to con[-]sider one of our controllers tha[t] can divide our 65 megabyat[e] (formatted) hard disk into tw[o] equal volumes of 32 megabyte[s] each.

Reliability

We offer you a choice betwee[n] iron oxide and plated media[—] the stuff that covers the har[d] disk and gives it its magnet[ic] properties. Iron oxide is,—wel[l] it's rust. If you inadvertentl[y] joust your disk, you may caus[e] the low flying head to dig ou[t] some iron oxide. A little ru[st] flake can ruin your whole da[ta]. Plated media is more resistant [to] damage, and if it happens, le[ss] data is lost.

We offer both types of har[d] disks. The iron oxide is old[er]



technology, and quite frankly, manufacturers understand it better. Their better understanding, combined with some of the special head locking mechanisms, gives us peace of mind when we sell you one.

Power

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

Our Customers

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

IBM	Sears
American Express	Honeywell
U.S. Army	MIT
AT&T (Bell Labs)	RCA
Bausch & Lomb	Lockheed
Xerox	Sperry

Easy to Install

If you're like most of us, raised on the boob tube rather than the Great Books, you'd rather see the movie than read the book. Well, now you can choose to read our installation manual or for only $9.95 more, you can get a VHS or Beta video cassette showing the simple steps for installation.

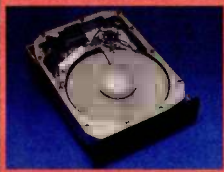
Warranty

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

Comes complete

All Express Systems products come complete with the appropriate software, tape and/or hard disk controllers, and cables where required. Hard disks are formatted and tested with the PC DOS of your choice. All drive sizes are formatted capacities.

If your application requires a stacking kit, power splitter cables, daisy chain cable, or some other variation, we'll supply these items at a nominal charge. We even ship our hard disks with Command Assist™ an on-line DOS-like manual to give you help with your DOS commands.



Complete Hard Disk Kits

Formatted MB	Height	Plated Media	Average Access	Transfer Rate	PC or PC/XT	AT
10	½	no	85 msec	5 Mbits/s	$ 395	$ N/A
10	½	yes	85 msec	5 Mbits/s	$ 495	$ N/A
21	½	yes	85 msec	5 Mbits/s	$ 795	$ 595
21	Full	no	30 msec	5 Mbits/s	$ 1,535	$ 1,340
32	½	yes	85 msec	5 Mbits/s	$ 995	$ 795
32	Full	no	30 msec	5 Mbits/s	$ 1,775	$ 1,575
65	Full	no	30 msec	5 Mbits/s	$ 2,295	$ 2,070
100	Full	yes	18 msec	10 Mbits/s	$ 4,995	$ 4,995
Removable Hard Disk						
10	½	no	90 msec	5 Mbits/s	$ 1,095	N/A

Tape Systems and Subsystems

Formatted Storage Capacity	Height	Data Transfer Rate (k/sec)	PC or PC/XT	AT
60 Mbytes	½	88	$ 995	$ 995
60 Mbytes Subsystem		88	$ 1,295	$ 1,295
21 Mbytes (unformatted) Start/stop Subsystem		24	$ 595	$ 595
26 Mbytes Floppy Tape® Subsystem		31	$ 749	$ 749

Controllers

All of our hard disk and tape controllers are available separately: Please call for prices.

Subsystem Chassis

Any of our disk or tape units are available in an external subsystem for an additional $250.00. You can mix & match any of our ½ high hard disks or tape drives together or add any single full height hard disk.

Tape Cartridges

Express Certified 555 foot 310 Hci ¼-inch Data Cartridge $35.00

Power Supply

130 Watt Power supply $75.00*
150 Watt Power supply $125.00

*with the purchase of any drive

More questions?

Because we spend so much attention on the front end with ensuring that our disks will arrive in working order, we have a customer service department that, unlike many of our competitors, has little to do. When you need us, you won't get a constant busy signal.

Call our friendly, knowledgable customer service staff to get answers to your questions—before or after the sale. Our people, who know the PC, can talk you through the sticky parts, and they'll respond to you quickly. Just call us.

How to order

Pick up the telephone and call 1-800-341-7549, to order. We accept Master Card, VISA, American Express and Diners Club. Or send a cashier's check or money order (We'll take a check, but you'll have to wait for it to clear) and tell us if you want one of our recommended configurations or you want to mix and match yourself. Corporations with a DUNS number may send purchase orders for quantities over five.

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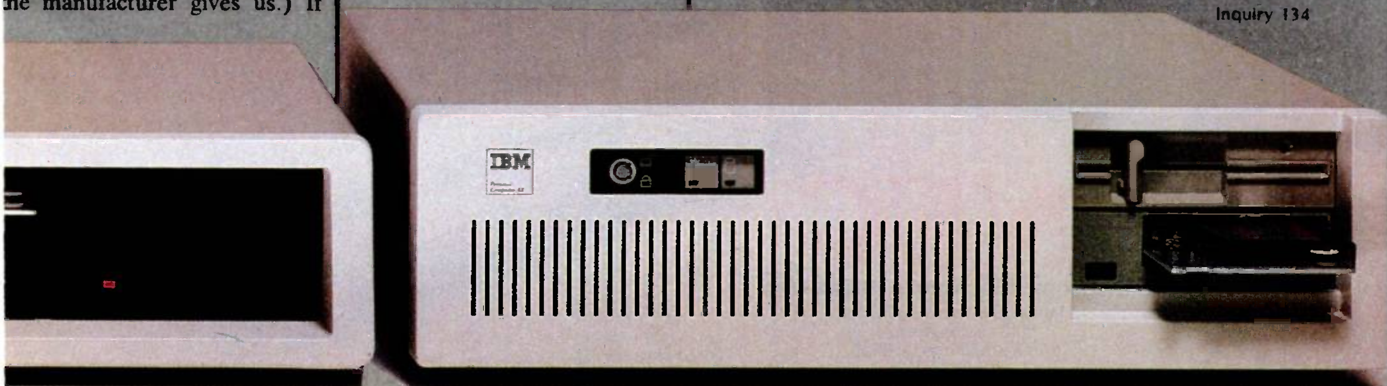

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At NEC, monitors and printers are not peripheral issues.

All too often, brand-name CPUs are "bundled" with mediocre peripherals—a practice that makes for profitable sales, but does nothing for the system's performance.

In Japan, where most computer peripherals are actually built, NEC is the largest personal computer company—by far. And NEC didn't make it to first place by offering second rate peripherals.

The monitors with the broadcast video heritage.

While dozens of companies market display monitors, only a handful possess the tube technology and manufacturing capability to actually *build* them. NEC is one of the few. In fact, NEC's complete line of color and monochrome monitors reflects the professional and broadcast video expertise that twice earned NEC Emmy Awards from the National Academy of Television Arts & Sciences.

Winning the printer race takes both speed and endurance.

Ask people who really know about printers, and they'll tell you that NEC builds the best. They may also point out that NEC builds printers for other computer companies. And if you ask them to choose one word to sum up what makes NEC printers stand out, it will probably be "reliable." This is why NEC has become the printer of choice for the most demanding installations.

So before you buy a peripheral from any name company, make sure the company puts more into the peripheral than just its name.

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TRI-MODE DOT MATRIX PRINTER

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FIGHTING FIRE WITH TECHNOLOGY

BY BRUCE DILLENBECK

The dBASE II *database-management system goes to work in community-action service*

THE PEOPLE'S FIREHOUSE, a housing and community-development organization located in the Brooklyn neighborhood of Northside, Williamsburg, and Greenpoint, undertakes a number of programs ranging from the rehabilitation and management of city-owned housing to tenant organizing and revitalization of the neighborhood's aging commercial strip.

In 1984 the Firehouse purchased a Texas Instruments portable computer and dBASE II software to aid in its fight against arson. After computerizing housing information obtained from various New York City agencies, the Firehouse computed Arson Risk Prediction Index (ARPI) scores for each property within the neighborhood it services.

THE ARSON RISK PREDICTION INDEX

Development of the ARPI was undertaken by the New York City Arson Strike Force in the years 1979 through 1981. The hypothesis that guided the development of a predictive index is that arson risk is associated with certain structural, economic, and demographic characteristics of buildings and neighborhoods. The index was the result of analyzing data gathered for 21,765 buildings in the city. Building upon the work of the cities of Boston and New Haven, the Strike Force identified a number of key variables associated with arson. The Strike Force developed a study file composed of buildings with known incidents of arson and an equivalent number of control cases from buildings that did not experience arson over the study time period. The sample of buildings not affected by arson was randomly drawn from each of New York City's five boroughs.

The Strike Force made use of a number of methods of statistical analysis to isolate the predictive variables. According to the Strike Force report:

> The final outcome, and the useful product, of this analysis is the Arson Risk Prediction Index (ARPI). ARPI is a measure of a building's arson-proneness. It is the result of a statistical technique known as discriminant analysis, a procedure which sifts a set of data items for those variables that most clearly distinguish between groups. . . . When there are only two groups, such as the present case, the result of discriminant analysis is a formula. If the necessary characteristics of a building are known, these values can be entered into a formula, with the result being a number which indicates that building's resemblance to the typical arson and the typical control building in the sample.

Ideally, certain variables would have a higher predictive capability than others, but in reality many of these are not readily available for a number of reasons, including (1) privacy of data, (2) cost of data collection, and (3) unavailability of data. Ultimately, several key variables were identified. Version

(continued)

Bruce Dillenbeck is the arson project planner for the People's Firehouse, 125 Wythe Ave., Brooklyn, NY 11211. He received a B.A. in political science from the State University of New York at New Paltz and an M.A. in urban planning from the University of Illinois.

To use the ARPI model at the neighborhood level required building a database including each of the variables needed to compute scores for every building.

1 of the ARPI formula, as used by the Firehouse, includes the following variables:

- building's prior fire history
- number of quarters in tax arrears
- vacancy rate
- building classification
- borough location
- corner location

Table 1 shows the weights (coefficients) developed for each variable.

ARPI AND dBASE II

To use the ARPI model at the neighborhood level required building a database that minimally included each of the variables needed to compute scores for every building. To build the database and compute scores required the use of a relational database program that could read several files simultaneously and a microcomputer with sufficient power and memory capacity to handle lengthy calculations. Ashton-Tate's dBASE II fit the bill, and the Texas Instruments Professional has the necessary power and memory to run ARPI using dBASE II. We had a hard disk installed with a capacity of 10 megabytes. A hard disk was necessary for the amount of information we needed to input.

The information required to compute ARPI scores was obtained from a variety of New York City government agencies. Needless to say, a major part of our effort was the amount of work required to input a voluminous amount of data. There are approximately 4000 separate parcels of property within the Firehouse service area (including vacant lots and nonresidential properties).

Our first task was to create and structure the necessary data-input files. We wanted to create an extensive housing database that could be used in a variety of research and planning applications. Thus, the produc-

Table 1: *The ARPI version 1 coefficients. Variables are of two types. For entries marked by an asterisk (*), the value of the coefficient is added to the total score if the answer is yes; 0 is added otherwise. The other coefficients are multiplied by the applicable number or percent and the result is added to the total score. A constant value of 1.84 is added to the final value. The more positive the total score, the higher the arson risk.*

Variable	Coefficient
Is building a 1- or 2-family house?*	−2.83
Is building a walk-up apartment house?*	−1.75
Number of quarters building is in tax arrears	.09
Is building an elevator apartment house?*	−1.30
Is building nonresidential?*	−1.66
Building vacancy rate	.01
Has building had a recent suspicious fire? (last 12 months)*	1.13
Number of fires in building during last 12 months	.33
Is building located on a street corner?*	.74
Is building in Manhattan?*	−.55
Is building in Brooklyn?*	.12

tion of ARPI scores was only one application of the creation of a housing database for our organization's purposes.

One requirement of using a relational database-management system (DBMS) is to have a key field across all files so that they may be linked together. Computing ARPI scores requires the DBMS to find records (here, common building) from four different files. You might expect that the address of each property could serve this purpose. However, the address of a property may be recorded differently from one government agency to another. A common mode of identifying addresses in New York City is by block and lot. A block is a physical city block and a lot is an individual parcel on that block. Each property is assigned a unique block and lot number by the New York City Finance Department for tax purposes. However, a number of the files we were working with did not have an identifying block and lot number. We were able to add the proper block and lot numbers from our Finance file (which served as our primary file) to individual records within other files that shared common addresses. Those records in other files that were defined by alternative addresses had to be matched by other means.

Once these two labor-intensive tasks of data input and matching records across files were achieved, all that remained was to write a program that could run the ARPI formula. To compute ARPI scores required a program that could read several files simultaneously, find each record within a file, select the relevant variable (field) from that record, and compute the total building score as the sum of all variables multiplied by the proper coefficients.

Using the Scores

Once ARPI scores were computed for each building, dBASE II enabled us to organize the information in a variety of useful ways. Using the dBASE II indexing function, we were able to arrange all ARPI scores in descending order from highest to lowest values and thus list problem buildings on a priority basis. Buildings falling within the top 100 scores were given our highest priority. ARPI scores were printed with other useful information from our files, including the address of each building, the name of the owner, and the building classification. We next indexed the top 100 scores by street names. This allowed us to see if problem buildings were clustering on particular blocks. A third index was done by the names of owners. This allowed us to discern if there were patterns among owners and problem buildings.

Future Directions

One weakness that some critics have found with ARPI is that, because it was constructed using a citywide database, it does not account for individual neighborhood dynamics. The Arson Strike Force subsequently developed a second version of ARPI that included a number of variables relating to neighborhood characteristics. These variables included census tract data on the number of people receiving different forms of welfare assistance and percentage data (again at tract level) of the same variables in version 1. The People's Firehouse may attempt a construction of the version 2 ARPI the next time it computes scores. For now, the People's Firehouse is devoting its efforts to responding to problem buildings. ■

Editor's note: The ARPI version 1 model used in this project was tested for validity by the Institute for Social Analysis. See Royer Cook's article entitled "Predicting Arson" on page 239 for a detailed discussion of the accuracy of the model.

...but we didn't.

Introducing the new COMPAQ DESKPRO 286™. More features, more speed, more power.

Most people think the IBM® Personal Computer-AT™ holds the records for speed, memory, and storage. But now COMPAQ® has created a personal computer that pushes the technology much further.

A faster computer

Most computer companies would have been satisfied with a computer that ran programs as fast as the IBM PC-AT. But not COMPAQ. The new COMPAQ DESKPRO 286 runs all the popular programs 30% *faster.*

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Most would have been content with 3 Megabytes of memory, the IBM PC-AT's maximum. But again, not COMPAQ. The COMPAQ DESKPRO 286 can expand to 8.2 Megabytes.

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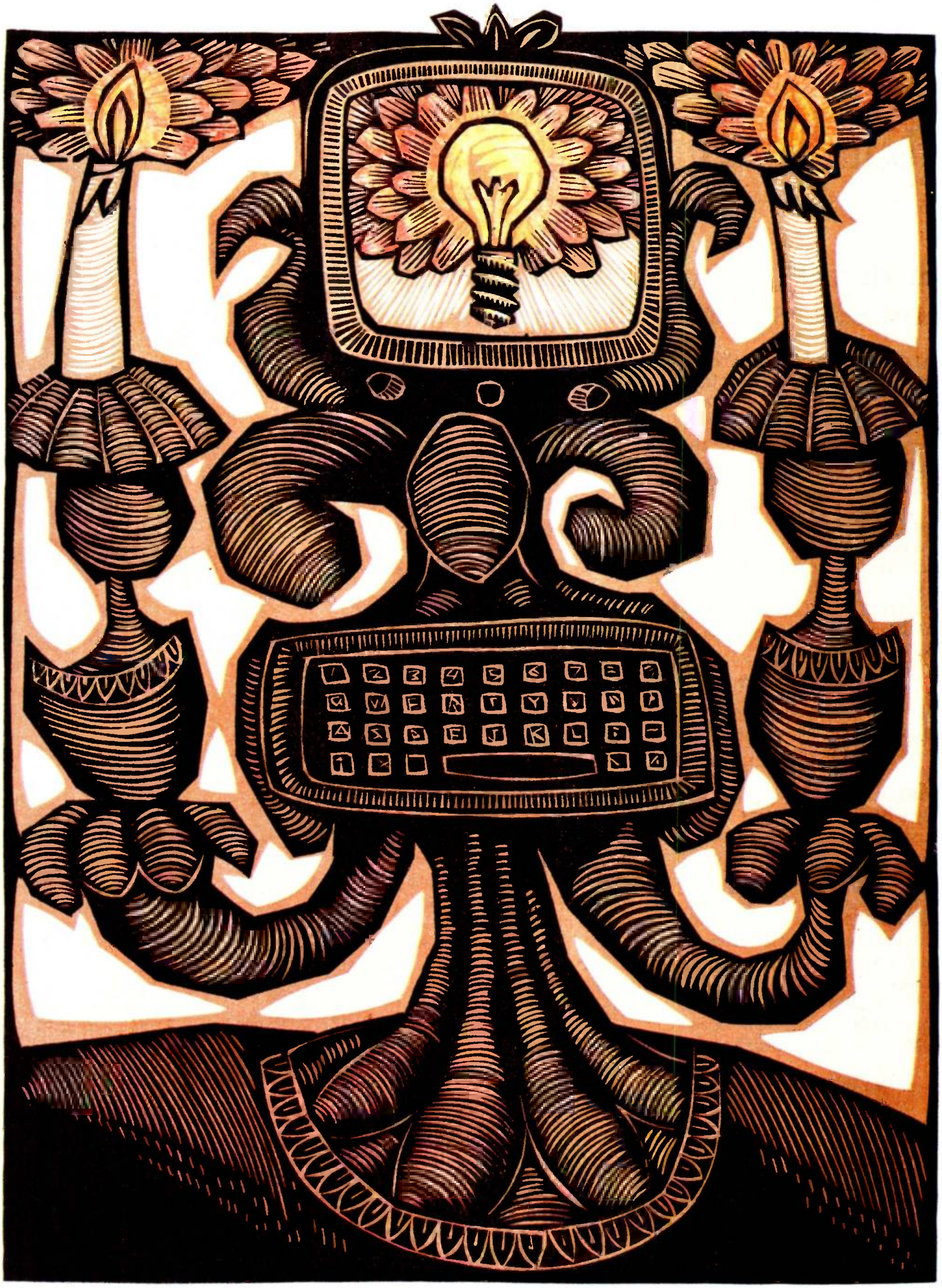


Reviews

LEADING OFF THE SECTION this month is John Unger's evaluation of the Ericsson Personal Computer. Considering the attention the company has focused on the ergonomic design of its machine, Mr. Unger rightly analyzes the degree of success Ericsson has had making the personal computer more comfortable to use. Aside from the way the hardware "fits" the user, how well does it function as a computing instrument?

Our second review, also of a system, spotlights the Stearns Desktop Computer. Reviewer Wayne Rash Jr. reports that the Stearns, though bright with promise (true 16-bit 8086 microprocessor running at 8 MHz), needs some polish with regard to execution (compatibility, quality control). He notes that the Stearns may be the answer to specific needs but warns that potential users should be aware of idiosyncrasies.

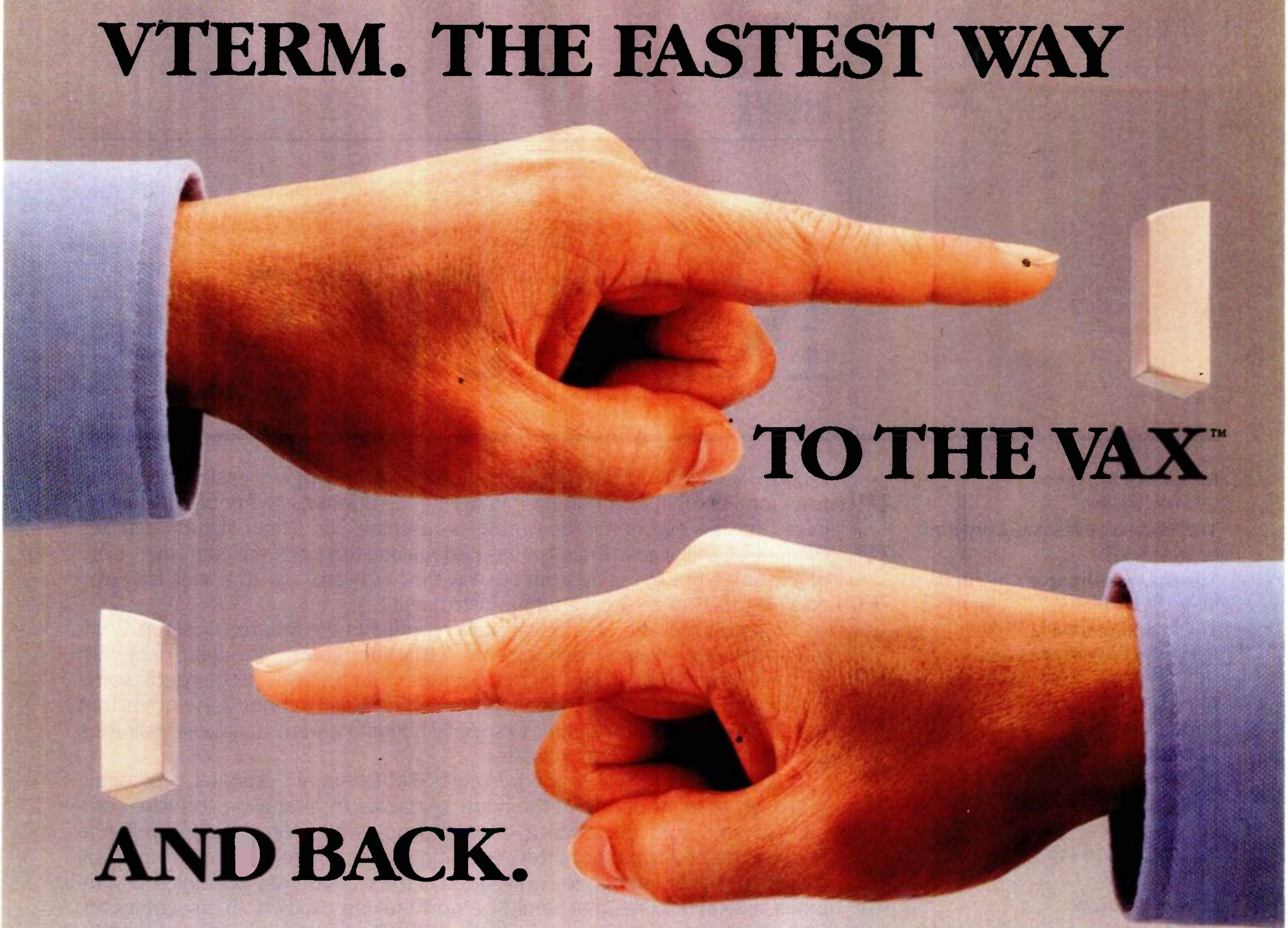
R. Jeyaraman's review of the portable STM Personal Computer provides a thorough account of one of the many portables to offer wide software compatibility and attractive physical characteristics. While not a true portable (the STM has no provision for battery operation and must be powered from a wall socket), it is light enough to be included in the class of transportables. It combines several features that would be worth taking a look at in any computer, regardless of size. For example, with an 80186 processor running at 8 MHz, operations internal to the processor are almost twice as fast as in an IBM PC. Transportability and speed are two valuable features for any computer.

One of the many incarnations of BASIC, BetterBASIC is seen by reviewer Art Huston to have hit and missed the mark in about equal proportion. While containing many features valuable to a BASIC programmer (the ability to access a full 640K bytes, for example), it also manifests limitations that could limit its wider appeal; as Mr. Huston observes, you need at least 256K bytes of memory to do any useful work in this language.

In our second language review, William Wong says that TLC-LISP's memory use and hardware support, along with such capabilities as a resident screen editor, turtle graphics, a Smalltalk-like class system, and a LISP Machine–like package system, are evidence of its utility in artificial intelligence work. All in all, he says that this LISP has excellent potential.

Zaven Karian evaluates GPSS/PC, a microcomputer version of a software package (the General Purpose Simulation System) that has been available only on mainframes and minicomputers. GPSS/PC is Minuteman Software's attempt to let the personal computer user create models of systems that consist of specific events. It differs substantially from implementations of the language on mainframes and minicomputers, and this review tells you how and what to expect.

Rich Malloy, BYTE's New York editor, gives us an evaluation of Toshiba's P1340 dot-matrix printer. He describes it as a medium-price high-density printer with good speed, especially in draft mode. This is balanced, he says, by a limited selection of fonts and a growing but still limited number of graphics packages designed to support the printer.



VTERM II AND VTERM/4010: FOR VT100 AND TEKTRONIX™ 4010 EMULATION, AND THEN SOME.

More and more people make the trip every day. Often several times. They're off to the VAX for a session or a file, then back to PC-DOS.

That's why we wrote VTERM – the fastest, most advanced communications program for PC users who communicate with VAXes, and other minis or mainframes.

Of course, VTERM starts with everything you'd expect from state-of-the-art terminal emulation software. Like full keyboard emulation. Macros. Disk capture. Unlimited setup files. Printer support. True plug compatibility, so you can run any VT100 or Tektronix 4010 program right from your PC keyboard.

MAKE YOUR PC FLY.

But then VTERM goes beyond everything else on the market. With a Hotkey that instantly toggles between host and DOS sessions while preserving your terminal screen and communications link. That means you can run host and local programs almost simultaneously. And because VTERM is written in assembly language, you get full throughput at 9600 baud.

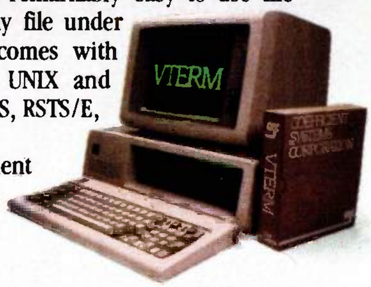
With VTERM, there's nothing to get in your way or slow you down. It's easy to use, yet packed with time-saving features. Like backscrolling, which redisplays up to 80 scrolled-off screens. And horizontal scrolling, which emulates 132-column display. (Of course, VTERM provides true 132-column display with an optional video board.)

KERMIT FILE TRANSFER AND MORE.

VTERM delivers the most powerful file transfer system available with any general communications package. You get four error-correcting protocols including XMODEM and Kermit, the emerging micro-to-mainframe standard from Columbia University.

And you also get VTRANS, a remarkably easy-to-use file transfer system that transmits any file under local or host control. It even comes with ready-to-run host software for UNIX and three DEC operating systems – VMS, RSTS/E, and RSX11-M/M+.

So why waste time? Call Coefficient Systems Corp. to order your copy of VTERM today.



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R·E·V·I·E·W·E·R'S N·O·T·E·B·O·O·K

MacCharlie, from Dayna Communications, Salt Lake City, Utah, has intrigued me since I first heard of it. The ability to use both IBM and Macintosh software, both in their own formats, on what closely approximates a single machine would solve a lot of problems for me. My case may be peculiar, given that a BYTE editor does a lot of running back and forth between machines. Still, being able to take advantage of the best software each has to offer struck me as something useful and worth looking into.

The arrival of MacCharlie pointed up some of the basic awkwardness of using DOS keyboard commands and icons in quick succession. It was rather like the initial stages of learning a foreign language when you translate everything back to your native tongue before the meaning comes through. Nevertheless, the confusion generated by sometimes forgetting which format I'm in hasn't caused any major problem. In fact, Dayna Communications seems to have anticipated the potential problem by adding a MacCharlie-generated click for each keystroke in the IBM-emulation mode. The Macintosh's operation is as silent as before.

In appearance, MacCharlie is just a beige box with one or two half-height floppy-disk drives (vertically mounted, drive A on the left), depending on whether you get MacCharlie or MacCharlie Plus. MacCharlie Plus comes with 640K bytes of RAM, while MacCharlie comes with 256K bytes. In the back are connections for hooking it up to the Macintosh, a printer, and a modem. Both the Macintosh and MacCharlie are powered by the same wall plug, and both are turned on and off by a switch on the front base of MacCharlie. The other piece of hardware is a keyboard mantle that your current Macintosh keyboard slides into and connects with through the standard Macintosh modular plug. It makes the keyboard wider by about one-third and gives you the numeric keypad and function-key layout of an IBM keyboard. The F1 to F10 keys appear to be defined in their normal manner for the software I've used.

Documentation is divided between an Apple-like user's manual and an IBM-style DOS/GW-BASIC manual. I've never liked the Macintosh user's manual for its noninformative "do-it-this-way-and-don't-worry-your-pretty-little-head-about-the-rest-of-it" style, and I don't care for the MacCharlie user's manual for the same reason.

While you can access the Mac disk drives from MacCharlie (and vice versa) through a utility called transfer.com, you don't really have full and easy command of four separate disk drives. In MacCharlie mode, you have a two-drive IBM system with the ability to dump data and programs to drives C and D in the Macintosh. If you want to run something from the Macintosh on MacCharlie, you have to transfer it to the MacCharlie side of the computer and run it under MacCharlie's version of MS-DOS (3.10). You have to be pretty sure you've got enough disk space on your MacCharlie drives. Alternatively, you can simply leave MacCharlie and run under the Macintosh operating system.

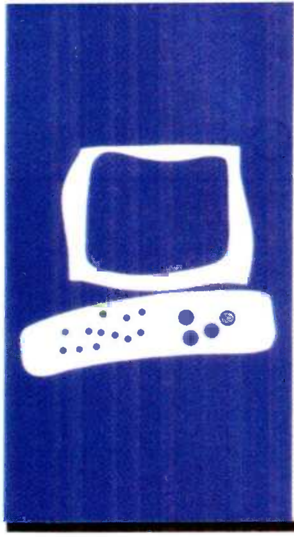
There's a great deal more to say about MacCharlie, but it will have to wait for a full review.

The 630/8 laser printer from BDS Corporation (Mountain View, California) has so far given every indication of being a good-quality unit with a relatively low cost. It will print eight pages a minute from an IBM PC. The characters look clear to the naked eye. Under a magnifying glass, there seems to be a spatter phenomenon. We think that it's because the laser puts enough of a charge on the drum to attract toner to areas immediately adjacent to the lines and curves of the characters. It's not so consistent as to cause a visible fuzziness when you're simply looking at a sheet of paper printed by laser. It looks more like individual particles of toner were picked up and deposited in a generally random pattern near the areas of greatest density.

This is another subject of an upcoming review. Beyond these first impressions there is little to report as yet.

Finally, we received an ITT XTRA XP and have just begun to exercise it preparatory to sending it out for a full review. This is ITT's 80286 machine; it runs at 6 MHz, has no wait states, and has given some of the fastest times so far recorded in BYTE's benchmark tests. The unit we received came with a single floppy-disk drive sitting over a half-height 20-megabyte disk drive. There are five expansion slots, one of which is taken by a monitor interface board. There is a serial printer port and a serial communications port, as well as a keyboard interface socket, on the back of the unit and separate from the expansion slots. The monitor is a 13-inch (diagonally measured) color unit that, when not running a color program, shows text characters in grayish-white on a black background. It has the typical ITT small footprint and only moderately quiet operation. The operating system is ITT-DOS (Microsoft) version 2.11 and, as yet, there haven't been any complaints about the way it has handled the tasks it has been given.

—Glenn Hartwig, Technical Editor, Reviews



S·Y·S·T·E·M R·E·V·I·E·W

The Ericsson Personal Computer

Highlighting IBM PC compatibility and ergonomics

BY JOHN D. UNGER

The features that distinguish the Ericsson Personal Computer from other clones of the IBM Personal Computer are its design concerns for ergonomics and user convenience, high-quality display, and high degree of compatibility with the IBM PC. Otherwise, the Ericsson is a rather unpretentious microcomputer.

The Ericsson comes in the familiar three-piece configuration of a combined central processing unit and disk-drive unit, keyboard, and monitor (see photo 1).

An accessory for the monitor is an ergonomic arm mount that gives you full control over vertical position, tilt, and rotation. A freestanding pedestal lets you vertically mount the main unit alongside or beneath your desk.

The Ericsson's display characters are beautifully formed and easy to read on the amber screen. The font is distinct yet not so unusual that it looks strange (see photo 2). For example, there is no chance for confusion between Q and O and 0.

Characters are formed from a 9- by 16-pixel matrix. The standard Ericsson display card supports 640 by 400 high-resolution monochrome graphics. Characters in the graphics mode are formed from a coarser 8- by 8-pixel matrix. The display is free of any smearing, ghosting, or flickering. Annoying reflections are prevented by a nonglare treatment of the tube's surface.

The keyboard is 20 percent more compact than IBM's and less than half its weight (see photo 3). It's basically an IBM look-alike, complete with the awkward left Shift key and other idiosyncrasies. The Caps and Num Lock keys have indicator lights, and the numeric keypad has an Enter key.

The feel of the keyboard is mushy, lacking a crisp or definite break when you push a key. My main complaint is the absence of any dishing or other difference in the F and J keys so that your index fingers can find where you are on the keyboard. This feature is a must for using a keyboard efficiently. It is most conspicuously absent in a computer like the Ericsson, which has paid such close attention to ergonomics.

INTERNALS

Access to the inside of the Ericsson is easily accomplished by removing two screws in the rear of the unit. The metal cover of the main unit slides off, exposing all of the internal electronics and giving you access to the six expansion slots. Inserting or removing expansion boards is a snap. The 8088 microprocessor runs at 4.77 MHz, the same clock rate as the IBM PC's, and the Ericsson has a socket for installing an 8087 coprocessor. The Ericsson comes with 256K bytes of RAM (random-access read/write memory) installed, 128K bytes on the motherboard, and an additional 128K bytes on a short expansion board in a special short slot. Like the IBM, this microcomputer does parity checking of its RAM on start-up. But the Ericsson's start-up diagnostics take about only 8 seconds with 256K bytes of memory installed.

Other expansion-board configurations can be added to bring the computer up to its full capacity of 640K bytes of RAM. The BIOS (basic input/output system) is contained in 32K bytes of ROM (read-only memory).

The Ericsson's generous 175-watt power supply (the IBM PC has 63 watts) is certainly capable of supplying the optional internal hard-disk drive and any other possible expansion configurations.

HARD STORAGE

The standard system comes with two Teac 5¼-inch double-sided double-density half-height drives. They are configured in the 40-track, nine-sector MS-DOS format for a total capacity of 360K bytes per drive.

INTERFACES

As with most clones of the IBM PC, the Ericsson has two ports built directly into the motherboard, thus saving an additional slot

John D. Unger (POB 95, Hamilton, VA 22068), a geophysicist working for the U.S. Government in Washington, DC, studies earthquakes and active faults in the eastern United States. He holds B.S. and M.S. degrees from MIT and a Ph.D. from Dartmouth College.

for other hardware. The RS-232C serial port can be used either for a printer or another serial device such as a modem. The other port is a Centronics-compatible parallel interface with the IBM-type DB-25S 25-pin socket. Of course, the expansion slots can be used to augment the number and types of interfaces simply by adding appropriate IBM-compatible boards.

HARDWARE OPTIONS

So many devices exist for PC-compatible machines that it is safe to say you'll be able to find whatever you need for your Ericsson. The manufacturer is offering very few hardware options.

Two items Ericsson mentions specifically are a half-height internal 10-megabyte hard-disk drive and a high-resolution 12-inch color monitor.

SOFTWARE

The Ericsson comes bundled with MS-DOS 2.11, GW-BASIC, and a useful set of system diagnostic programs. The system disk includes the usual supply of utility programs plus some other routines prepared specifically for the Ericsson.

One of these programs seemed just a bit too user-friendly. In addition to the normal MS-DOS disk-format routine, Ericsson includes, and the manual describes, a separate routine to format a disk and copy the system files on it. Normally, you format and copy system files by using the /s option. In fact, the Ericsson "special" routine is nothing more than a .BAT file that invokes the format program with this option.

The system diagnostic routines are menu-driven and easy to run. They can be used to test the system board, total RAM installed on the system (including that on expansion boards), disk drives, keyboard, monitor, and printer. These routines should be a great help in diagnosing any problems you may have with the computer.

The programs that I've run (including WordStar and Multiplan) indicate a high degree of software compatibility. However, don't forget that there is no clone that is truly 100 percent compatible with the IBM. So, if you have any doubt, try that crucial piece of software on an Ericsson before you buy one.

BENCHMARKS

The "At a Glance" graphs show the results of the standard BYTE benchmarks. There are no big surprises. Differences in the BASIC benchmarks are due to the differences between BASICA used with the IBM and GW-BASIC used with the Ericsson. The Ericsson's CPU runs at the same 4.77 MHz clock speed as the IBM PC's. This means that the benchmarks for the system utilities reflect differences between the MS-

(continued)

Photo 1: *Overall view of the Ericsson PC showing the system unit, the keyboard, and the monitor.*

AT A GLANCE

Name
Ericsson Personal Computer

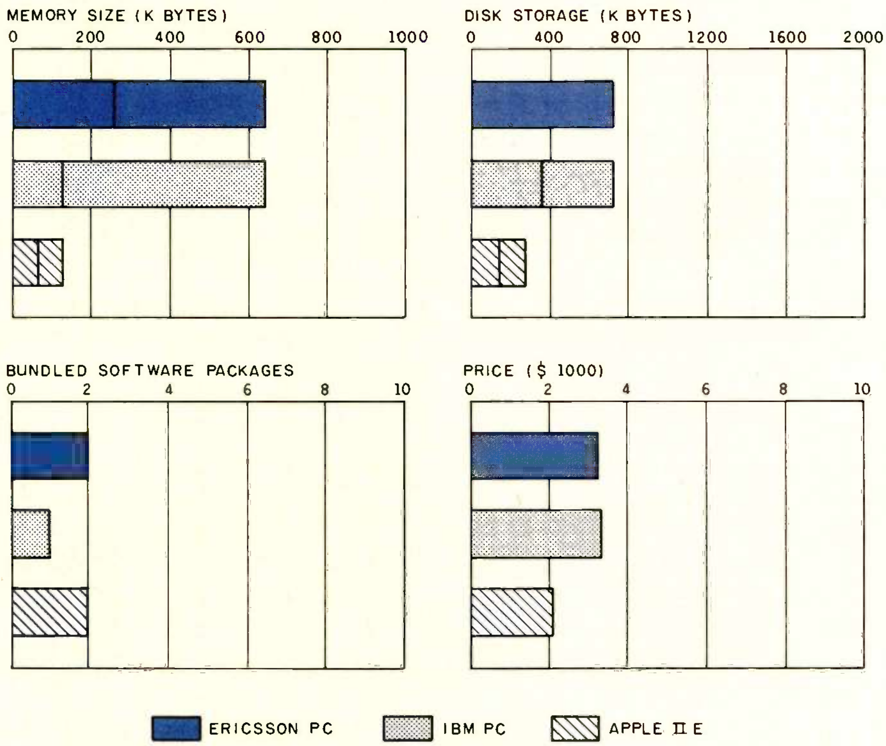
Manufacturer
Ericsson Information Systems
Greenwich Office Park 1
Greenwich, CT 06836
(203) 661-1666
(800) 367-3746

Components
Processor: 8088, 4.77 MHz; socket for 8087 coprocessor
Memory: 256K dynamic RAM
Mass storage: Two 360K 5¼-inch drives; optional 10-megabyte hard disk
Display: Monochrome (standard), 80 by 25
Keyboard: Detached QWERTY with 84 keys, including 10 function keys (foreign-language keyboard layouts available)
Expansion capability: Six full-length slots (IBM PC bus)
I/O interfaces: One RS-232C serial port, one DB-25S Centronics-compatible parallel port

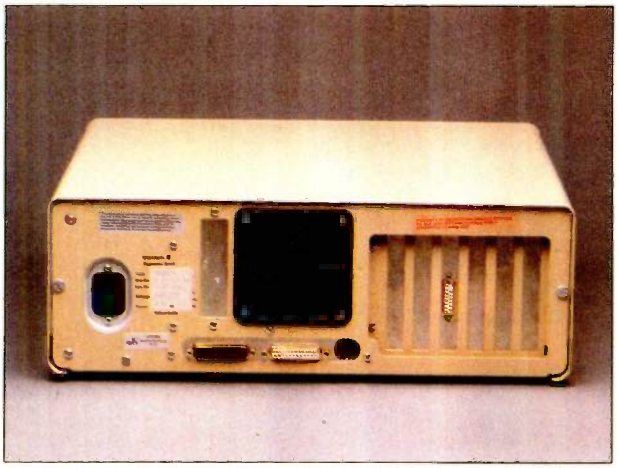
Software
MS-DOS 2.11, GW-BASIC

Documentation
User's guide and manual, DOS guide and manual, GW-BASIC guide

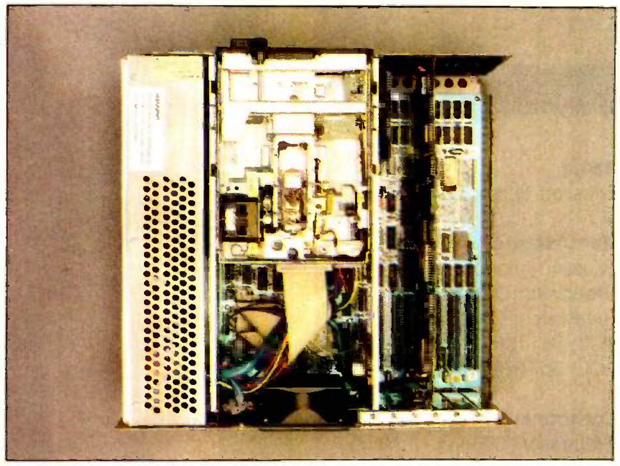
Price
Model with dual floppy-disk drive $3295
Model with single floppy-disk and 10-megabyte hard disk $5230
(Both models include 256K RAM, high-resolution monochrome graphics board, high-resolution monitor, and ergonomic arm for the monitor.)



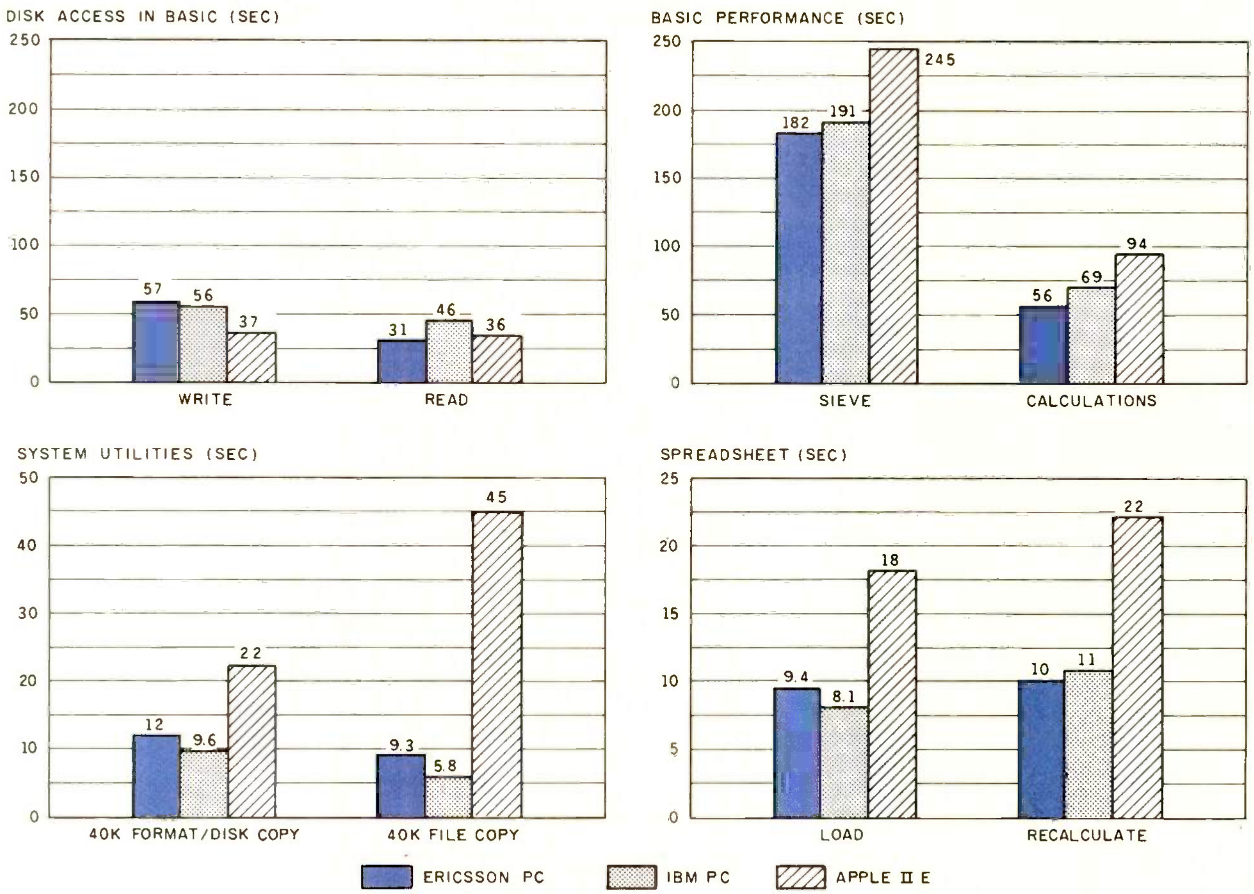
The Memory Size graph shows the standard and optional memory available for the computers under comparison. The Disk Storage graph shows the highest capacity for a single floppy-disk drive and the maximum standard capacity for each system. The Bundled Software Packages graph shows the number of software packages with each system. The Price graph shows the list price of a system with two disk drives, a monochrome monitor, a printer port and a serial port, 256K bytes of memory (64K bytes for 8-bit systems), and the standard operating system and BASIC interpreter for the computers compared.



Rear view of the main unit showing the serial and parallel ports and output connectors from expansion ports.



Top view of the main unit with the cover removed to show expansion slots and internal hardware.



The graph for Disk Access in BASIC shows how long it takes to write and to read a 64K-byte sequential text file to a blank formatted floppy disk. (For the program listings, see June 1984 BYTE, page 327, and October 1984, page 33.) The Sieve column in the BASIC Performance graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations column shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. The System Utilities graph shows how long it takes to format and copy a standard text file to disk (adjusted time for 40K bytes of disk data) and to copy a 40K-byte file using the system utilities. The Spreadsheet graph shows how long it takes to load and recalculate a 25- by 25-cell spreadsheet where each cell equals 1.001 times the cell to its left. Microsoft Multiplan 1.10 was the spreadsheet used. The tests for the Ericsson used MS-DOS 2.11 and GW-BASIC 2.01. Tests for the Apple IIe used ProDOS (except for the spreadsheet test, which was done with DOS 3.3). The IBM Personal Computer was tested with PC-DOS 2.0.

DOS and PC-DOS programs that are used to copy files and format disks.

DOCUMENTATION

Overall, the information on how to use the Ericsson effectively and efficiently is well organized and easy to follow. There are only two documents included with the computer. Each is divided into two parts: a concise guide and a comprehensive manual.

I received two sets of these documents. One pair was for using the system and its hardware, and the other described the use of the operating system. I also got a copy of a brief guide for GW-BASIC, which was so terse it was almost useless. Only very experienced GW-BASIC users will benefit. Perhaps the companion manual was not yet available.

The user's guide and manual are both well written and easy to understand. They begin by assuming no computer knowledge on the part of the user and explain the operation of the system in a clear and logical way. The DOS guide and manual follow the same approach as the user documents. These are not mere rewrites of the MS-DOS documentation but are tailored specifically for the Ericsson.

Besides the lack of a GW-BASIC manual to accompany the guide, the only documentation missing is a technical manual that discusses the nitty-gritty of the operating system and the differences between the Ericsson's DOS, system hardware, and software and the IBM's.

Photo 2: *The Ericsson's display in high-resolution text mode showing the character set.*

Photo 3: *Ericsson's keyboard is similar to* IBM's.

COMPATIBILITY

I found no reason to doubt Ericsson's claim that this microcomputer is as PC-compatible as any other PC clone. All of the programs I have written using the IBM PC's video memory, both monochrome and graphics, run just fine on the Ericsson. Although I don't have a comprehensive collection of commercial software for the IBM PC, the software I do have also runs without a glitch on this machine. Nothing in the design of the system appears to compromise complete compatibility with the IBM expansion bus and boards.

SUPPORT

Ericsson Information Systems (the American connection) is marketing the Ericsson PC through independent dealers. The individual dealer's commitment to support and service is an important consideration when purchasing an Ericsson. Don't expect to get much technical advice by using the company's 800 phone number, though. All they seem to be able to give out is the name and phone number of the nearest dealer.

CONCLUSION

If you want to buy an IBM PC or a highly compatible clone, the Ericsson Personal Computer is worth looking at. The features that set it apart are its attention to ergonomic design and its high degree of compatibility with the IBM PC.

I found nothing compelling in the performance of this microcomputer to make me choose it over another clone on this basis alone. In a nutshell, the Ericsson is a solid, dependable computer, but it lacks hardware innovations to make it stand out. ■

The Stearns Desktop Computer

Options and support may not outweigh inflexibility

BY WAYNE RASH JR.

With a true 16-bit 8086 microprocessor running at 8 MHz, the Stearns Desktop Computer is much faster than the IBM Personal Computer. (See the benchmark results in the "At a Glance" section.) However, the Stearns appears to have problems related to IBM PC compatibility and quality control.

The Stearns (see photo 1) has about the same footprint as the IBM PC, but it is lower, owing primarily to the use of half-height disk drives. The keyboard can be stored under the system unit. The monochrome monitor appears virtually identical to the IBM monochrome monitor, but the Stearns can support a full-page 15-inch monitor, preferred by some word-processing users.

HARDWARE

To get inside the computer, you simply remove three screws and slide off the case. Like the IBM PC and most of the clones, the Stearns is a traditional single-board computer. Six slots on the motherboard handle items like the video display, extra memory, communications, hard-disk controller, and so forth. However, only one of the expansion slots is compatible with boards designed for IBM PC work-alikes. The others use connectors unique to Stearns.

Standard equipment on the Stearns includes a monochrome display/printer board and an asynchronous communications port. The display/printer board is on the expansion chassis; the serial port is mounted on the computer's motherboard and appears on the bottom center of the system unit's rear. The serial port uses an 8251 serial chip, preventing you from using third-party communications programs unless you buy an optional serial board based on the 8250 chip. Stearns does offer a communications package for the 8251.

The printer port, also serial, uses a DB-9 connector instead of the more common DB-25. You must buy a special cable for your printer from Stearns or make your own. If you want to use a parallel printer, you must buy the optional parallel-printer card from Stearns and then run the parallel-printer driver. This is not a great handicap since most letter-quality printers are available in either version, but it is important if you already own a parallel printer.

The monochrome-display card for the 12-inch monitor is standard equipment for the Stearns, but you can get other cards as options. The full-page display requires its own card, which cannot coexist with the version for the 12-inch monitor. You can also buy a graphics card from Stearns, as well as a display card for a color monitor. The display produced by the monochrome card closely resembles that of the IBM PC monochrome monitor and adapter. As far as I can tell, you cannot use a third-party display adapter with the Stearns.

The motherboard has a provision for the Intel 8087 math coprocessor, but you must use the high-speed version of this chip since the 8087-3 usually used with the IBM PC will not run at 8 MHz. Here the documentation included with the machine is poor; it does not explain that you need the high-speed version of the chip, and there is no discussion concerning the proper settings of the DIP (dual in-line package) switch settings.

THE KEYBOARD

The touch of the keyboard (see photo 2) is light, like that of the AT&T PC 6300. The software for the Stearns makes considerable use of the 10 function keys, arranged across the top of the keyboard. For example, part of the boot sequence sets up the function keys to perform MS-DOS commands. On the screen are blocks in reverse video that show the functions currently assigned (see photo 3). Each of the keys can have as many as four functions at any time; there is a special key for rotating among the functions. You can reassign the functions with a special program.

The keyboard caused me consistent problems, and I found it significantly less usable

Wayne Rash Jr. is a member of the professional staff of American Management Systems Inc. (1777 North Kent St., Arlington, VA 22209), where he consults with the federal government on microcomputers.

than most others, including IBM's. Some of my difficulties owed to the unusual key placement. The Control key is underneath the Shift key to the left of the space bar rather than next to the A key. The Caps Lock key is next to the A. The backslash and vertical-bar keys, heavily used in MS-DOS 2.1, are "third functions." To use them, you must press the Shift and Control keys simultaneously and then press the indicated key. Some keys have been added to the Stearns keyboard, including a Print key and an extra Control key on the right side of the space bar. The S1–S4 keys are used to switch between virtual consoles when using Concurrent CP/M. The Caps Lock and the Num Lock keys have light-emitting diodes that glow when activated.

Operational problems compounded my frustration. During the time I had the Stearns computer, the keyboard generated duplicate letters on a random basis. The Stearns technical staff replaced the keyboard twice, but the problem recurred. At one point, they suggested that I might be the problem and recommended that I change my style of typing. Finally, after the unit had been shipped back to Stearns, the technical staff informed me that they had discovered a loose screw on the motherboard that periodically caused the problem.

The differences in the layout of the keys and some changes in function caused problems with programs designed for the IBM PC and compatibles. For example, a Stop Screen key seems to be designed to perform the same function as the Scroll Lock key that it replaces, but Ashton-Tate's Framework, for example, did not recognize its existence.

USING THE STEARNS

Local dealers will help most Stearns users get started. Dealer personnel set up the system, install the software, and do the initial training. As a result, the user manual includes only the barest installation instructions.

When you turn on the power switch, located toward the rear on the right side, the computer does a self-test routine and then waits for you to choose the boot device. You must choose either the hard disk or the floppy disk each time you start using the system, an inconvenient feature. Most systems default to the hard disk unless the floppy disk is chosen specifically.

After you indicate the boot device, the operating system loads. As a general rule, you don't have to enter the time and date as the system starts since the Stearns has a clock and calendar that keep track of the date and make it available to MS-DOS during the boot sequence. The device failed, however, when I was evaluating the machine.

I installed the Stearns in my office to try the word-processing and spreadsheet operations. The dedicated function keys

(continued)

Photo 1: *The Stearns Desktop Computer with optional hard-disk drive.*

were a convenience at times, but I found that, even after using the machine for a month, I was much more productive using an IBM PC XT, despite its slower speed. The unusual locations of the keys, especially the Control keys, made using WordStar a chore. The special function keys did add to the ease of operation, but WordStar has so many commands that you still need the Control keys for most operations.

Stearns has modified WordStar, Word Perfect, and Multiplan to work with the optional full-page monitor. Users of Multiplan should find the ability to see an entire page of text at one time a real convenience. For word processing, it is a matter of personal taste.

SOFTWARE AND COMPATIBILITY

The Stearns is not bundled with an operating system, though you can purchase ST-DOS ($40), MS-DOS 2.11 ($65), and Concurrent CP/M ($350). The review unit came with IBM's PC-DOS on the hard disk. As with other IBM PC-compatibles, you can't use IBM's BASIC since you don't have access to the IBM read-only memory. Instead, you can use Microsoft's GW-BASIC. On the Stearns it ran programs designed for the IBM PC without any trouble; however, I could not test the Stearns's ability to emulate IBM graphics in BASIC since the review machine did not have graphics capability.

The company advertises the Stearns as an IBM PC-compatible computer, but the claim is not fully true. Hardware compatibility is virtually nil. There is a single IBM-type expansion slot on the motherboard of the Stearns, but, according to the company, this slot is not supported for boards not supplied by Stearns. In other words, you will not be able to use a third-party modem or memory board with the Stearns. The rest of the expansion slots use a proprietary bus for which I could find no third-party products.

Software compatibility is a mixed bag. There are versions of WordStar, dBASE II, Multiplan, and Word Perfect that take advantage of the computer's capabilities, and many programs written for the IBM PC will also work. Lotus 1-2-3 seems to run, but I could not test the graphics. According to Stearns, Framework will run only with difficulty, but I could not get it to run at all. Lotus Symphony runs, but you first have to load a patch. WordStar 2000 will not run at all and, according to the local dealer, neither will Microsoft's Flight Simulator. The Stearns is an office machine, and business users will not likely spend much time with programs like Flight Simulator, but it is considered a classic test of compatibility.

Stearns told me on several occasions that it does not support software it does not supply. In a sense, then, you're on your own when it comes to third-party software, though I found that the software-consultation people at Stearns tried their best to be helpful in this area.

Photo 2: *The Stearns keyboard. Note the placement of the Control, Alternate, and function keys.*

Photo 3: A *sample screen. Reverse video is used to show currently assigned functions.*

DOCUMENTATION AND SUPPORT

Stearns provides a 56-page manual called *Introducing the Stearns*. The book

(continued)

AT A GLANCE

Name
Stearns Desktop Computer

Manufacturer
Stearns Computer Systems
10901 Bren Rd. East
POB 9384
Minneapolis, MN 55440
(612) 829-0361

Size
22 by 15¾ by 5½ inches;
40.5 pounds (system unit and keyboard)

Components
Processor: 8-MHz 8086
Memory: 128K RAM, expandable to 640K
Mass storage: Two 360K half-height floppy-disk drives
Display: 80 by 25 display, graphics optional; 80 by 56 display, optional
Keyboard: QWERTY layout
Communications: Two RS-232C serial ports

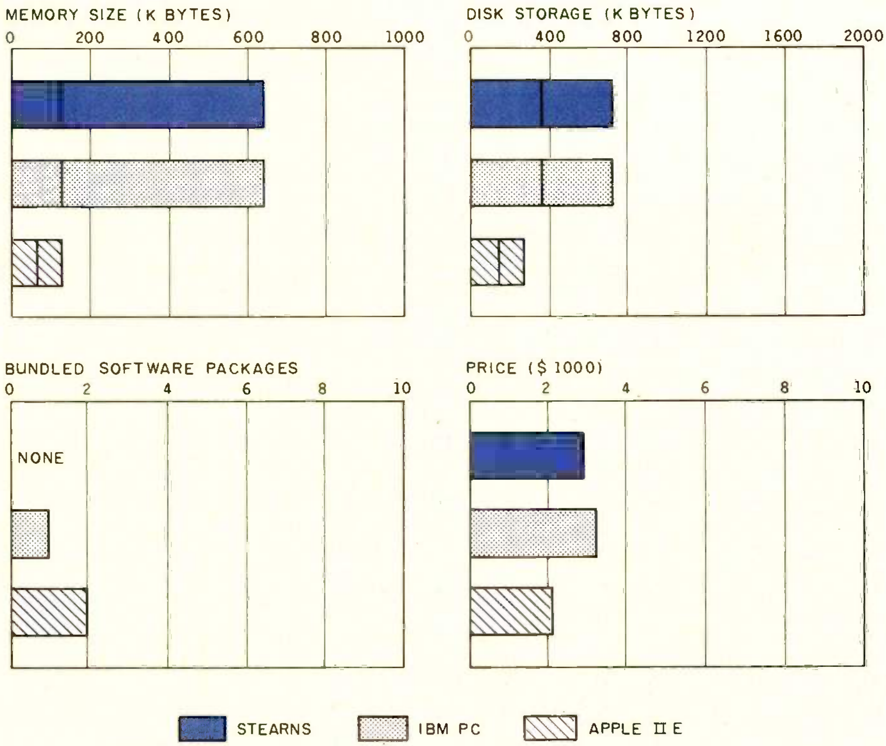
Software
ST-DOS, $40; MS-DOS 2.11, $65; Concurrent CP/M, $350; GW-BASIC, $250

Options

10-megabyte hard disk	$2000
20-megabyte hard disk	$2600
8087-2 coprocessor	$550
Color board & monitor	$500
Parallel printer card	$98
128K memory expansion	$249
256K memory expansion	$499
512K memory expansion	$749

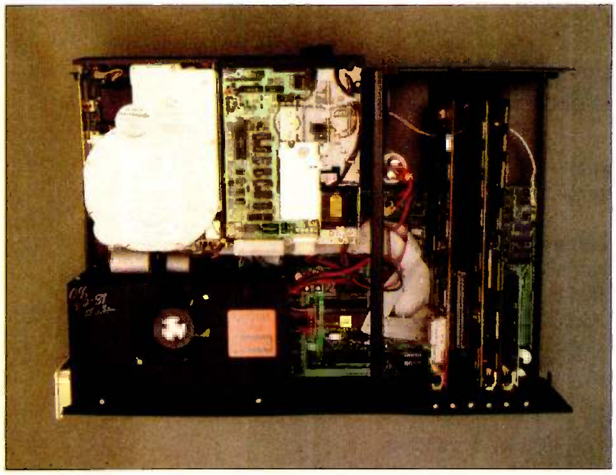
Documentation
56-page manual

Price
$2995 (usually includes delivery, setup, and training; price of the unit reviewed, $4995)

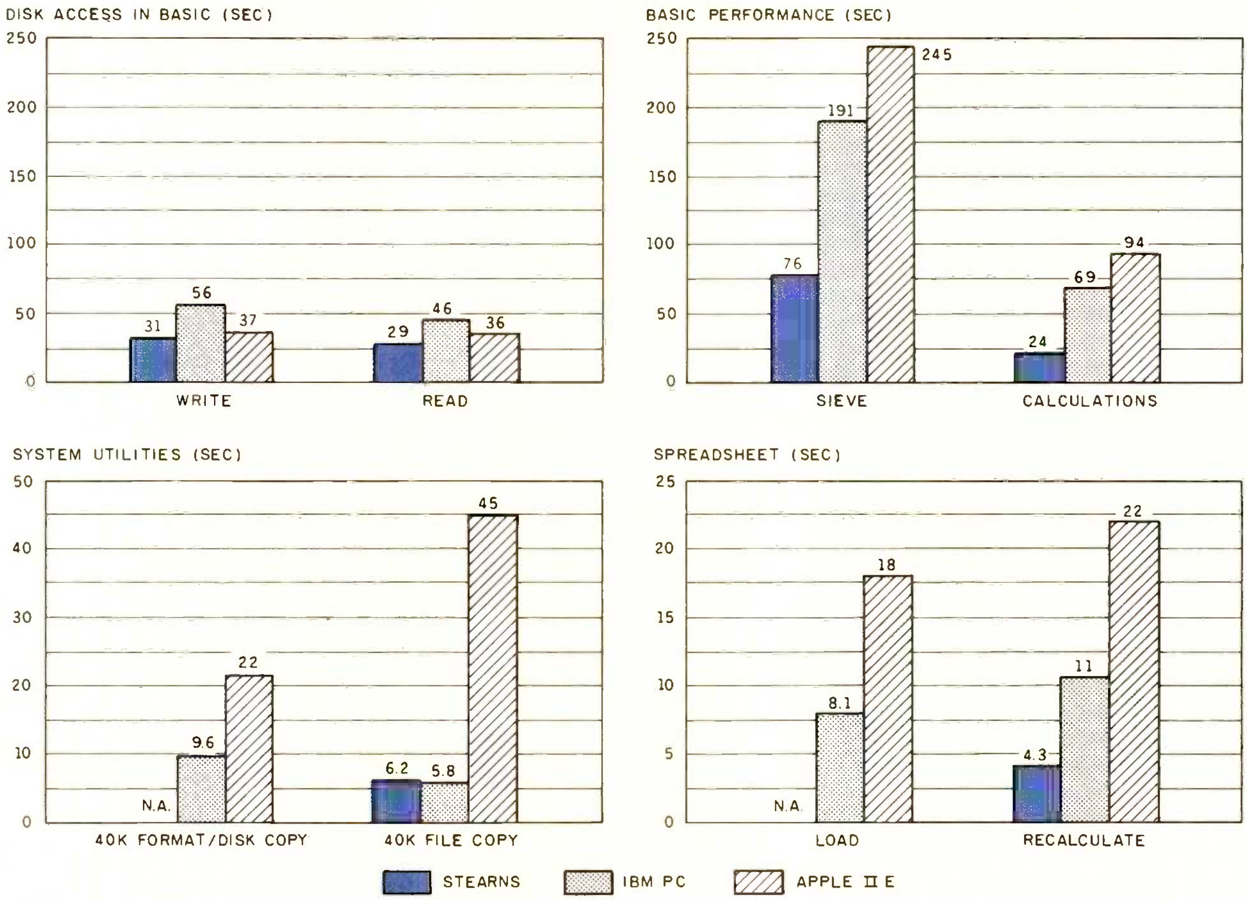


The Memory Size Graph shows the standard and optional memory available for the computers under comparison. The Disk Storage graph shows the highest capacity for a single floppy-disk drive and the maximum capacity for each system. The Bundled Software Packages graph shows the number of software packages included with each system. The Price graph shows the list price of a system that comes with two high-capacity 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), and the standard operating system and BASIC interpreter for the computers under comparison.

The rear panel of the Stearns has an asynchronous serial port and, to the right, a serial printer port.



Inside the Stearns. The slots, fan, floppy-disk drive, and hard-disk drive are evident.



The graph for Disk Access in BASIC shows how long it takes to write and to read a 64K-byte sequential text file to a blank floppy disk. (For the program listings, see "The Chameleon Plus" by Rich Krajewski, June 1984 BYTE, page 327, and October 1984, page 33.) The Sieve column in the BASIC Performance graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations column shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. The System Utilities graph shows how long it takes to format and to copy a standard text file to disk (adjusted time for 40K bytes of disk data) and to copy a 40K-byte file using the system utilities. The Stearns came with a hard-disk drive. As a result, the file transfer was from the hard disk to the floppy disk; the disk-copy test could not be done. The Spreadsheet graph shows how long it takes to load and recalculate a Multiplan 25- by 25-cell spreadsheet where each cell equals 1.001 times the cell to its left. Tests for the Stearns used PC-DOS 2.1 and GW-BASIC. Tests for the Apple were done with ProDOS. The IBM was tested with PC-DOS 2.0.

contains basic information needed to load the operating system. However, the manual does not explain how to run a program, how to back up a disk, how to add devices, or how to increase memory. I assume that Stearns intends that dealers teach customers how to do these things. Of course, a good deal of information on these topics is available from the operating-system manual, although no specific operating system comes with the machine. The Desktop Computer comes with virtually no hardware documentation.

Stearns envisions a major role for the dealers. Users are expected to buy their computer, software, and any hardware add-ons from an authorized dealer. The dealer delivers the computer, installs and tests it, and trains users. On-site warranty service is standard. I was fortunate in having an excellent dealer who spent quite a bit of time in my office.

Support from the factory is also quite good. I spent a great deal of time talking to the people in software consultation and never failed to get a polite, well-considered answer. The company maintains a toll-free line to answer customer questions.

This high-quality help is very important. I had a number of problems with the Stearns Desktop Computer. I have already discussed the keyboard problem. There were other troubles. The clock/calendar board stopped working, and with it, a system that was supposed to tell the computer about device assignments. This latter problem occasionally caused error messages when the system was turned on, but it did not interfere with operation. I finally stopped using the machine when it began erasing autoexec files on a random basis and sometimes scrambled files during the copying process.

The computer is really meant to be serviced by the dealer. I had to change the video boards in order to try out both types of monitors; even this required help from the factory, since the user documentation omits references to the DIP-switch settings. The technical reference manual that contains the information is not bundled with the machine.

CONCLUSIONS

The Stearns Desktop Computer is fast, but it is less flexible than other machines on the market. It is particularly unfortunate that the computer does not support third-party expansion boards. The Stearns does offer a few unique features, like the full-page screen, but most of them are of limited usefulness. The Desktop Computer locks you into a single source of supply. Still, people interested in an advanced word-processing environment and close dealer support may find this is the machine they need. ■

S·Y·S·T·E·M R·E·V·I·E·W

The Portable STM *Personal Computer*

An IBM PC-compatible portable with innovative features

BY R. JEYARAMAN

The portable STM Personal Computer has many features that are generally not found on microcomputers. These special features include an 80-character by 25-line liquid-crystal display (LCD) with electroluminescent backlighting and a built-in, 300/1200-bps, auto-dial, auto-answer modem and speaker phone (see photo 1). Two half-height disk drives, either 96-track-per-inch (720K-byte) quad-density drives or IBM-compatible 48-tpi (360K-byte) double-density drives, are also included with the main unit.

The STM also includes two serial ports, one parallel port, one small computer system interface (SCSI) hard-disk connector, and an IBM-compatible expansion input/output (I/O) connector. The machine offers both composite and red-green-blue (RGB) color output with a monochrome resolution of 720 by 350 pixels and 640- by 200-pixel color resolution. Also included is a built-in thermal printer.

On the back of the STM portable PC from left to right is a connector for I/O expansion, an SCSI, a parallel printer port, RS-232C port B, a connector for an RGB color monitor, RS-232C port A, a composite-video connector, a telephone connector for the modem, a reset button, and an on/off switch.

The STM's keyboard is detachable. When you move the computer, you can place it securely inside the screen cover. All of these features are enclosed in a compact rectangular box 20 by 11 by 4 inches that weighs only 17 pounds. The machine's weight is slightly uneven because the right side, where the floppy-disk drives are housed, is heavy.

The STM PC is not battery-powered, so you have to look for an electrical outlet. Unlike many transportables, this machine has only a 110-volt AC (alternating current) connector. For people who want to use the computer in other countries, an international model runs directly on 220 volts AC. The computer doesn't have a carrying handle, but an accessory carrying bag is available.

COMPATIBILITY

The STM PC is almost IBM PC-compatible. For example, it runs Lotus 1-2-3, Flight Simulator, WordStar, dBASE II, and many other popular IBM PC programs without difficulty. (In order to prevent hanging up Flight Simulator in LCD mode, you need to enter a preliminary instruction called FS105.) Some programs that directly access the graphics display might not run in the LCD mode.

STM has a list in its newsletter of about 100 popular software packages that run on the STM PC. I tested a few that were not listed and all of them ran without difficulty. I have not found any software for the IBM PC that does not run on this portable, but some of them needed PC-DOS 2.10.

THE 80186

In terms of PC compatibility, the biggest difference is that the STM PC uses the Intel 80186. The internal processing speed is 8 MHz, about twice as fast as the 8088 used in the IBM PC. The 80186 also includes or substitutes the operation of many support chips needed for the 8088, thus decreasing the size of the motherboard. The benchmark results reflect this increase in performance, but the disk access time is about the same as that of the IBM PC (see table 1).

The register set of the 80186 is identical to that of the 8086 with one minor exception. The 80186 is object code–compatible with the 8086 and adds 10 instruction types to the 8086 instruction set.

OPERATING SYSTEM

My STM came with MS-DOS 2.11 as its operating system (MS-DOS 3.1 is now available). BASIC is not included on the system disk; GW-BASIC is sold as an option.

The STM's memory is limited to 512K bytes. The memory is expandable on the motherboard by replacing two sets of 64K-

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byte chips with 256K-byte chips. For almost all purposes, 512K bytes of memory should be enough.

The STM is memory-thirsty. On boot-up it leaves about 193K to 197K bytes free for use on a 256K-byte system and about 455K bytes on a 512K-byte system. Also, the operating system formats disks only in 360K-byte mode. It does not recognize command options such as /8 for eight-sector disk formats. I solved this problem by using PC-DOS 2.10 to format disks in eight sectors. Also, STM MS-DOS cannot access drives other than A or B. Asking for a directory of a RAM (random-access read/write memory) drive C or D gives the message "Illegal drive specification" even after you install a RAM drive C (except with programs such as Instadisk). With the STM PC you are limited to only two drives and nine sector disks.

DISPLAY

The STM has three modes of display: the LCD with an 80-character by 25-line display and connections for a high-resolution monochrome monitor or RGB monitor.

The LCD on the STM portable is easier on the eyes than other LCD portables I have seen (see photo 2). Two thumb-wheel controls above the LCD adjust the contrast and turn on the electroluminescent backlighting.

On start-up, you can choose the appropriate display mode for LCD, monochrome, and RGB output. You can press the F2 key to alter the character size (8- by 8-, 8- by 9-, or 9- by 9-dot matrix).

Using the LCD under typical indoor lighting with the blue-green backlighting on didn't produce any noticeable glare on the screen. I could read the display and work on it easily. However, using the computer in diffused daylight produced reflections on the screen with the normal LCD mode; it was sometimes difficult to read the display. Using the backlighting made the screen more readable.

Connecting the computer to a monochrome monitor and color monitor resulted in a pleasing normal display. It is convenient to work the computer with an external monitor.

Running graphics programs on the STM points out another difference between working with an external monitor and with the LCD. The STM's LCD is vertically condensed. It has a different aspect ratio compared to a cathode-ray tube (CRT) display. Therefore, each figure is elongated lengthwise. A circle looks like an ellipse; a cube appears to be a rectangle.

The STM does produce some radio frequency interference (RFI). The manual states that the equipment complies with the limits for a Class A computing device (subpart J of part 15 of the FCC rules), but the manufacturer's label at the bottom of the portable unit I have says that it complies with the limits for a Class B device. To test this classification, I used the STM PC and two other computers separately in a room where I had a television functioning. I observed significant disturbance in television reception when I used my STM portable, while the other machines caused no

(continued)

Photo 1: *The STM Personal Computer with two 5¼-inch floppy-disk drives and an 80-character by 25-line LCD with electroluminescent backlighting.*

Table 1: *Benchmark results in seconds for the STM Personal Computer.*

Operation	Time
Disk Access in BASIC (write)	31.1
Disk Access in BASIC (read)	29.7
BASIC Sieve	80.2
BASIC Calculation	23.5
Format/Disk Copy	7.9
File Copy	5.7
Spreadsheet (load)	5.1
Spreadsheet (recalculate)	3.9

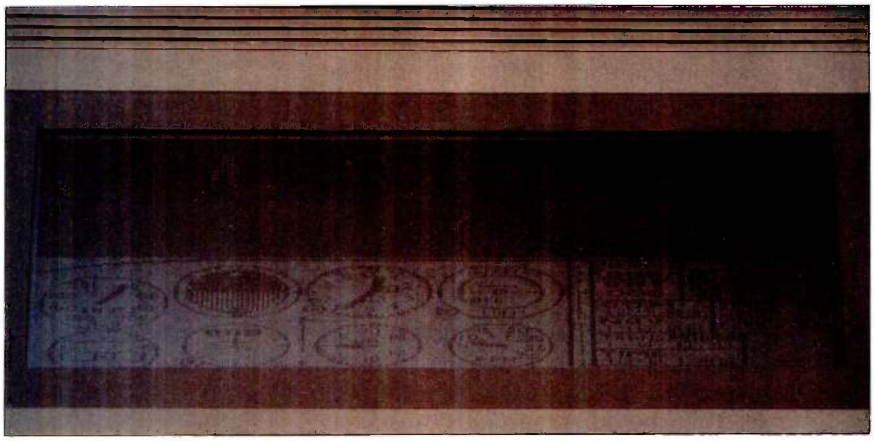


Photo 2: *Sample screen display of the STM Personal Computer showing Microsoft's Flight Simulator.*

Photo 3: *Keyboard for the STM Personal Computer. Note the enlarged return key and the special function keys on top of the alphanumeric keys.*

difference with the distance, direction, power outlet, and time of day kept the same. Thus, it appears that my computer complies with the Class B specification.

KEYBOARD

The keyboard is fully IBM PC-compatible in function, but the key arrangement is somewhat different (see photo 3). In enlarging the return key, the designers moved the PrtSc key and rearranged other keys around the numeric keypad. These changes might slow down a touch-typist who is used to the keyboard of the IBM PC. The special function keys are also moved from their position on the left side of the keyboard and arrayed across the top.

The keyboard doesn't have status lights on Caps Lock and Num Lock keys. The eight-line telephone-style jack connection from the keyboard to the computer's central processing unit (CPU) is sturdy, but not very flexible. Inserting the coil in its place for packing is also difficult until you find a technique of your own.

Otherwise, the keyboard is nice to use. It is light and convenient for a laptop.

MODEM

The internal modem is connected through the RJ11 modular phone jack at the back. The software that controls the modem is supplied on the DOS disk and lets the user create a directory of phone numbers, names, and communications modes. It failed to work reliably at 1200 bps, but it worked fine at 300 bps. An optional Hayes-compatible 1200-bps internal modem is available.

The speaker phone's status is indicated by mute and off-hook light-emitting diodes (LEDs) on the front panel. Normally it is in mute. When you use the phone, you must push the F3 key to talk. The fan's noise and the hum from the LCD caused some problems. When I used the speaker phone to call a friend, the noise was so bad that he thought I was calling long-distance from overseas. My advice is

(continued)

AT A GLANCE

Name
STM Personal Computer

Manufacturer
STM Electronics Corp.
Suite 250, 535 Middlefield Rd.
Menlo Park, CA 94025
(415) 326-6226

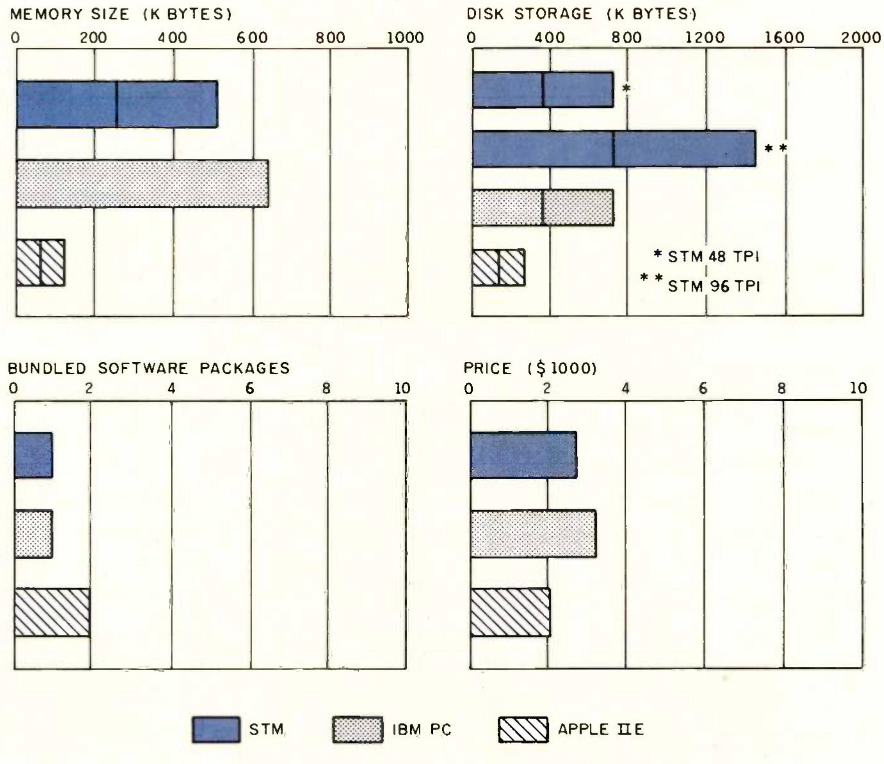
Size
20.3 by 10.8 by 4 inches
18 pounds

Components
Processor: 8-MHz 16-bit Intel 80186 (8086/8088-compatible)
Memory: 256K bytes of dynamic RAM expandable to 512K bytes
Mass storage: Two 360K-byte double-sided double-density 5¼-inch floppy-disk drives or two 720K-byte double-sided quad-density 5¼-inch floppy-disk drives
Display: 80-column by 25-line LCD with electroluminescent backlighting
Keyboard: Detachable 83-key layout with numeric keypad
I/O interfaces: One parallel printer port (Centronics-compatible), two RS-232C ports, SCSI for hard disk, IBM PC I/O bus-expansion connector

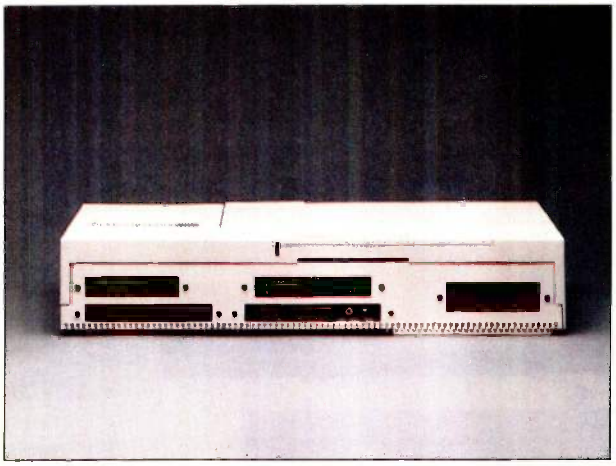
Software
STM MS-DOS 3.1 (includes software support for the modem/speaker phone, thermal printer, and external monochrome and color displays); GW-BASIC is optional for $65

Documentation
317-page MS-DOS system manual with index

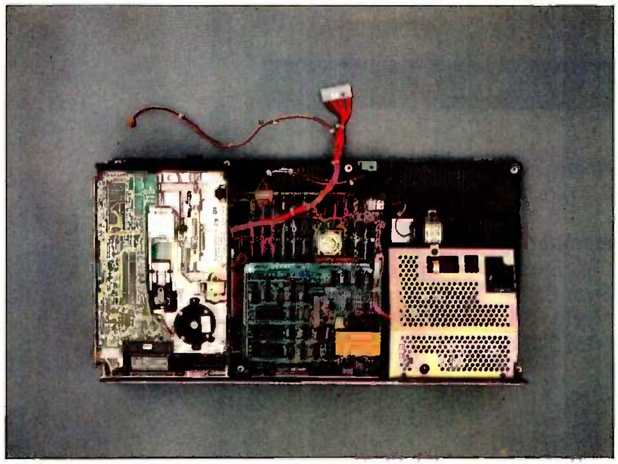
Price
STM-1009 with two 48-tpi drives and 256K bytes of memory $2759
STM-1001 with two 96-tpi drives and 256K bytes of memory $2759
STM-1013 with two 48-tpi drives and 512K bytes of memory $3259
STM-1005 with two 96-tpi drives and 512K bytes of memory $3259



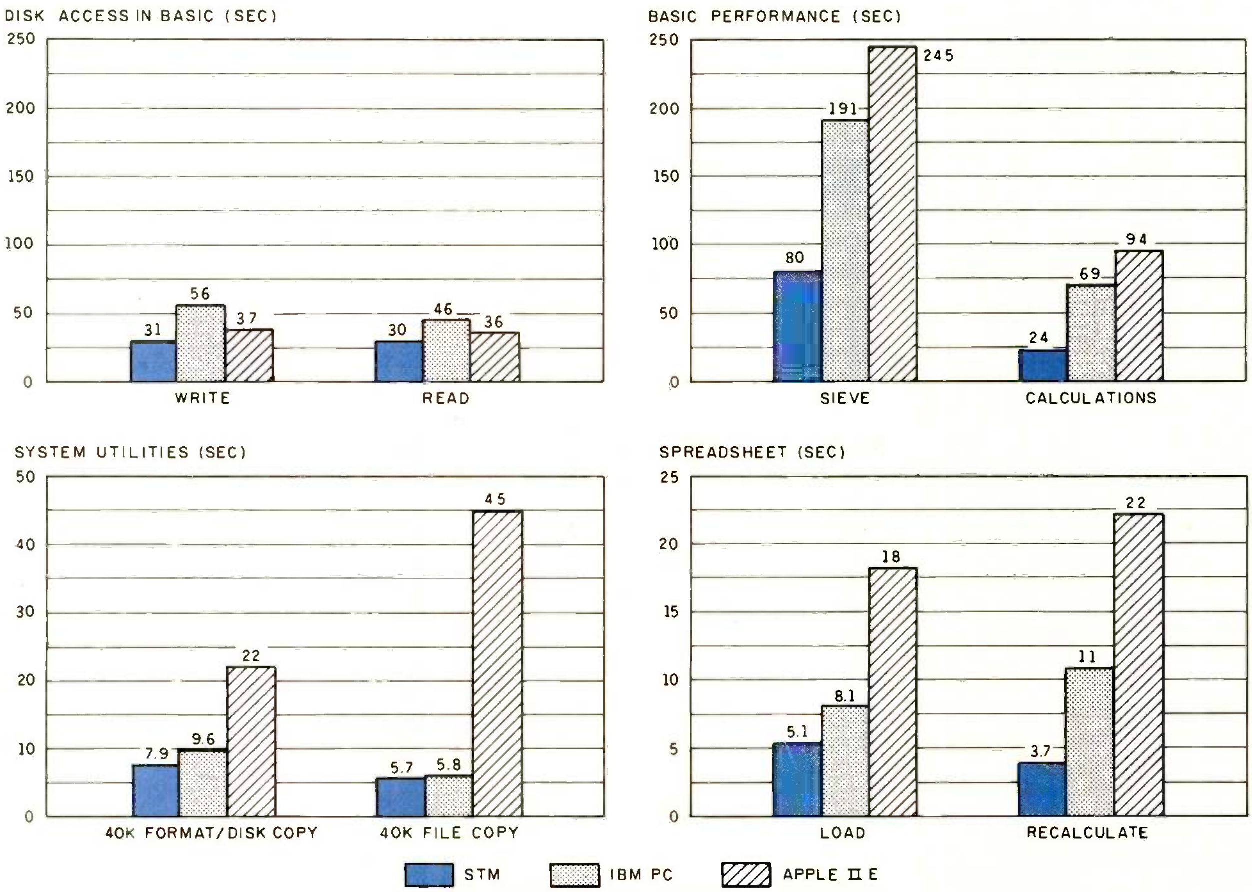
The Memory Size graph shows the standard and optional memory for the computers under comparison. The Disk Storage graph shows the highest capacity of one and two floppy-disk drives for each system. The Bundled Software Packages graph shows the number of software packages included with each system. The Price graph shows the list price of a system with two 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 the computers, and their standard BASIC interpreters.



The rear view of the STM shows a full complement of connectors.



Inside the STM are the connector for the LCD dangling beneath the power supply on the right, the main circuit board in the center, and the floppy-disk drives on the left.



The graphs for Disk Access in BASIC show how long it takes to write and to read a 64K-byte sequential text file to a blank formatted floppy disk. (For the program listings, see June 1984 BYTE, page 327, and October 1984, page 33). The Sieve columns in the BASIC Performance graph show how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations columns show how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. The System Utilities graph shows how long it takes to format and to copy a disk (adjusted time for 40K bytes of disk data) and to copy a 40K-byte file using the system utility programs. The Spreadsheet graph shows how long it takes to load and recalculate a 25- by 25-cell spreadsheet where each cell equals 1.001 times the cell to its left. Microsoft Multiplan was the spreadsheet program used. The tests for STM used MS-DOS 2.11 and GW-BASIC 2.01. Tests for the IBM PC used PC-DOS 2.10 and those for Apple used ProDOS.

Compared to other computers, the STM Personal Computer appears to be delicate.

not to use the speaker phone if your table phone is nearby.

Documentation

STM's documentation comes in one IBM-style binder. It has clear descriptions of DOS functions and other controls. Technical details are negligible. However, a technical manual is available from the manufacturer for $75.

Shortcomings

Compared to other computers, the STM appears to be delicate. I handle mine with care. An abrupt movement can loosen the internal connections. The parts are not readily replaceable, including the disk drives, which are Canon third-height drives.

One inconvenient feature of my machine is a design deficiency regarding the RCA-compatible monochrome adapter. The back panel was not precisely cut or positioned for inserting the adapter plug into/over the outlet. I had to make some adjustments to accomplish this.

Once you expand the memory to 512K bytes or buy a machine of that configuration (for $3259), there is nothing you need to or can do in the heart of the STM computer.

Summary

I recommend the STM PC for those who need a lightweight IBM-compatible portable computer with fast internal processing and connections for external monitors. The STM eliminates carrying an external modem, printer, phone, and so on along with your computer.

I find the portable STM computer very useful. I especially like using it with an external monitor. Except for the price, I approve of all the major aspects of this machine. ■

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CWSS-885

BetterBASIC

A powerful language with a few quirks

BY ART HUSTON

Summit Software Technology's BetterBASIC is potentially one of the most powerful languages on the market. It provides access to a full 640K bytes, speedy compiled programs, windows, a complete system for creating functions and procedures, access to machine-language and to the basic input/output system (BIOS), graphics, event trapping, and extensibility, which allows you to create new BetterBASIC commands. Moreover, the language maintains the interactive nature of structured BASIC while letting you create structured, modular code. All are great features, and they would probably require the purchase of many separate library modules if you were programming in, say, C.

THE ENVIRONMENT

When loading, the program checks for a file called B.CNF, an ASCII (American Standard Code for Information Interchange) file containing a series of MODULE = commands with which you can configure BetterBASIC for your needs. Each module is really a library of the commands that will be available during this invocation of BetterBASIC. The disk has MATH.BCD, a floating-point math module you can replace with an 8087 module; CONSOLE.IBM, which supports console and screen functions; MAIN, the core BetterBASIC commands; FILE.DOS, for file input/output (I/O); GRAPHICS.IBM, for graphics commands; PLAY.IBM, which contains music and sound commands; and EVENT.IBM, which has event-driven or interrupt functions.

To save memory, you can specify only those commands you need for a given program, or you can create your own procedures and functions and save them as a module, thereby extending the language. This is similar to the concept of libraries, but in BetterBASIC, the compiler, linker, libraries, and editor are all in memory concurrently. Therefore, you must specify your library on entry to BetterBASIC and not in a separate link command. Also crowded into memory are the source code, object code, and variable table. You can't do any serious work without at least 256K bytes.

The editor is identical to Microsoft BASIC's; each line must begin with a line number. There are a few improvements, however. Explicit error messages flag syntax errors and the like with an arrow to the offending code. In addition, BetterBASIC automatically indents all program loops and block structures.

Incremental compiling, however, is what separates BetterBASIC from the pack. The software compiles each line of code when you enter it. As a result, BetterBASIC is both fast and interactive. In the debugging stage, for example, you can check variable values directly from the console without having to recompile the entire program. There are, however, some disadvantages, which I discuss in the "Data Types" section.

To execute a program, you simply type RUN. After a short pause to check the integrity of the program (for example, GOTOs cannot be to a nonexisting line or to a line outside the current program block), the program executes. Saving the object code requires that you purchase the run-time module for an additional $250. You can save the source code with the normal SAVE *filename* command, but it is saved in an incrementally compiled form and not as ASCII text. You can save the file in ASCII with the command LIST *filename*.

DATA TYPES

BetterBASIC's math package supports the data types BYTE (0..255), INTEGER (−32768 to +32767), and REAL (.1E−254 to 9.99E+253). In addition, you can globally specify between 6 and 24 digits of precision for REALs by using the PRECISION command. The formula 2+(precision/2) determines the number of bytes of storage. BetterBASIC sets the default length of string data to 16 unless you reassign a maximum length between 0 and 32767.

(continued)

Art Huston (154 Park St., Stoughton, MA 02072) works as a programmer of financial software in Boston.

You can declare variables implicitly or explicitly; as in all structured languages, the latter is encouraged. The command AUTODEF ON/OFF allows you to specify which mode you want. When you define a variable, BetterBASIC enters it into the variable table; every use of the LIST command lists the variables at the beginning of the program (see listing 1).

The use of an incremental compiler means that BetterBASIC assigns a data type to each variable as you enter it. Unfortunately, it is difficult to change the data type. If, for instance, you assign the variable *counter* as a BYTE and then realize it must be an INTEGER, you have two choices. The first is to define a new variable, *counter1*, as an INTEGER and then edit every *counter* to *counter1*. The second is to save the listing in ASCII, edit the declaration, and reload it. You will even find that variables will be listed in chronological order by declaration, and it will be difficult to edit your code in order to make the declarations seem more orderly. The BetterBASIC system is clearly somewhat rigid, and after awhile you may find yourself missing your standard editor-compiler-linker setup.

In addition to these simple variable types, BetterBASIC supports arrays, pointers, and records, as well as arrays of records, arrays of arrays, and so on. With pointers and records you can create linked lists, binary trees, and the like, although not without some difficulty. For example, the following code

```
STRUCTURE: EmployeeType
STRING: FirstName, LastName,
  JobTitle[64]
INTEGER: EmpNum, Age, Birth-
  Date
REAL: Salary
Employee PTR: LeftNode, Right-
  Node
END STRUCTURE
```

defines a record consisting of seven data fields and two pointers for traversing the left and right nodes of a binary tree. The SET command points the two pointers to various records. The pointer, however, must point to a predeclared variable; there is no equivalent to Pascal's New() procedure, which dynamically allocates space for new variables. In other words, to use the pointers effectively in the above structure, you would have to say

```
EmployeeType ARRAY(100):
  Employee
EmployeeType: Fred, Joe, Sally
```

which defines exactly 103 records of type EmployeeType, hardly an example of dynamic data structures for which pointers were intended. Moreover, there is no nil function to check if a pointer is uninitialized; in Pascal, the nil function usually indicates the end of a linked list.

PROGRAM-CONTROL STRUCTURES

BetterBASIC includes several new constructs or "block structures," which allow you to create programs without GOTOs. Block structures prohibit you from jumping in or out with GOTOs, they can define local error handling, and they automatically indent when you list the program, providing easy-to-read and logical listings. You can exit prematurely from each type of block structure with an EXIT statement.

The simplest is DO . . . END DO, which executes only once with an unconditional entry and exit. The DO . . . REPEAT loops infinitely until it executes an EXIT statement. You can modify both the DO and the REPEAT with an IF or UNTIL clause, resulting in statements like

```
DO IF YEAR>1999
     INPUT "Do you really want to
     live in the 21st century";A$
     A$ = UPPER$(A$)
REPEAT IF NOT(A$ = "Y" OR
  A$ = "N")
```

Other constructs include DO X TIMES, WHILE . . . DO, and FOR . . . NEXT.

Unfortunately, there is no multiple-line IF . . . THEN . . . ELSE, forcing you to use GOTO (or one of the new constructs) to bypass a section of code. The designers probably left it out in order not to compromise compatibility with old Microsoft BASIC code. Also puzzling is the absence of a CASE or SELECT statement to choose different operations based on the value of a single expression.

DIFFERENCES AND SIMILARITIES

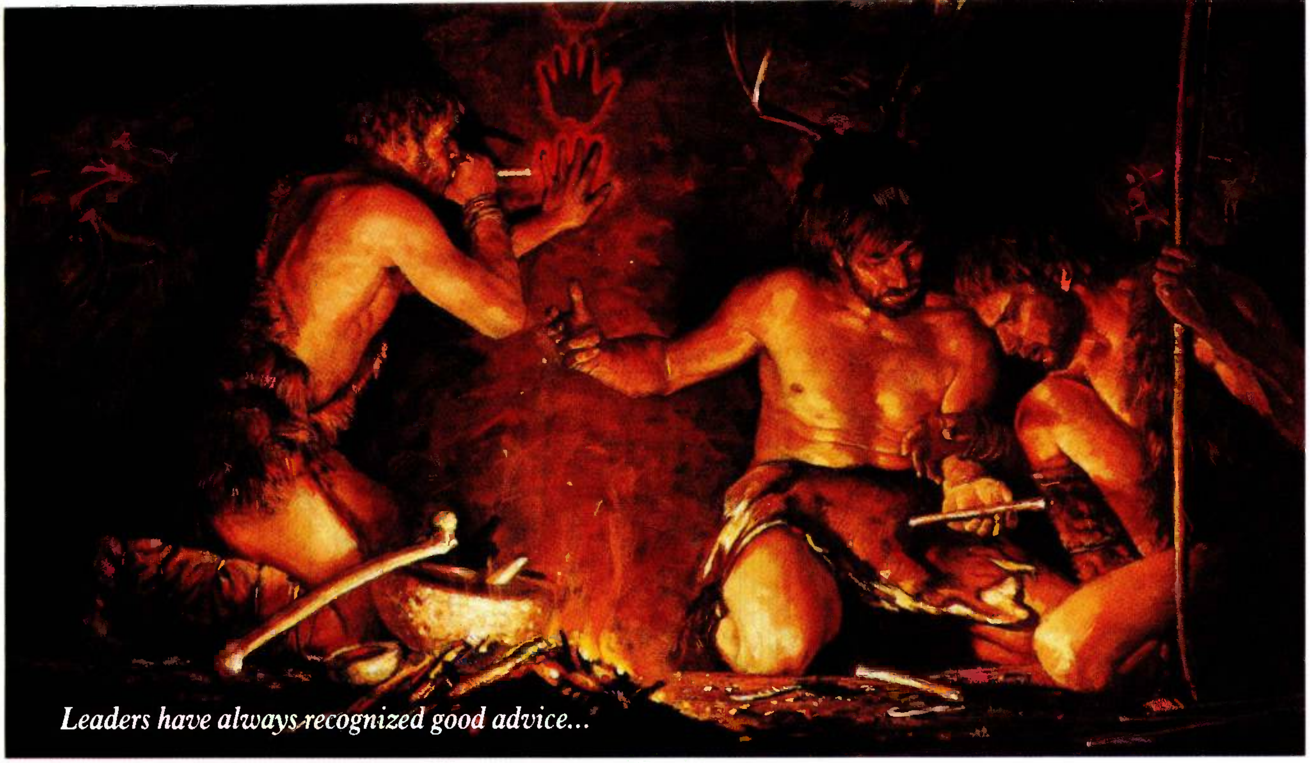
The documentation and the $10 demo disk list almost all the differences between BetterBASIC and Microsoft's interpretive BASIC. For the most part, BetterBASIC improves upon interpretive BASIC. In addition to many new functions (UPPER$ and LOWER$ to make strings uppercase and lowercase, for instance), BetterBASIC improves others. Rather than the clumsy FIELD, GET, and PUT commands to access random-access files, BetterBASIC uses the STRUCTURE command to define a disk record. It then accesses those records with READ RECORD and WRITE RECORD. The only significant omis-

(continued)

Listing 1: *When you use* LIST, *BetterBASIC lists the symbols at the beginning of your program. By default, only referenced variables are listed; as an alternative, you can use the /A option with* LIST *to list everything. The default is helpful in eradicating variables that were useful in earlier program versions; the program should simply be saved in* ASCII *with the* LIST filename *command and then reloaded. Only then will it truly disappear from the variable table.*

```
BYTE: QuitFlag, DoitFlag
INTEGER: Counter, Employee_Num
STRING: FirstName, LastName, JobTitle[64]

    10 QuitFlag = 0:DoitFlag = 0
       . . . .
```



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AT A GLANCE

Name
BetterBASIC

Manufacturer
Summit Software Technology
POB 99
Babson Park
Wellesley, MA 02157
(617) 235-0729

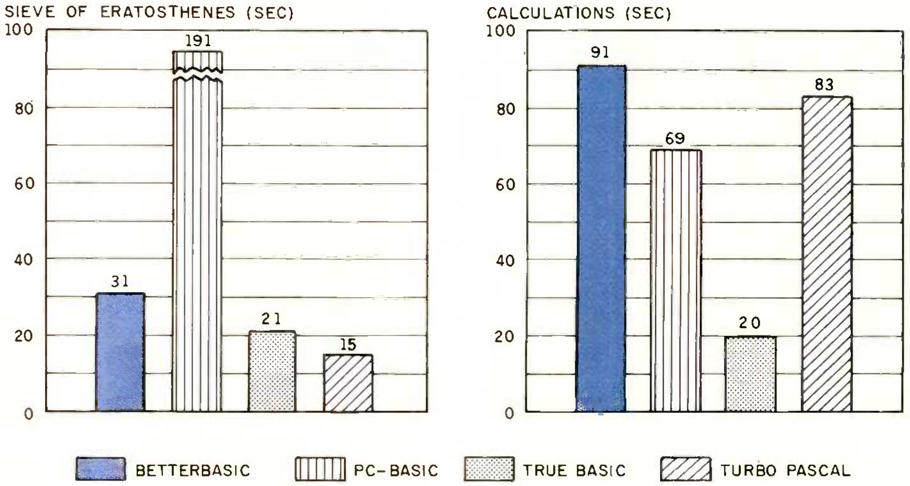
Computer
IBM PC with 192K RAM and a disk drive

Features
Incrementally compiled BASIC with excellent procedure and function capabilities, access to the BIOS and DOS interfaces, windowing, extensibility, and more

Documentation
600-page user's guide plus on-screen error diagnostics pointing to the incorrect portion of a program line

Price

BetterBASIC	$199
8087 math module	$99
Run-time system	$250
High-speed binary math module	$49
Btrieve interface module	$99
Demo disk	$10



The benchmark for the Sieve of Eratosthenes measures (in seconds) how long it takes for each of the tested languages to run one iteration of a program to determine all of the prime numbers between 3 and 14,003. The Turbo Pascal (version 2.0) time is for 10 iterations of the algorithm and finds all the primes between 3 and 16,384. The Calculations graph shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision (seven significant digits) numbers. See the review of True BASIC in the May 1985 issue of BYTE, page 279, for the listings of the standard Calculations and Sieve benchmarks. This code runs unchanged in BetterBASIC.

sion I encountered was the missing ERL command to return the error number of the last error.

Bit Smashing

The PEEK, POKE, CALL, DEFUSR, and USR commands in traditional BASICs allow only limited access to the read-only memory (ROM), operating system, and machine-language routines. BetterBASIC implements the first three but omits the latter two, which CALL makes redundant anyway. In addition, the BYTE and INTEGER commands (used to declare variables of type BYTE and INTEGER) take an optional address consisting of segment and offset, making it easy to access the location. For instance, if hexadecimal address 100:0FF is the printer's line count, you can change the value with the following code:

```
BYTE: LineCount[100h:0FFh]
100    LineCount = 0
```

This is a lot easier and more readable than the traditional BASIC code,

```
100 DEF SEG 100h
110 POKE 0FFh, 0
```

The BYTE and INTEGER commands are superb for accessing memory addresses that never change, but many programs will need memory addresses to be calculated at run time. The BYT and WORD commands perform an admirable job of allowing you to both alter and find out the contents of these addresses.

The CODE command loads machine-language code from disk. CALL calls the procedure by name, passing arguments if you require them. You can use CODE? to find the memory address of a given procedure. The AND, OR, ASH (arithmetic shift), INP (read a port), ROT (rotate), SH (shift), and XOR commands let you manipulate bits; SEG and OFFSET return the segment and offset of a given datum; and INTERRUPT and ON INTERRUPT allow you to halt a program to run a designated procedure. BIN$, OCT$, and HEX$ return the binary, octal, and hexadecimal representations of a number.

Revision 1.1 of BetterBASIC contains the SYSCALL procedure, which allows you to issue calls directly to the BIOS and to DOS. Another unique feature, the SHELL command, permits you to pass command lines to the MS-DOS command interpreter.

Windows

BetterBASIC uses a windowing system. With the DEFINE WINDOW

(continued)

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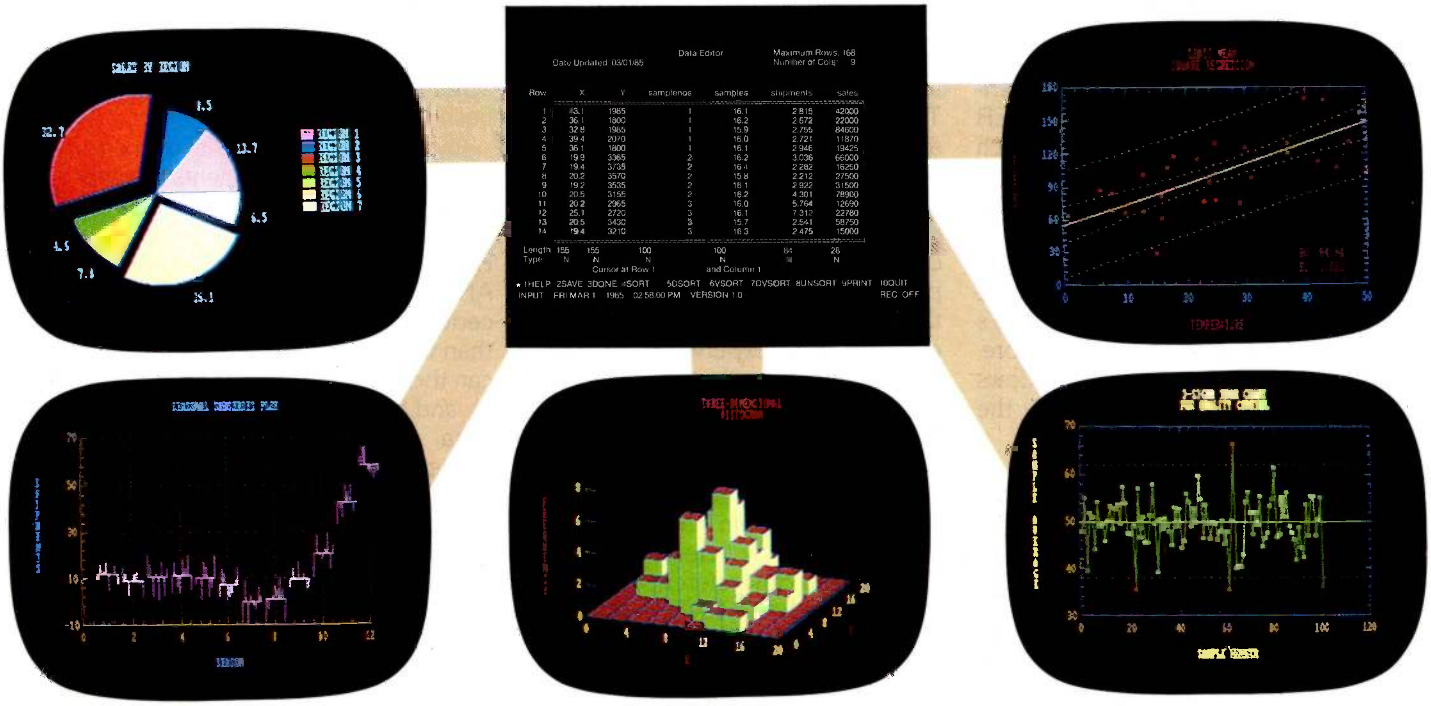

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Inquiry 324

Problem-solving at the speed of thought.

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STATGRAPHICS operates on IBM PC's and compatibles under DOS, Version 2.0 or later. A minimum of 384K RAM, a graphics adapter and compatible monitor, and two double-sided disk drives or a hard disk are required. An 8087 math coprocessor and 512K RAM are recommended.

statement, you can define up to five windows at one time, each with independent scrolling, their own borders, titles, foreground and background colors, and character attributes. The FRAME and HEADER commands draw borders around each window and place a title at the top. With the SELECT command, you can choose the desired window. In addition, with SAVE PAR, RESTORE PAR, SAVE SCREEN, and RESTORE SCREEN you can save a window's parameters and contents. Therefore, you could have "pop-up" windows and menus that do not destroy the underlying screen material.

THE PROCEDURE SYSTEM

Despite some problems, the BetterBASIC procedure and function system is one of the best aspects of the language. Each user-defined procedure and function has its own work space separate from the main program. LIST lists only the main program; revision 1.1 lets you use LIST ALL to list the entire program, including procedures and functions. To enter and exit procedures and functions, you use the commands PROCEDURE <name>, END PROCEDURE, FUNCTION <name>, and END FUNCTION. You define the input parameters by listing them as in BYTE ARG, INTEGER ARG, STRING ARRAY ARG, and so forth. This has the disadvantage of losing flexibility as compared to more traditional text-editor/compiler combinations; it's difficult to change the order or the data type of parameters since they're inserted into the variable table as soon as they're entered. In my experience, it's a rare programmer who doesn't change his or her mind frequently.

Using /VAR with a procedure variable means that changing the variable in the subprogram changes it in the calling program (that is, the variable is called by reference, not by value). You can reference external variables with the EXTERNAL command. The DYNAMIC command lets you create recursive functions. Most of these commands are standard Pascal fare, but BetterBASIC adds much more. The /OPT = value makes a parameter optional and, if you have not declared it, has it assume a default value. Think of how useful this is with the LOCATE procedure in BASIC; LOCATE 1,1 moves the screen to the upper left-hand corner of the screen; LOCATE ,,1 turns on the flashing cursor.

Each module can have its own error handler. Keyword arguments are supported (for instance, KEYWORD ARG: Value \ RED \ GREEN \ BLUE). It's also possible, using the ANY ARG construct, to create procedures taking arguments of more than one data type. The subprogram can then use the TYPE( ), DIM( ), DIM (,), and SIZE( ) functions to return the data type, dimension, subarray dimension, and size of a datum. You then explicitly tell the compiler what type to treat it as using the syntax varname:DATATYPE; for example, A:BYTE means "treat A as a byte."

This capability pays real dividends. Consider that you can write one sort routine to handle sorts of any data type. By contrast, the BASIC VAL statement accepts numerics of the type BYTE, INTEGER, and REAL; in Pascal, you would have to write BYTEVAL, INTVAL, and REALVAL functions.

BetterBASIC also introduces the idea of procedure families. Using the same name, you can call separate and distinct procedures or functions that are distinguished by the parameters you pass to them. See listings 2 and 3 for examples.

Revision 1.1 also lets you CHAIN to other programs with common variables; programs can even be called as procedures with some variables in common and the rest swapped out to disk until the procedure returns. This overlay technique makes it possible to build larger-than-memory programs with room left for large arrays.

Listing 2: *An example of BetterBASIC procedure families. The first (root) subprogram carries a simple name, something like* TEST. *Its siblings are named* TEST.A, TEST.B, TEST.C, *and so on. Each one has a different set of parameters.*

```
FUNCTION MULT
INTEGER ARG: X,Y
10 RESULT=X*Y
END FUNCTION

FUNCTION MULT.A
STRING ARG: Text
INTEGER ARG: X
STRING: TempText[32767]
10 TempText=" "
20 DO X TIMES
30      TempText=TempText+Text
40 REPEAT
50 RESULT=TempText
END FUNCTION

PROCEDURE MULT.B
INTEGER ARG: X,Y
STRING ARG: StudentName
10 PRINT "The answer is ";X*Y;". Nice try, ";StudentName;"!"
END PROCEDURE
```

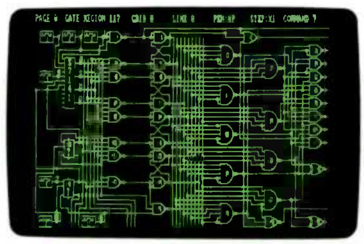
DOCUMENTATION, SUPPORT, BUGS

BetterBASIC's documentation is better than the industry average. The introduction to BetterBASIC programming is adequate for programmers already familiar with BASIC, the intended audience, but not for begin-

(continued)

MICRO CAP and MICRO LOGIC put your engineers on line... not in line.


"Typical MICROCAP Transient Analysis"


"Typical MICROLOGIC Diagram"

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MICROCAP is an interactive analog circuit drawing and simulation system. It allows you to sketch a circuit diagram right on the CRT screen, then run an AC, DC, or Transient analysis. While providing you with libraries for defined models of bipolar and MOS devices, Opamps, transformers, diodes, and much more, MICROCAP also includes features not even found in SPICE.

MICROCAP II lets you be even more productive. As an advanced version, it employs sparse matrix techniques for faster simulation speed and larger networks. In addition, you get even more advanced device models, worst case capabilities, temperature stepping, Fourier analysis, and macro capability.

MICROLOGIC: Your Digital Solution

MICROLOGIC provides you with a similar interactive drawing and analysis environment for digital work. Using standard PC hardware, you can create logic diagrams of up to 9 pages with each containing up to 200 gates. The system automatically creates the netlist required for a timing simulation and will handle networks of up to 1800 gates. It provides you with libraries for 36 user-defined basic gate types, 36 data channels of 256 bits each, 10 user-defined clock waveforms, and up to 50 macros in each network. MICROLOGIC produces high-resolution timing diagrams showing selected waveforms and associated delays, glitches, and spikes—just like the real thing.

Reviewers Love These Solutions

Regarding MICROCAP . . . "A highly recommended analog design program" (PC Tech Journal 3/84). "A valuable tool for circuit designers" (Personal Software Magazine 11/83).

Regarding MICROLOGIC . . . "An efficient design system that does what it is supposed to do at a reasonable price" (Byte 4/84).

MICROCAP and MICROLOGIC are available for the Apple II (64k), IBM PC (128k), and HP-150 computers and priced at $475 and $450 respectively. Demo versions are available for $75.

MICROCAP II is available for the Macintosh, IBM PC (256k), and HP-150 systems and is priced at $895. Demo versions are available for $100.

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Inquiry 318

ners. And there are a few errors, such as on page 69 where an integer pointer is declared incorrectly, resulting in a syntax error. The quick-reference section claims to list all the commands, declarations, program-control keywords, procedures, functions, and operators. But there are gaps in version 1.0. Revision 1.1 documentation fills some of these gaps; there is now, for example, a section on windows. The "Syntax Visuals" section, despite its curious title, does a more than adequate job of defining each command.

I found BetterBASIC to be mostly bug-free with only a few exceptions. One such exception was the EOF() function, which sometimes failed to detect the end-of-file marker in disk files, crashing the program. This was a real problem since the ERL function is not available.

The disks are not copy-protected. Summit Software's telephone-support people are quick, courteous, and informative. I called for help in redefining a variable's data type; I received an honest admission that it was a problem and that Summit is contemplating a fix in future versions. The person on the phone suggested an interim solution until the software is enhanced.

Listing 3: *With BetterBASIC's procedure families, you can define siblings for built-in procedures like* PRINT.

```
PROCEDURE Print.a
REAL ARG: X
10 Print "The value is:";X
END PROCEDURE
```

CONCLUSIONS

Many users will be interested in this product. Nonetheless, a few quirks make it difficult for me to wholeheartedly recommend this language over all others.

First and foremost, BetterBASIC's incremental compiler, for all its interactiveness, may get in your way, making it difficult to redefine data types, change parameter requirements to a procedure or function, and so on. A decent text editor, despite the drudgery of having to call it up each time, may provide much more flexibility and surer results. And many programmers may miss SELECT/CASE and multiline END . . . IF statements.

Still, BetterBASIC does provide compiled programs, functions and procedures, a windowing environment, extensibility, graphics, and access to 640K bytes. For some people, the last feature alone will be enough reason to discard standard interpretive BASIC. ■

 Inquiry 185

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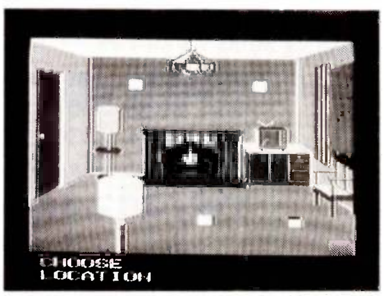

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S·O·F·T·W·A·R·E R·E·V·I·E·W

TLC-LISP

A fully featured LISP implementation

BY WILLIAM G. WONG

TLC-LISP is an implementation of LISP for 8086/8088-based machines running PC-DOS, MS-DOS, CP/M-86, or Concurrent DOS. It can use all available memory up to 1 megabyte and supports the 8087 numeric coprocessor. A resident screen editor, turtle-graphics support, a Smalltalk-like class system, and a LISP Machine–like package system make TLC-LISP an attractive alternative for artificial intelligence (AI) work.

BASIC FUNCTIONS AND LISP EXTENSIONS

Talking about extensions to LISP is like talking about the interstate highway system—it goes everywhere. LISP has so many dialects that the family tree looks bushy. TLC-LISP is based on MacLISP, LISP Machine's LISP, and Logo. Most of the basic functions, such as FIRST (CAR), REST (CDR), LIST, AND, OR, and COND, are identical. Others, such as the TLC vector constructs, differ from the base.

TLC-LISP supports functions that evaluate parameters (EXPRs) and those that do not (FEXPRs) along with LISP MACROs. You can use keywords to specify the number of parameters to a function as in MacLISP.

In addition to flexible parameter binding, TLC-LISP treats all objects as "first-class objects," which means that all items can be parameters to functions, all items can be returned as the result of a function, all items can be assigned to a variable, and all items can be tested for equality. For example, many languages will not permit functions to return functions, files, or even vectors as results. In TLC-LISP, functional objects (called closures) can be returned as easily as integers or strings. Although this might not appear to be useful, it turns out to be a powerful construct.

TAIL RECURSION ELIMINATION AND LOOPS

Although most LISP implementations, including TLC-LISP, have looping constructs (DO, REPEAT, and FOR), many do not eliminate tail recursion. Tail recursion occurs when the last expression a function invokes is itself, with a different set of parameters. More generally, it occurs when a function invokes another function such that the variables used by the calling function will never again be accessible. In any case, you can throw away the parameters, local variables, and return information. Throwing away this information, which is usually kept on the program evaluation stack, is called tail recursion elimination.

Using tail recursion in TLC-LISP is usually as efficient as using explicit loop constructs. This means that you do not have to sacrifice the clarity and flexibility of a recursive definition for speed.

NUMBERS, STRINGS, AND VECTORS

TLC-LISP supports a number of primitive object types other than the conventional LISP "list." These include small and large integers, floating-point numbers, character strings, and vectors. Small integers have 10 significant bits and large integers have 32 bits. Large integers must be allocated from free space while small integers are not, which makes small integers faster to use.

TLC-LISP uses a 4-byte single-precision floating-point format that matches the 8087 numeric coprocessor. It also uses the 8087 (if it is installed) for faster manipulation of floating-point values. You can manipulate all numeric values by using arithmetic and trigonometric functions. You can also manipulate integers by using bit-wise logical functions.

Strings can be up to 64,000 characters in length and TLC-LISP supports a full set of string-manipulation functions. Substring generation actually creates references to a string instead of a copy of the string. This lets modifications of one string be viewable by another. A copy-string function is also supplied. Character-insert and -delete functions are available along with string search,

(continued)

William G. Wong (1333 Moon Dr., Yardley, PA 19067) is president of Logic Fusion Inc. and a developer of systems and applications software.

AT A GLANCE

Name
TLC-LISP 1.45

Manufacturer
The LISP Company
Suite 4
430 Monterey Ave.
Los Gatos, CA 95030
(408) 354-3668

Computer
IBM PC or compatible with PC-DOS, MS-DOS, CP/M-86, or Concurrent DOS and 128K bytes (without resident editor) or 256K bytes (with resident editor)

Features
Basic LISP system, LISP p-code assembler and compiler, LISP source code for file utilities, display drivers, screen editor, turtle graphics (requires IBM PC color graphics adapter), general utilities, and a pretty-printer utility

Price
$250

which is very useful for text editing.

Vectors are a more general case of strings, as each vector element can be any LISP object and not just a character. Access to any element takes a constant amount of time for any length vector, which makes them faster than using normal LISP lists. Vectors are also more space-efficient than lists of a similar length. You can access, replace, delete, or insert elements of a vector. Note that insertion or deletion does not change the size of a vector and all changes are destructive. A vector-copy function is supplied for nondestructive operations.

Vector elements are 2 bytes each and vectors are limited to 32,000 elements. Vector elements can be vectors, allowing construction of multidimensional arrays. These arrays do not have to be homogeneous.

CLASS SYSTEM

The class system is similar to the LISP Machine Flavors system. They both provide an object-oriented programming environment similar to Smalltalk, another AI language. A class has a set of functions that it recognizes. Each instance of a class contains a set of variables on which these functions operate.

The class system is hierarchical, with each subclass inheriting the attributes of its ancestors. Also, a class may override these inherited values and procedures, which lets you customize a class to a particular situation. (For further information on class systems, see the August 1981 issue of BYTE and "An XLISP Tutorial" by David Betz, March, page 221.)

PACKAGE SYSTEM

Another feature of TLC-LISP that most micro-based LISPs lack is the package system. Normally a language supports a single symbol table. Unfortunately, developing modular programs in such an environment can be difficult because a common name such as SEARCH might be used in more than one module. A single symbol table would allow only one instance of SEARCH, which would preclude using two modules that had a different meaning or value associated with SEARCH.

The TLC package system solves these problems and makes modular systems a breeze. A package is essentially a separate symbol table or "name space" that logically contains symbols, function definitions, packages, and so on. Each package has a name, and you can explicitly specify a symbol in a package by using the package name as a prefix. However, this differs from a prefix-naming convention in that you specify the package name when you load the package and not when you implement it.

Like the class system, the package system is hierarchical in nature, and the system will search the "super packages" if it does not find a symbol in the specified package.

The package system alone is worth quite a bit when dealing with large application implementations and externally created libraries. Its power and flexibility exceed that of most native-code linkers.

I/O SUPPORT

In micro-based LISP implementations, file management and peripheral support has been limited. Not so with TLC-LISP. This program includes full support for multiple random-access files with byte granularity. Directory manipulation functions are also included.

TLC-LISP actually supports a more general character-stream facility that is not restricted to disk files or peripherals. Instead, a stream is an object, similar to the UNIX pipe, that can generate or accept characters like a normal disk file interface. The difference is that the stream is really a function the programmer can specify.

Like the class system, the implementation of streams lets you easily customize a module's file interface without modifying the module itself. For example, assume a text-processing module such as a compiler is available with a simple interface. The module uses a single stream as input and two streams as output, one for

(continued)

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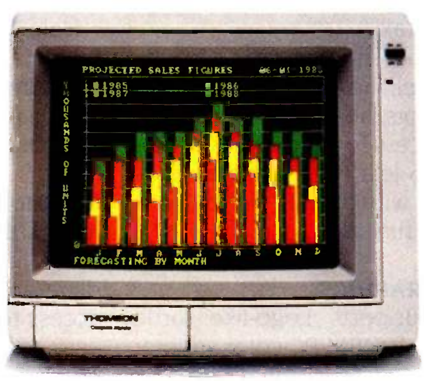

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normal results and one for error results. The compiler does not perform any other special functions with regard to the input or output. You can implement this general text-processing facility as a module by using the package system. In this case, other modules could use the same facility. In fact, multiple stream-processing packages could be made into a single, more powerful package.

TLC-LISP contains a number of built-in stream-processing functions for normal read and write functions, including a table-driven read-macro facility. The program supplies a number of read macros but you can add additional ones.

The only I/O (input/output) feature missing from TLC-LISP is the ability to save the current program image on disk and restart it at a later time. This can be a problem when developing an application since TLC-LISP lets you save only function definitions and variable values.

OPERATING-SYSTEM SUPPORT

This language makes access to all operating-system functions available at two levels. The normal interface includes functions that access disk files and peripherals. These protect the program from normal errors and should not cause the system to abort prematurely due to improper parameters or syntax.

The second interface, at a more primitive level, includes access to PC-DOS interrupts, absolute memory access, and access to internal LISP structures. It also lets you run other programs from within LISP via the MS-DOS EXEC function.

TURTLE GRAPHICS

TLC-LISP supports Logo-like turtle graphics on the IBM PC color adapter card or on IBM PC-compatible units running CP/M-86 or MS-DOS. The functions available are essentially a superset of those found in most Logo implementations, with a multiple set of independent turtles instead of just one turtle. One turtle is standard but you can HATCH additional ones at will.

The graphics are fast and the number of turtles does not affect the drawing speed, which is faster than most Logo implementations. Compiling functions using turtles also increases the speed of execution.

Split-screen support is an adjunct to the turtle graphics, and a window package is included. A more general overlapping window system can be constructed but is not supplied.

SCREEN-BASED TEXT EDITOR

TLC-LISP comes with a fast and fully functional screen-based text editor that you can use to edit function definitions, variable values, or text files. As a text editor (rather than a structure editor), it lets you move and delete blocks of text without regard to list structures. However, a function must have the proper syntax before you can place it back into the system.

You can use the editor to handle general text files that are unrelated to LISP. A program can also invoke it. The editor keeps all text in memory, which makes it fast but limits the size of external files. Most of the commands are a subset of the WordStar control commands. You can leave the editor, return to the top level of LISP, and come back without losing the current text. This is extremely useful for trying out a small change immediately.

Help is available and a single-line menu is always present at the top of the screen. Expressions in the text can be parsed, evaluated, or compiled with only two keystrokes.

ERROR HANDLING AND DEBUGGING

TLC-LISP has a very good error-handling and trace package. It provides access to all state information and is easy to customize. The documentation covering this aspect is complete. All errors that are not fatal can be caught and processed under program control.

TLC-LISP supports the CATCH and THROW functions plus a function called UNWIND-PROTECT. These are actually control-flow functions like DO but are used extensively for error handling and debugging. The debugging and trace packages use these functions, along with more primitive ones that can examine the evaluation stack. The packages are line-oriented rather than screen-oriented (as in IQLISP), and you can customize the packages using the window system found in the turtle-graphics package.

TLC-LISP also includes an EVAL-HOOK that allows program intervention while evaluating expressions.

MEMORY ALLOCATION

TLC-LISP requires 256K bytes of RAM (random-access read/write memory) to perform adequately, but it will use all available memory. Half a megabyte is recommended for any large development projects. The basic LISP kernel uses about 60K bytes and the operating system is typically 20K bytes, leaving the rest for LISP programs and data.

TLC-LISP divides memory into object space and byte space. Object space is used for items such as uncompiled function definitions, lists, numbers, and symbols, while byte space is used for compiled function definitions, strings, vectors, and buffers. The object space has an upper limit of 256K bytes, while byte space can be up to 1 megabyte.

LISP list cells are 4 bytes long, consisting of two 16-bit pointers that always reference something in object space. The size of any item in object space is also some multiple of 4 bytes. This means that a list cell can reference a maximum of 64,000 4-byte objects, giving the 256K-byte limit. Items in byte space are referenced from descriptors contained in object space.

TLC-LISP uses a big-bag-of-pages (BIBOP) allocation scheme for object space, as opposed to the tagged allocation scheme used by IQLISP and the partition boundary scheme used by muLISP. The BIBOP scheme starts by dividing object space into a set of fixed-size pages all initially unallocated. These pages are allocated as different objects are created. Each page contains only one

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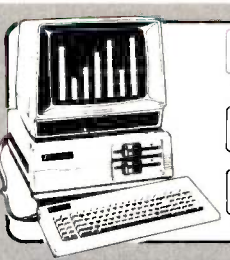

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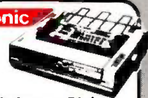

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The complete set of object types lets you use TLC-LISP for almost any application.

type of object. For example, list cells would be in a different page than integers. This scheme works quite well in terms of efficiency and speed, given the memory limitation of the 8086. The 16-bit list-cell pointers are the natural pointer size for the 8086 and the lack of individual type tags on objects keeps their size down, thereby increasing the number that can be allocated from a given space.

Another TLC-LISP option is the auto-load facility. This lets you keep objects (data as well as function definitions) on disk and load them only when they are accessed transparent to the function using the object. You can specify any auto-load object as a "smash" object or a "no-smash" object. Smash objects are brought in once and replace the auto-load definition. No-smash objects are brought in each time the symbol value is accessed.

GARBAGE COLLECTION

Garbage collection is the bane and salvation of LISP. On one hand, it must be done occasionally to recover objects that can no longer be accessed; this takes time. On the other hand, this collection is done automatically and is transparent to the program except for the time it takes. Garbage collection occurs whenever the system runs out of unallocated space or when you invoke the GC function. The time it takes to complete the collection varies depending upon the amount of memory, the amount of garbage to be recovered, and the complexity of the data structures. This can be less than a second to around 10 seconds. Garbage collection on a machine with 500K bytes, a 50/50 object/byte space split, and a simple data structure takes about 2 seconds.

COMPILER

TLC-LISP comes with a pseudocode compiler that you must manually invoke to convert a user-defined function into a compiled function. P-code runs at least twice as fast as interpreted code and takes up about two-thirds the space. It loads faster from disk because of its format and reduced size. You cannot modify a compiled function by using the editor, so compiled modules can be supplied without the source code (for proprietary reasons).

Another advantage is that compiled code resides in byte space while interpreted code resides in object space (limited to 256K bytes). Using compiled code increases the amount of object space for a given program, leaving more room for LISP list cells, which are normally used with abandon.

The disadvantage is that the original source text is not available for debugging or modification using the editor. Thus, debugging typically occurs on interpreted definitions that will be compiled. TLC-LISP lets you use compiled and interpreted functions at the same time so only the functions being examined need be interpreted. You can invoke the compiler from the editor and keep the source text in a disk file or on the property list of the symbol that has the compiled definition.

PERFORMANCE

TLC-LISP performs very well when compared with other LISP or Logo implementations and interpreted systems such as BASIC. It also performs well when compared with compiled languages depending on the application (LISP performs better when symbolic computation is involved).

Compiled TLC-LISP p-code speed is similar to muLISP, which uses an automatically compiled d-code (distilled code). Interpreted TLC-LISP is slower and runs about the same as interpreted IQLISP, which has no compiler.

TLC-LISP's turtle-graphics functions run at least twice as fast as Dr. Logo's. Using multiple turtles in TLC-LISP does not seem to decrease or increase the drawing speed, although turning off the turtle marker speeds things up quite a bit.

DOCUMENTATION

The TLC-LISP manual is well written and organized. It is divided into three parts—a general discussion of LISP, system interaction, and a TLC-LISP reference manual—with three extensive bibliographies. Some of the documentation for newer options, such as the compiler, is found in text files on the distribution disks.

The first section, while not intended to be a LISP tutorial, is complete, with examples that you can use with the program. Some of the additional features of TLC-LISP, such as the class system and turtle graphics, are discussed in detail. The system section is short and essentially describes the command-line options and terminal customization for the non–PC-DOS versions. The reference-manual section includes syntax definitions and examples for all available functions, grouped by functional properties.

SUMMARY

TLC-LISP is an excellent product and a respectable LISP environment for a microcomputer. TLC-LISP's inability to save and restore the current system image can be a problem, but this is more than offset by numerous features, such as a screen editor that allows fast and flexible program development. The compiler provides a way to speed up the execution of programs while reducing the amount of space a program takes up.

The complete set of object types lets you use TLC-LISP for almost any application, and the package system lets you create programs in a modular fashion. The class system gives access to a Smalltalk-like environment, while the turtle graphics provide a powerful display tool with Logo-like simplicity. These features are normally unavailable except on mainframes and LISP machines that cost significantly more than a PC and TLC-LISP. At $250, the program is a bargain. ■

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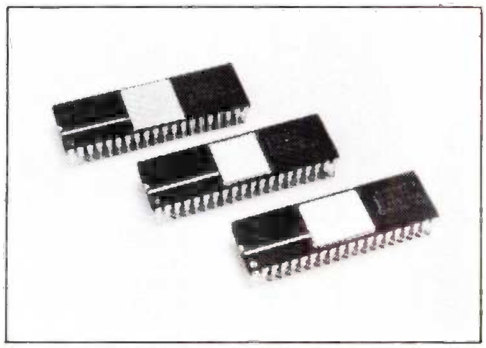

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MODELING QUEUES

GPSS is a discrete-event simulation language; that is, it lets you create models of systems that consist of specific events, such as customers arriving at a store, airplanes arriving at an airport, and so on. [*Editor's note: For an explanation of computer simulation and discrete-event versus continuous simulation, see "Computer Simulation: What It Is and How It's Done" by Richard Bronson in the March 1984 BYTE, page 95.*]

In very broad terms, a GPSS simulation consists of creating transactions, the allocation or deallocation of resources used by transactions as they move through various portions of the simulated model, and the eventual deletion of transactions from the system. Since more than one transaction may be present in the simulated system at a given time, the transactions compete for resources. GPSS has built-in features that resolve contentions for resources by monitoring their use and scheduling all activities within the model.

A classic example of discrete-event simulation involves customers arriving at a barbershop. Figure 1 illustrates a very simple GPSS model in which transactions (customers) arrive at the barbershop every 30 minutes, plus or minus 10 minutes (the GENERATE statement), enter a waiting line (the QUEUE statement), capture the barber (the SEIZE statement), leave the waiting line (the DEPART statement), get a haircut or equivalently advance the simulated clock by 25 minutes plus or minus 5 minutes (the ADVANCE statement), release the barber so he may be used by another customer (the RELEASE statement), and leave the barbershop (the TERMINATE statement).

When this program executes, GPSS automatically resolves contentions for the resource (the barber in this case) on a first-come first-served basis; although the program does not contain any output statements, statistics relevant to the waiting line and the resource are provided by default at the end of execution.

Previous implementations of GPSS on mainframes and minicomputers have typically treated the system as a translator, similar to a compiler or an assembler, that converts GPSS source code into an executable image appropriate for the host computer. GPSS/PC represents a major departure from this tradition by embedding the GPSS language within an interactive simulation environment. There are some relatively minor differences in language constructs between GPSS/PC and GPSS V, an established standard, but the main distinction of GPSS/PC is its interactive user interface, which supervises the entire modeling process of program entry, debugging, modification, and execution.

INTERACTION WITH GPSS/PC

You start working with GPSS/PC by booting PC-DOS or MS-DOS and then invoking the program. Usually, the first thing you do during a session is load a GPSS source program, either by entering line-numbered source statements from the keyboard or by accessing previously stored source code from a disk file. In either case, GPSS/PC scans the program lines as they are entered and warns you if there are any syntax errors. The ASCII representation of the program, together with line numbers, is saved in

(continued)

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AT A GLANCE

Name
GPSS/PC

Type
Simulation language

Manufacturer
Minuteman Software
POB 171
Stow, MA 01775
(617) 897-5662 or
(800) 343-0664, ext. 4800;
in Massachusetts,
(800) 322-1238, ext. 4800

Format
5¼-inch floppy disk

Computer
IBM PC and compatibles

Features
Interactive modeling environment, on-line help, keystroke-error prevention, assignable function keys, integrated line editor, dynamic memory allocation, unlimited precision, dynamic plot facility, math library functions

Documentation
User manual, 394 pages; reference card

Price
$950

memory as the "savable program." By interpreting commands such as SAVE, DELETE, and DISPLAY, GPSS/PC acts as a keyboard monitor and provides a working environment in which programs can be created, modified, saved to disk files, and executed. You can also edit programs under GPSS/PC control (through the EDIT command) or with an editor available under PC-DOS or MS-DOS.

GPSS/PC keeps a coded record of all GPSS entities you create during a session as the "current model." When statements are scanned, appropriate additions are made to the current model. If you enter statements without line numbers, the additions made to the current model are not incorporated into the savable program. Thus, consequences of unnumbered statements are not permitted to extend beyond the session during which the statements are made.

Throughout a session, you interact with GPSS/PC through 13 commands. These commands make GPSS/PC a more powerful modeling tool than its counterparts on many mainframes and minicomputers. Among other things, GPSS/PC lets you interrupt a running simulation, inspect internal model statistics, alter certain program statements, and continue with the execution of the simulation; dynamically modify the structure of a model by changing named values and even changing the block structure of a model in the middle of execution; use any simulation primitive at the user-interface level to control the running of the simulation; and observe the dynamics of a model parameter through the PLOT feature (which produces a plot of a specified state variable on the screen during program execution), interrupt the execution of the simulation, make changes to the model, and observe the effect of these changes on the model parameter in question.

```
GENERATE    30,10
QUEUE       WAIT
SEIZE       BARBER
DEPART      WAIT
ADVANCE     25,5
RELEASE     BARBER
TERMINATE
```

Figure 1: A *simple barbershop model done with* GPSS/PC.

IMPLEMENTATION PROS AND CONS

When a significant software product that has been available only on large computers is implemented on a microcomputer, the result is generally a mixed blessing. When taking software from mainframes to microcomputers, developers almost always have to impose memory size or performance constraints because of the limitations of the microcomputer.

One negative aspect of GPSS/PC is its slow execution speed. Response times associated with GPSS/PC model

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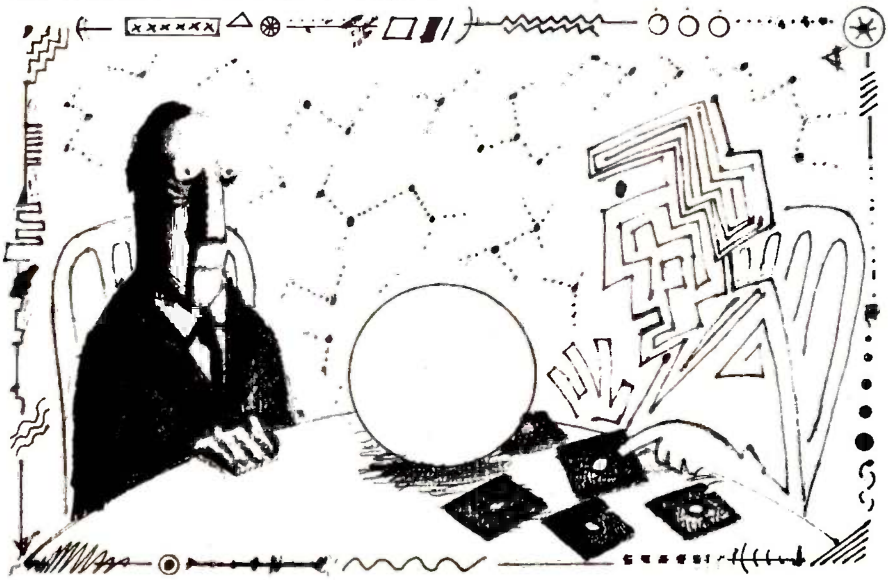

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executions are perceptibly longer than the corresponding response times on a VAX-11/780 with about 25 interactive users under the VMS operating system. But slow execution times cause a serious problem only in simulations that are extremely demanding on the central processing unit. Most "typical" models, such as the case studies provided by T. J. Schriber in *Simulation Using GPSS*, have acceptable execution times. (Source code for these case studies is included on the GPSS/PC distribution disk.) The nominal execution speed of GPSS/PC is 0.003 second per block when a 4.77-MHz 8088 processor is used. Compatible systems with 8-MHz 8086 processors should exhibit faster execution times, as will systems with an 8087 coprocessor. GPSS/PC response times, although long when compared to corresponding times on minicomputer or mainframe systems, are quite good when compared to similar microcomputer products.

A second potential problem may come from the 256K-byte minimum memory stipulation, which is too small for large simulations. To run large simulations, and to have a comfortable excess of disk storage, you will need at least 512K bytes of memory and two floppy-disk drives.

GPSS/PC's slow execution speed is more than balanced by the much faster model-development time made possible by its interactive environment. In the traditional mainframe environment, software development consists of a repetition of the debug-edit-compile-link-execute cycle. Discrete-event model development requires more iterations of this cycle since, in addition to the usual elimination of syntax and semantic errors, you need to execute the simulation with a variety of model specifications and parameter configurations. GPSS/PC makes it unnecessary to repeat this cycle and thereby significantly reduces the overall model-development time.

GPSS/PC checks syntax errors with each keystroke and, if it detects a syntax error, notifies you immediately and corrects the error. This feature alone speeds up the model-development process and substantially enhances the effectiveness of the modeler. Semantic, or logical, errors are more difficult to deal with. GPSS/PC helps you diagnose semantic errors with an extensive array of debugging aids. The ability to suspend program execution, determine the values of internal parameters, make model changes in mid-simulation, and continue the execution of a suspended program all contribute to your efficiency as a modeler.

The real issue of trade-offs between large-system and microcomputer implementations of GPSS should focus

(continued)

on the overall impact of the working environment provided by each implementation. Ideally, the simulation environment should be an extension of the mind of the analyst. The environment should immediately respond to syntax errors, inquiries concerning the status of a simulation in progress, and data-structure manipulations by the modeler. GPSS/PC does remarkably well in this respect. As computation expenses continue to represent smaller portions of the cost of model development, and as personnel expenses continue to grow in proportion to other expenditures, the trade-off between slower processing time and more efficient use of personnel time will continue to make GPSS/PC an attractive choice.

COMPATIBILITY

GPSS/PC is not completely compatible with other GPSS dialects; you'll have to modify previously written programs to use them with GPSS/PC. The comparisons I make in this section are limited to GPSS V, probably the most widely used version of GPSS.

Five GPSS V blocks (executable statements) are not included in GPSS/PC: JOBTAPE, PRINT, WRITE, CHANGE, and HELP. Three of these deal with input/output. The JOBTAPE and WRITE blocks deal with the infusion of transactions into a GPSS model from auxiliary files. In all likelihood, Minuteman did not include these blocks because of the additional file-processing burdens that would be imposed by their implementation. The function of the HELP block is to provide interfacing between GPSS and program modules written in other languages, typically assembly or FORTRAN. This block would also require the manipulation of auxiliary files. The developers of GPSS/PC say they plan to incorporate the WRITE and HELP blocks into version 2, the next release.

Through the PRINT block GPSS V lets you request output at certain points during the simulation. Although the GPSS/PC interactive features make this block less essential than it is with GPSS V, a PRINT block could still be useful. Similarly, although you can achieve the purpose of the CHANGE block (dynamically altering one model block to another) through the GPSS/PC interactive process, it would still be helpful to have a CHANGE block.

Of the seven GPSS V control statements not included in GPSS/PC—AUXILIARY, JOB, LOAD, READ, REALLOCATE, REWIND, and SAVE—all except REALLOCATE deal with the use of data or program module files in connection with a GPSS run. These control statements are not as important in the interactive GPSS/PC environment as they are in batch-processing settings. Their absence from

GPSS/PC is not of great consequence. The REALLOCATE statement lets you reclaim previously allocated portions of memory that are no longer necessary for program execution; since GPSS/PC allocates memory dynamically, this statement is superfluous in the GPSS/PC context.

GPSS/PC has several standard numerical attributes beyond those available in GPSS V. GPSS/PC's internal integer-storage scheme lets it store integers with virtually unlimited precision. This removes GPSS V restrictions and lets you choose simulation time units most appropriate for the problem at hand. The unlimited precision also makes it unnecessary for you (or the program) to distinguish between byte, halfword, and fullword savevalues and transaction parameters.

The standard output generated by the TABLE and TABULATE statements of GPSS V is more detailed than the corresponding output produced by GPSS/PC. Another difference occurs in output when a simulation is terminated because all existing transactions are processed, not because of the value of the termination counter. (For example, you instruct the program to process 100 transactions but only 90 transactions exist.) GPSS V provides the usual output in this situation; GPSS/PC suppresses all output.

Documentation

The GPSS/PC user manual is not, and does not claim to be, an introduction to GPSS programming. Minuteman has very wisely chosen to recommend standard texts on GPSS to beginners (see the bibliography). The manual is a useful and well-written document that supports the software. Minuteman also makes the *GPSS/PC Newsletter* available to registered users at no charge.

Conclusion

GPSS/PC makes a serious contribution to simulation software by introducing interactive concepts into the model-development process. The differences between GPSS/PC and GPSS V are minor. Most experienced GPSS programmers will quickly learn to take advantage of the special features of GPSS/PC. ■

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Schriber, T. J. *Simulation Using GPSS*. New York: John Wiley & Sons, 1984.

personal computer IBM has ever made.

The Toshiba P1340 Printer

This fast high-density dot-matrix printer has few type fonts available

BY RICH MALLOY

Printers seem to be the fastest changing segment of the personal computer industry. Every year some company seems to come out with a new way to put words on paper. And perhaps the fastest changing item in the printer industry is the dot-matrix printer. The output from these printers now ranges from barely legible to exact typewritten look-alikes.

The Toshiba P1340 is a good, medium-price, high-density dot-matrix printer. It claims a draft-mode speed of 120 cps (characters per second), and in high-quality mode, it composes each character on a high-density matrix 36 dots wide and 24 dots high. It can draw graphics at a dot density of approximately 180 dpi (dots per inch). At a list price of $799, the Toshiba competes with the Epson FX-80+ and the Texas Instruments Model 855, both of which have similar speed, dot density, and price.

Unfortunately, the Toshiba does not offer as many type fonts as these other two printers. Also, at the present time relatively few software publishers have adapted their graphics software to run with this new printer. By the time you read this, however, a number of good graphics packages should be available for it.

Description

In terms of size and noise, the Toshiba is very much like its close competitors. It fits well and attractively on a desk or a small printer stand. It is noisy when printing, but it will not drive your office mates out into the hall with their hands cupped over their ears.

The Toshiba comes with either a Centronics-type parallel or an RS-232C serial interface. I did not test the serial interface, but the information about it in the manual indicates that it is fairly well behaved (i.e., it doesn't use any unusual signal lines; presumably you will not have to go to the trouble of seeking out an expensive custom cable). The model I tested had a parallel interface, and it worked fine with my IBM PC.

Toshiba informs me that a free software package now available lets you run MacPaint, MacWrite, and Microsoft Word on the Macintosh with a serial Toshiba P1340. I have not tested this. [*Editor's note: You can obtain information regarding this software by calling Toshiba at* (714) 250-0151.]

Two paper-feeding mechanisms are standard with the Toshiba: a tractor-feed and a friction-feed mechanism. Both work fairly well.

Print Options

The Toshiba features only five different type fonts (see table 1 and figure 1). You can elongate each typeface to double width, which gives you a total of 10 variations. In comparison, the Epson FX-80+ has dozens of variations. The Toshiba fonts you will probably use most are high-quality Courier, which has 10 characters per inch (cpi), and high-quality proportional. These fonts look very close to typewriter quality, but certain characters, such as the lowercase s, are clearly products of a dot-matrix print head. The Toshiba can underline characters, but the manual does not indicate any type of boldface, superscript, or italic print. You can double-print characters to simulate the effect of boldface, but these characters are not really bold enough.

Also, the Toshiba has its own dialect of control codes and graphics codes. You will probably have to keep a short list near the printer.

The printer uses the standard 96-character ASCII (American Standard Code for Information Interchange) set of characters. These occupy codes 32 to 127 (decimal). But, as is the case with many printers, the codes above 127 do not seem to conform to any standard. Codes 128 to 159 are not used. Codes 160 to 191 are for certain symbols and foreign characters. Codes 192 to 223 are also not used. And codes 224 to 255 are for block graphics characters. You

(continued)

Rich Malloy is the New York editor for BYTE *magazine. He can be reached at* BYTE, McGraw-Hill, *43rd Floor, 1221 Avenue of the Americas, New York,* NY 10020.

AT A GLANCE

Name
Toshiba P1340

Manufacturer
Toshiba America Inc.
Information Systems Division
2441 Michelle Dr.
Tustin, CA 92680
(800) 457-7777

Type
Dot-matrix impact printer

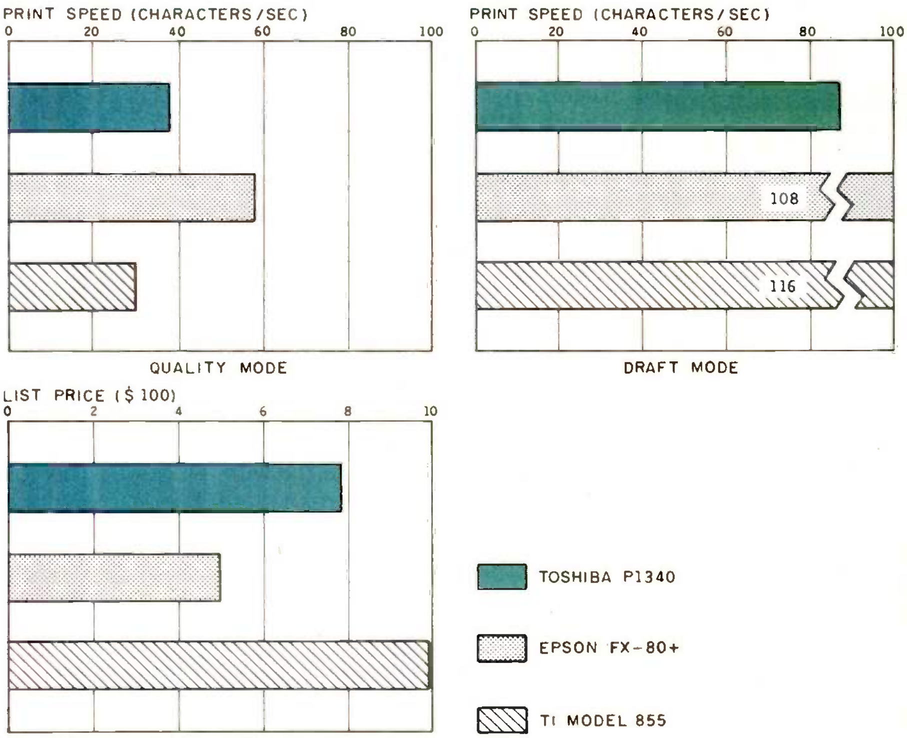
Size
16$\frac{1}{2}$ by 11$\frac{3}{5}$ by 5$\frac{9}{10}$ inches,
22 pounds

Features
High-density dot-matrix print
Highest speed: 120 characters per second (claimed)
Highest resolution:
text—360 dots per inch
graphics—180 dots per inch

Interfaces
Parallel or serial

Documentation
40 pages, 8$\frac{1}{2}$ by 11 inches

Price
$799



These graphs show a comparison of the Toshiba P1340 printer with the Epson FX-80 + and the TI Model 855 printers in print speed, list price, and print quality. We did not have the near-letter-quality option board (its list price is $219) for the Epson FX-80 +, so we used emphasized mode rather than near-letter-quality mode for it. The print speeds were determined by timing how long each of the printers took to print 50 lines of 80 As (see "The Art of Benchmarking Printers" by Sergio Mello-Grand in the February 1984 BYTE, page 193). The prices shown include tractor-feed mechanisms for each printer.

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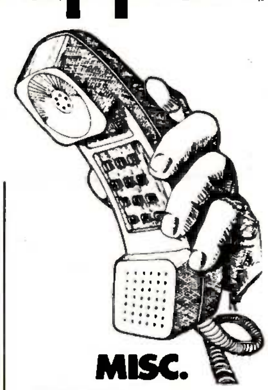

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Table 1: A *list of possible typefaces and speeds for the Toshiba* P1340 *printer.*

	Normal		Elongated	
	Density	Speed*	Density	Speed*
Font	Characters/inch	Characters/second	Characters/inch	Characters/second
High-speed—10	10	120	5	60
High-speed—12	12	144	6	72
High-quality—10	10	47	5	23
Proportional	11.6	54	5.8	27
Condensed	16.7	78	8.3	39

*These speeds are claimed by the manufacturer. Actual speeds might be 10 to 30 percent lower.

This is the Toshiba P1340 printer's letter-quality output.

This is the Toshiba P1340 printer's proportional font output.

This is the Toshiba P1340 printer's draft-quality output.

Figure 1: *Examples of the Toshiba* P1340's *type fonts.*

can use the block graphics characters, which Toshiba calls coded graphics, only in the printer's high-quality mode.

The Toshiba has four international character sets: the above-mentioned ASCII, British, French, and German. You select the particular set with a series of microswitches inside the printer. These sets do not contain any different characters; they are merely rearranged.

The printer has the potential for good graphics (180 dpi horizontal and approximately 144 dpi vertical), but I did not have any software that was compatible with it. Also, the print head apparently heats up during graphics printing. The manual contains the warning: "When you must print graphics continuously, be sure to pause the printing for at least one minute after each 1/6 page is printed (assuming a 10- by 11-inch page), and repeat less than five minutes." I'm not sure exactly what that means, but it sounds as if even a simple Lotus 1-2-3 graph might take at least six minutes, or you will burn out the print head.

Speaking of the manual, it leaves a little to be desired. All the vital information is in the documentation, but it could be presented more logically. For example, here is how the manual defines the "Define Vertical Spacing Increments" command: "This command is used to define the height of a line space in 1/48-inch increments. However, the actual physical line space in the P1340 dot-matrix printer is defined by 2½ times (C1)(C2) in 1/120-inch increments. That is, odd-numbered increments of 1/48 inch are approximated to the nearest 1/120-inch movement."

A few examples might have helped explain what this means, but not one example was included—a much too common fault in printer manuals. Fortunately, the manual does have two sample BASIC programs in the appendix that illustrate the various type fonts and a simple graphics application.

Conclusion

The advantage of a high-density dot-matrix printer is that you can do high-quality text printing, high-speed draft printing, and graphics all on one machine. Also, the price is fairly reasonable. But for the same price or a little more, you can probably buy a low-cost daisy-wheel printer with almost perfect type quality and a low-cost dot-matrix printer with very high graphics compatibility.

For those who want to have only one printer, who do not require a large number of different fonts, and who are willing to take the chance that some graphics software packages might not be immediately compatible with this printer, the Toshiba P1340 might be a good choice. [*Editor's note: Toshiba has informed us that an enhanced model of this printer should appear about the end of this year.*] ■

R·E·V·I·E·W F·E·E·D·B·A·C·K

THE WORD PLUS

George Sheldon's review of The Word Plus spelling checker (June, page 393) is missing basic information. As the author of the spelling checker in T/Maker, I judge a program based on the total time of the checking/correcting process and disk space requirements. The review didn't mention disk requirements and gave only a single time—the scanning and look-up time for one rather large document.

A spelling checker review should give the time required for the program to scan the document and for the user to check and correct the flagged words. A dummy document with five flagged words, of which three are accepted and two are corrected, would do the job. This should be done for a large document and for a short memo. Even good spellers make typos, even in short documents. A spelling checker should be attractive and quick enough to be used on short notes.

Big dictionaries take a lot of space. This can be critical on a floppy-only system. A review should indicate how much space is required. If large user-generated dictionaries are possible, their space and time-to-scan requirements should be noted. A review should also note how long it takes to add words to the dictionaries.

Finally, the special features of a particular spelling checker might be more important to some people than just checking spelling. This review mentions customizing a small dictionary for a writer of children's books and using the dictionary for word puzzles. Some spelling checkers can make indexes or concordances, or do batch replacement of abbreviations with whole phrases.

Mr. Sheldon's article was better than the average spelling-checker review. However, it didn't give the necessary information to help someone decide whether or not to purchase this particular package.

THOMAS W. MORAN
Bethesda, MD

The Word Plus review was especially interesting because it brought home the pricing discrepancy in software offerings.

I have a spelling checker, Fleet System 2 from Professional Software Inc., that has a dictionary of 75,000+ words. That's almost twice as many words as The Word Plus. In addition, Fleet System 2 has more features of value to a writer. Fleet System 2 not only lists the number of times each word is used in a document, but the number of different words used, of unique words, of sentences, and of paragraphs; the average word length; the average number of words per sentence and per paragraph; and the average number of sentences in a paragraph.

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The price that I paid for Fleet System 2 (word processor and spelling checker) was $49.95 with a backup disk. The price difference between Fleet System 2 and The Word Plus ($120) certainly ought to provide BYTE readers with a caveat.

JOHN ULLMER
Boerne, TX

JRCAPTAIN INFORMATION

In response to the inquiry by P. M. Moretti (July Review Feedback, page 299), I have an expanded PCjr with a Tecmar jrCaptain that gives me a total of 256K bytes of RAM; up to 128K bytes can be partitioned as a RAM disk. I also have the IBM internal modem for the PCjr and use PC-Talk for communications software. In downloading files from our university's mainframe, which operates as an IBM 370, I too have experienced trouble. During the time that PC-Talk is writing to disk, I lose six characters. The same loss occurs when downloading from a university VAX operating under UNIX. I suspect the problem is that neither remote computer recognizes the XON/XOFF convention that PC-Talk uses to try to temporarily halt transmission of the file.

One way to eliminate the problem is to use a larger modem buffer. Another way is to get the PCjr to write more quickly to the disk or to stop suspending data reception while writing. I tried to eliminate the problem by having the system write to a RAM disk instead of to a floppy, but I had problems. PC-Talk resides in the first 128K bytes of memory after being loaded from a floppy disk. The largest RAM disk that I could partition in this configuration was 32K bytes. Anything larger resulted in an error message that the program was too large to reside in memory. (A similar message occurs if I place PC-Talk on a 128K-byte RAM disk and try to load it from there.) When PC-Talk tries to write to the RAM disk, a message appears that there is a media error.

The Tecmar board itself works well and the PCjr is a dream with the second drive. System programs such as a word processor are placed on the RAM disk. Data files are on the floppy disk. The system works quietly and very quickly.

NELSON POLE
Chagrin Falls, OH

GENEVA PX-8

I was disappointed that BYTE published the letter from Gregor Owen in July's Review Feedback (page 300) without confirming his statements. His comments regarding the Epson Geneva PX-8 and its review in BYTE (February, page 302) are at best misleading and often inaccurate.

The most glaring error is stating that one cannot transfer WordStar text files to another computer. I regularly transfer WordStar files from the PX-8 to my Kaypro using TERM in the Epson and MODEM7 in the Kaypro without any difficulties. This ability also solves any of the printer problems, since once the files are in the Kaypro, the full range of printer options is available.

Because of its limited storage, the PX-8 does not make a very good stand-alone computer, but the file-transfer capability makes it a good second computer at a competitive price.

BRUCE R. ROTHWELL
Seattle, WA ■

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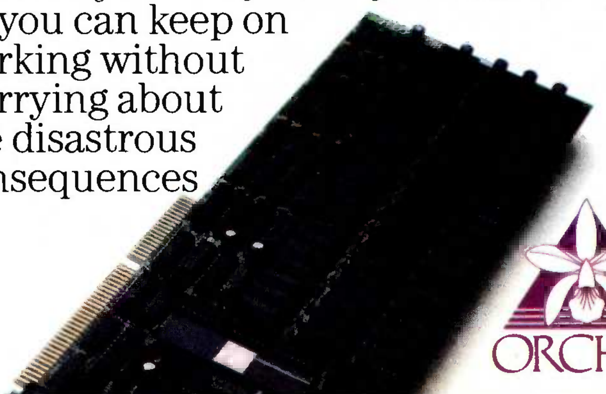

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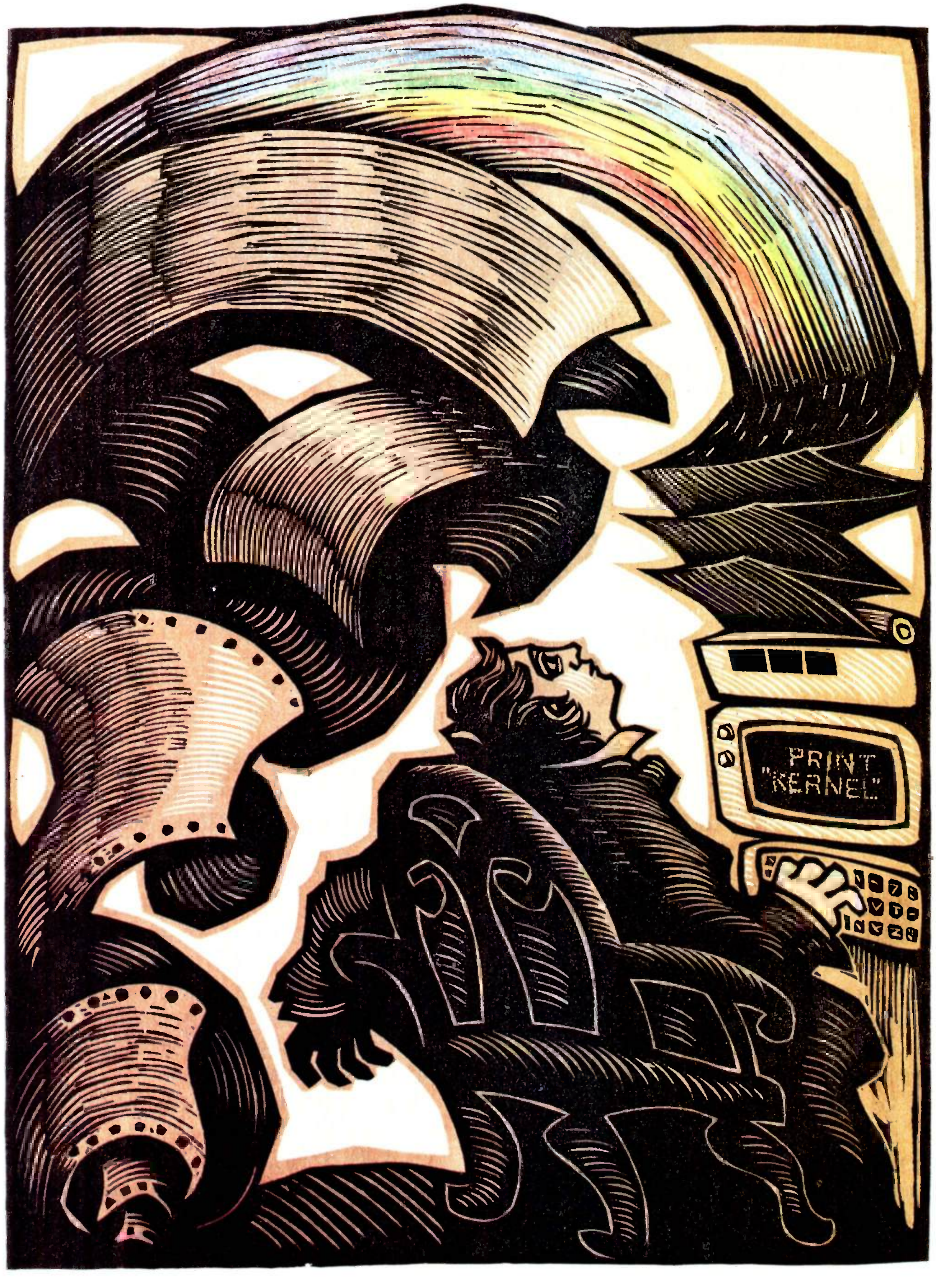
PRINT
"KERNEL"

Kernel

THIS MONTH FINDS JERRY in an upbeat mood. Although a few minor details remain to be finished, the construction at Chaos Manor is done. Also, he and Larry Niven have a genuine best-seller in *Footfall*. In his column, Jerry discusses two new computers, learns new things about the Printer Optimizer, discovers Ampro's Little Boards, and starts to become a BIX addict.

In last month's column, Bruce Webster briefly discussed the Amiga and predicted success for it. He has now had some experience with the machine and is so impressed with it that he thinks it will sell in large numbers. Bruce also looks at more Macintosh products and a couple of information services.

In BYTE U.K., Dick Pountain reviews two expert-system shells. In reviewing Expert-Ease, Dick set up an expert system to identify edible fungi; the knowledge-acquisition phase involved simply typing in descriptions of fungi from a textbook. The other expert-system shell he looked at was Tess, which is one of the many shells that has been influenced by EMYCIN. They work on the principle of providing a high-level language in which the user writes the rules that make up the knowledge base. Helix Expert Systems recently notified Dick that Tess has been changed slightly and it is now being sold under the name Expert Edge in both the U.S. and U.K.

In May, Bill Raike attended the Tokyo Microcomputer Show, where he saw two new portable computers from NEC. He concludes that the PC-98XA is a well-thought-out adjunct to the popular PC-9800 series of machines, with outstanding graphics capabilities. The PC-9801U2 has 3½-inch microfloppy-disk drives that can hold up to 640K bytes each. In this month's BYTE Japan, Bill describes the two new NECs in more detail and tells us about other products he saw displayed at the show.

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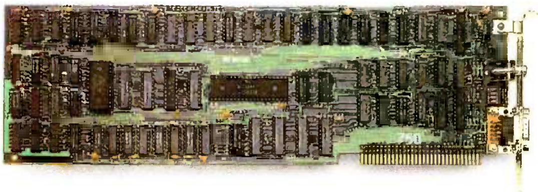
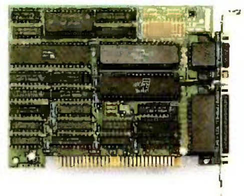

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BY JERRY POURNELLE

It's finished. A few details remain, like bookcases and the rolling ladder, but by and large the rebuilding of Chaos Manor is complete. I'm writing this from my new office, and although there's junk piled everywhere, nothing has been sorted out, and much of my life remains in storage boxes, withal it's wonderful. The sun is shining, there's not a bad view from any window in my office, I've returned safely from a publicity tour through Silicon Valley and points north to find new machines to play with, and *Footfall* by Niven and Pournelle is on the best-seller list. Marvelous.

The fly in the ointment is that I don't think I ever had more to write about, but I've got to cut back on the size of the column; something about the number of editorial pages and making up for the size of the 10th Anniversary issue. It wasn't my idea. There's even a silver lining to that cloud: those who truly want to read more of my ravings will get the opportunity through BYTE's new BIX network, about which more later.

KAYPRO STRIKES AGAIN

Way back when the Kay family first brought them out, I dubbed Kaypro machines the "Chevrolet pickup trucks of the micro industry." This was partly to contrast them with the Osborne 1, which I considered analogous to a VW; but even after the Osborne went west, it was no bad description. Kaypros have never been very pretty, but they're as useful as a pickup truck and about as reliable.

So far we've had at Chaos Manor a Kaypro 2, a 4, and a 10, every one an early model; and every one of them still works after hard service with low repair and service costs. To illustrate: we still have an IBM Selectric typewriter because my senior editor, John Carr, prefers it to a computer for general office work. I pay IBM around $100 a year for a maintenance contract for the Selectric. This is hardly unreasonable—but repairs to all three Kaypro machines haven't run that high. I continue to recommend the Kaypro as a great beginner's machine that will remain useful long after you've become an expert.

Kaypro has never been thought of as glamorous; but just as Chevrolet has sports models, Kaypro has brought out the 286i, an IBM PC AT clone. We've had ours, Big KAT, for nearly a month. It has been moved three times, lived through floor sandings and other activities that create dust, and been operated by people utterly unfamiliar with MS-DOS 3.0; and it has responded heroically.

I haven't had the chance to test everything, but so far I have not found a PC program that the Kaypro 286i won't run. That includes not only games but a program that explicitly says it might not work on an AT or under GW-BASIC, namely, Jim Baen's rather wonderful Quikscreen. It also runs XyWrite. More about Quikscreen and XyWrite later.

There's an awful lot to like about Big KAT. For example, it runs both monochrome and color programs; indeed, it runs SideKick in color while running monochrome programs. The screen is nice (I have the optional Kaypro monitor), the letters are well-formed, the keyboard is *very* pleasant to use, and I could see myself writing on this sucker all day.

There are annoyances. For one thing, the cursor is a blinking underline. I do not like blinking underline cursors. What I really want is a transparent nonblinking blob. Of course, there may be a way to get Big KAT to give me that; although most of the construction work here is done, there are enough interruptions to keep me from spelunking in the Kaypro manuals.

For all that: when we moved upstairs, I brought Big KAT, leaving Lucy Van Pelt, our fussbudget genuine IBM PC, downstairs for the boys and the staff. I've been doing considerable programming on Big KAT: things like revamping my accounting program and

(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.

getting Mrs. Pournelle's reading-instruction program to fly. I've yet to crack the manual except to look up DOS (disk operating system) commands; and everything is working splendidly.

I also play games (to test PCompatibility, of course). So far we haven't found any that don't work—although sometimes Big KAT is a bit *too* fast for certain games, as for example Gato, which zooms along so that it seems more like being in a PT boat than a submarine. On the other hand, games with lots of calculation, like Avalon Hill's Incunabula and Cygnus's Star Fleet I, become much more enjoyable when played on a fast machine.

You'll be hearing a lot more about the Kaypro 286i in future columns; meanwhile, if you're looking for a PCompatible machine with a lot of pluses, you can't afford not to look at the Kaypro.

The AT&T Safari Group

Thinking about AT&T reminds me of the story about the old millionaire who was told that his playboy son lost a million dollars last year. "How long can he keep that up?" the financial analyst asked.

The millionaire leaned back, thought, and said, "About 84 years."

AT&T has technology, determination, and a *very* deep purse. The company can survive a lot of marketing disasters; and eventually you just know that its people will come up with a hit.

You can't ignore AT&T, but I find that visiting their exhibits at COMDEX can be a bit disconcerting. These expositions are held in Atlanta in late spring and Las Vegas in the fall: hot weather. I generally wear a short-sleeved bush jacket, which is no problem in most places; but everyone in the AT&T exhibits is dressed in dark pinstripes. Worse, most of their extremely polite young men and women have never heard of BYTE, much less of me, and seem a bit uncomfortable about the kinds of questions I tend to ask.

Thus, imagine my surprise when at Atlanta COMDEX last spring I found a chap wearing an AT&T badge, dark suit—and a necktie made of *camouflage cloth*. I stared. He laughed. I stared again. He introduced himself: Fred Hicinbothem. He'd been reading BYTE, and this column, for years.

It turns out there are a number of them. They worked on the AT&T UNIX PC, which had an internal code name of Safari; and when the project was complete, they went out and bought a bolt of camouflage cloth and sewed it into neckties. Thus, if you ever see that necktie at an AT&T booth, you can be sure the wearer is from AT&T Information Systems, which used to be called Bell Labs, the outfit that comes pretty close to being the long-range technical development shop for the human race. You can also be sure you're in the presence of a wizard thought bright enough that the company will overlook sartorial irregularities.

Anyway, the end result of my encounter with the Safari necktie was an offer of an AT&T UNIX PC. It arrived during the tag end of the construction here and didn't get uncrated until last week, so I haven't a lot to report. It has been dubbed Bellerophon. There's a pile of software, including some applications stuff, but mostly it's a UNIX hacker's workstation and development tool, for which it ought to serve quite nicely. However, there's also a pretty fair shell around the UNIX system, with pop-up menus and the like, giving the machine a decidedly Macintosh-like flavor; and some business stuff like file/database and the like.

So far, Bellerophon has really been used for only two purposes. My son Alex is a UNIX hacker; he very much likes the machine. He glues himself to it at every opportunity, although I suspect it's largely to play Rogue, a game of unimaginable fascination. Second, I've been using the machine to access the BYTE BIX network for my practice sessions. Prior to using the UNIX PC, I'd installed our Omni-Tel internal 1200-baud modem in the Kaypro 286i; that worked splendidly, and I wouldn't have changed over, except that Bellerophon's green screen

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Note All prices subject to change without notice. Mention this ad. Some prices are specials. Ask about COD and POs. All format's available. UNIX is a trademark of Bell Labs is somewhat easier to read than Big KAT's. Besides, the UNIX PC came with a built-in two-line modem and communications software. I'm neither a C hacker nor a Rogue player, and I wanted to *use* the machine for *something*; communications seemed a natural.

I still use it, and I like it; but there is one interesting bug. It won't hang up. There's a hang-up command, but when I invoke it, the machine reports that it can hang up only active calls. The problem is that it is *in* an active call.

Second, you must tell the UNIX PC which of the two incoming phone lines is for data and which for voice; and although you can—and indeed must—set up a pretty complete file before you can call and make computer contact, you cannot specify which phone line to use as the data line. Instead, you must run the mouse about until you have told the machine that one line is a data line; after which you can't change it back to voice until you've hung up. I'd prefer software that would let me specify what I wanted and work accordingly. Indeed, since the machine has a rather good internal clock, it would be no great trick to have it switch one of the lines to "data" at certain times of the day, or whatever.

Worse, though, the only reliable way to hang up is to physically remove the little modular phone plug from the back of the machine. That's awkward. (I've reported this to the designers, who assure me that the next release will have it fixed. So far, I've found the AT&T design team extraordinarily interested in user feedback. We'll see how high up the policy ladder that interest extends. Meanwhile, Shift-Exit will hang up a data line. I don't know why that wasn't obvious to me. . .)

The UNIX PC comes with *tons* of documents. You don't really need most of them because the built-in software has plenty of help files and menu prompts; I never had to open a document to set my communications files and such like. You should read at least the opening chapters, though. One of the first things the documents tell you is not to turn the machine off if you can help it; but if you must do it, go through a shutdown procedure. That's all very well, but power is not always reliable, particularly when they're constructing; as luck would have it, not long after I started using Bellerophon, someone tripped a circuit breaker.

It almost drove the machine nuts. When you turn on the UNIX PC, it boots automatically; but it's a long procedure, nearly five minutes. One thing it does—or says it does—is to examine the files to see that they're intact. After the power glitch, Bellerophon powered up and said it was

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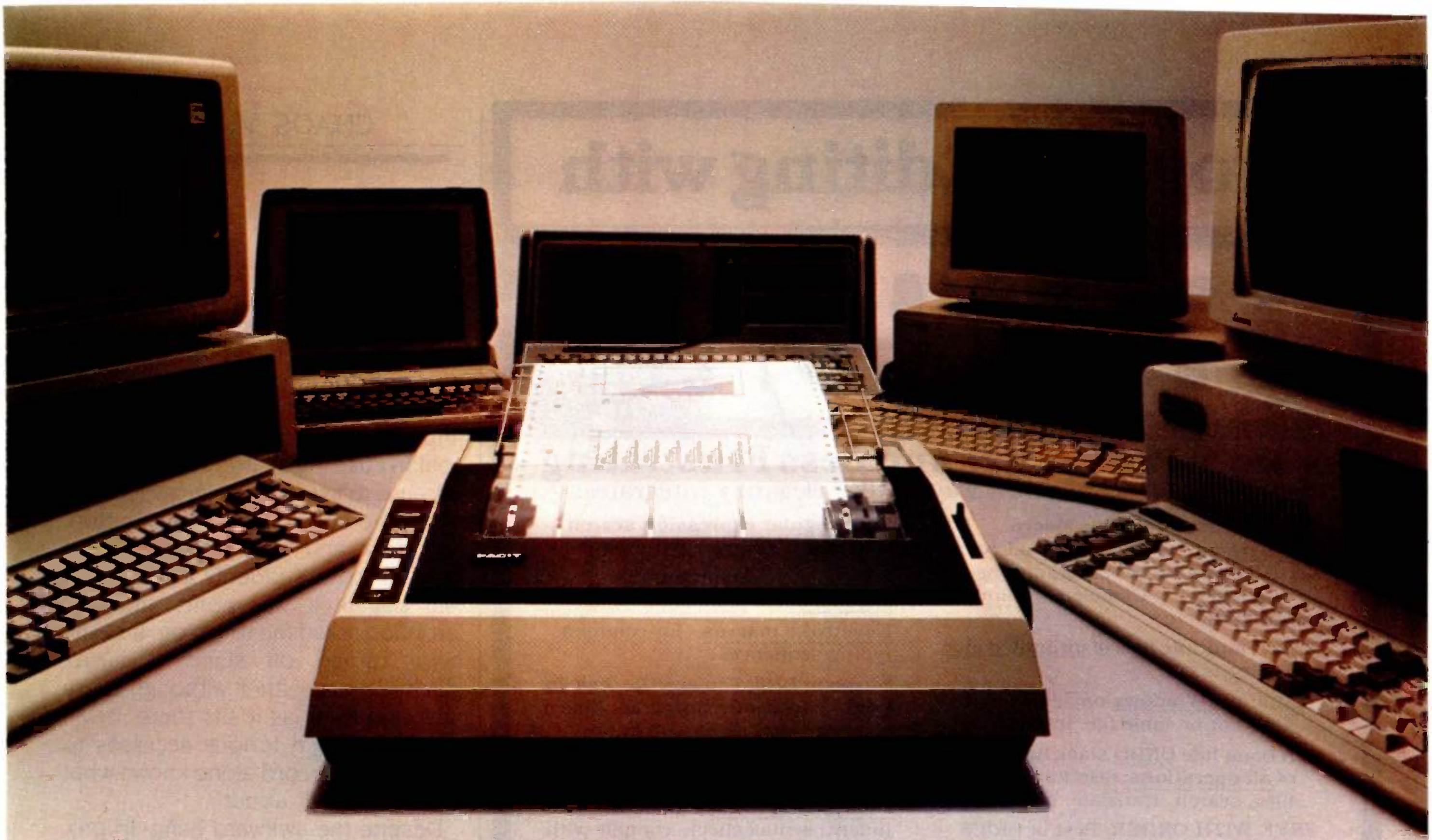

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checking the files; began to talk to itself; flashed a screen full of garbage; and rebooted, to go through the whole procedure again.

This happened 14 times. I tried shutting off the machine (of course I couldn't use the shutdown procedure, because to use that you must successfully have booted), the Reset button, and dark and powerful magic. No help. Then, as suddenly as the problem began, it was gone, and Bellerophon asked me to log on. It hasn't been turned off since. It hasn't glitched since, either, although every now and then, as it sits there, it will suddenly begin furious accesses to the hard disk. Lord alone knows what it talks to itself about.

Despite the awkward hang-up procedure, I prefer Bellerophon to Big KAT for communications; this may have more to do with the locations of the two machines than anything else, but I don't think so. Mostly I just *like* the machine, which seems to be everything the Fortune 32 ever promised to be, only the UNIX PC has real working UNIX and the closest thing to a user-friendly UNIX shell that I've ever seen.

I would prefer a longer (or less stiffly coiled) keyboard cord. You're not supposed to turn it off, ever, but there is no automatic screen blankout such as you find on good terminals like the Ampex. There's no auxiliary power outlet. Despite such minor annoyances, all in all it's a handsome and impressive little machine that, given some decent software, may become very popular. Ashton-Tate and other software houses have announced their intention to support it, and there are lots of UNIX hackers out there who'll love this little beast; I'd say the chances for a flood of software are pretty good. It's hard to predict hits in this business, but AT&T will inevitably have one someday, and this just might be it.

Optimizing the Laser Printer

I've had Applied Creative Technology's Printer Optimizer for a couple of years now. Mostly we used the

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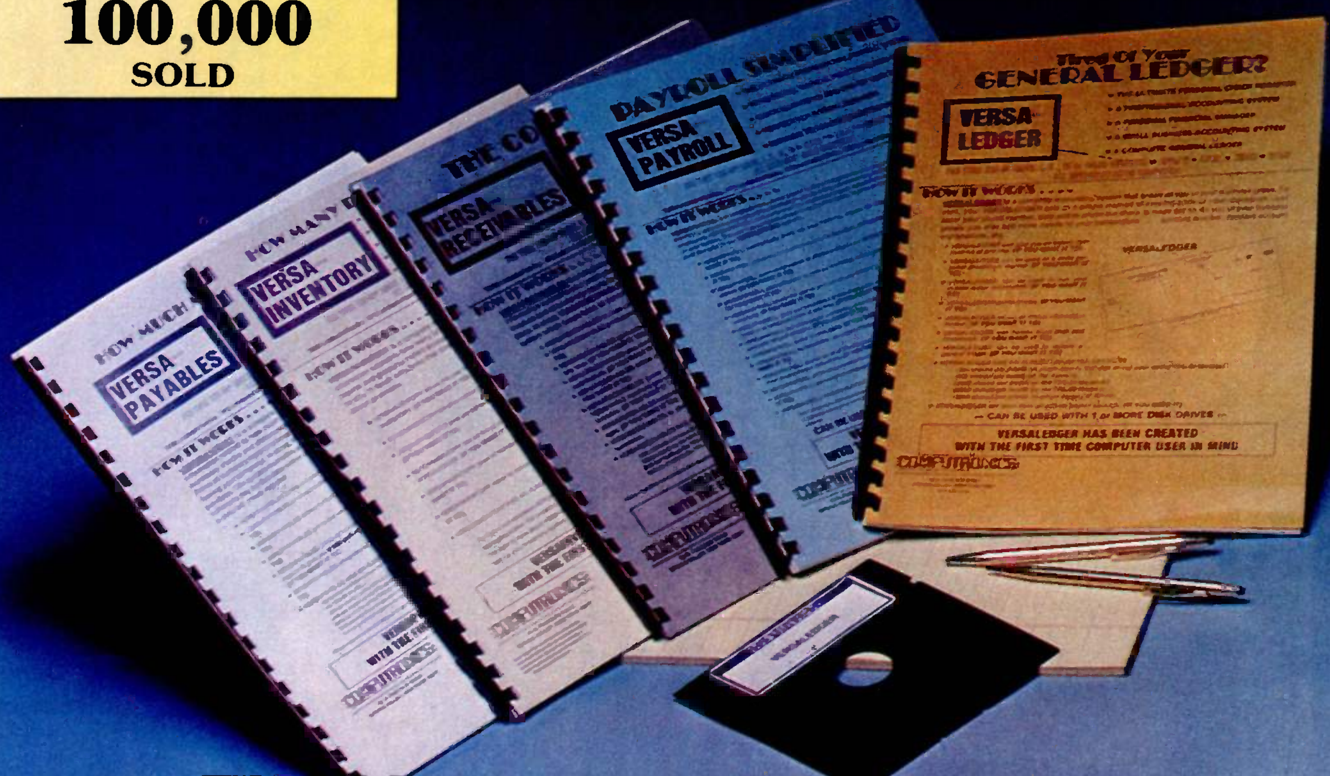

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Optimizer as a printer buffer. That is, among other things the Optimizer is a box full of memory that your computer thinks is a very fast printer. The computer sends out the print job at 9600 baud or more; the Optimizer stores it in up to 256K bytes of memory and doles it out to the printer at the printer's normal pace. The result is that pretty soon the computer thinks the print job is done and reports for other duties.

When we got the Hewlett-Packard LaserJet laser printer, I saw no real need for the Optimizer because the LaserJet works at 9600 baud anyway. That wasn't very intelligent. The Printer Optimizer is a *lot* more than a printer buffer.

Trivial example: Don Castella from the Chicago outfit Disks Plus came over the other day to show me a new machine based on the Ampro Little Board. Came time to connect to a printer. We had two choices: serial or parallel. Parallel is simple enough, but the cable wasn't long enough unless I wanted to move the LaserJet, which I didn't. Serial connection is usually a black art—except that with the Printer Optimizer it isn't, because all the pins of the RS-232C cable are switchable inside the Optimizer, making it a snap to connect up nearly *anything*. It took Castella about two minutes to get things humming.

That, however, isn't the real value. The LaserJet has some fantastic capabilities. Plug in the right font cartridge, and the LaserJet does some *really* fancy printing, provided, of course, that you send it the exceedingly complex series of control and escape characters to tell it what to do.

With the Optimizer that's simple. The Optimizer has a keypad on the front; you use that like a telephone auto-dialer, except that instead of telephone numbers, you program in the various escape sequences to control the LaserJet. For example, you can set things up so that you dial "1" for Courier 10 pitch, "23" for boldface, "45" to print sideways, and so forth. Tim Wilde, president of Applied Creative Technology, has written complete instructions for how to do that; they now come with the Optimizer.

There's more. You can program the Optimizer simply by sending it a plain ASCII (American Standard Code for Information Interchange) text file from your computer: meaning that you can have as many different sets of auto-dial codes as you like, each stored on disk. The "programming language" is absurdly simple and has provision for comments so that it's simple to give orders to your printer. Examples: you can enter a translation table so that you can make the LaserJet do things

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that your text editor does not know how to do. You can even store a graphics letterhead, which the Optimizer prints out on command. All this stuff is stored in a battery-backup memory chip and stays until you send in a new table.

You can dial "landscape" so the LaserJet prints sideways: 9.6 lines per inch so that it does 66 lines on the page (sideways); and print out spreadsheets. Put little forms into the LaserJet so that it prints stuff in boxes. Overstrike. Have a translation table that puts a strike bar through the zero whenever it sees a zero. Use the European character set. Print the odd symbols that the LaserJet knows but that most text editors can't find.

All that and more. Of course, the Optimizer can also control an NEC Spinwriter (which has some odd alternate characters that most editors can't find) or indeed *any* printer that wants special control and escape sequences. You program the Optimizer with a simpleminded straight text file that has statements like (1 = 27, 40, "sOS"); your computer doesn't have to be able to send anything other than simple text, meaning that the Optimizer can cause the LaserJet to print stuff that you cannot display on your computer screen and your computer cannot send out.

Another feature, valuable for DisplayWrite users: DisplayWrite supports only the NEC 3550, but with an Optimizer you can put in a translation table to convert the NEC escape sequences to those digestible by the HP LaserJet.

Adapt printers to AutoCAD. Daisywheel printers for the Macintosh. LaserJet for almost anything. All possible with the Optimizer.

I've known the Optimizer's secret for only a week, and already I'm beginning to wonder how I ever got along without it. Highly recommended.

Begging Off, with Joystick

I said above that I never had more to write about, and it's true; but, alas, one thing I promised for this month didn't get done. I haven't done a comparison of the HyperDrive Mac versus a MegaMac with the Corvus hard disk.

Both work, and work darned well. Add the OmniTel external modem, MITE communications software, and the Printer Optimizer so that the Mac can talk to any printer you like, and the Macintosh becomes a really powerful and useful critter.

It's especially powerful if you have Microsoft Excel. My word, that's a great program. Longtime readers must know I'm no MacEnthusiast, but if I had to do lots of spreadsheet

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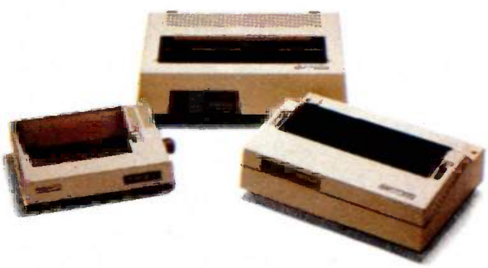

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work, I'd use Excel even if I had to buy the Mac to get it. The IBM PC AT equipped with Lotus 1-2-3 may steam with power—a recent article about Lotus said it did, anyway—but I'll take Excel every time. One word of caution: I have a prerelease Excel. I've found no bugs, but I haven't done a lot with it, either. As usual, the documents could use improving, but Excel is so darned intuitive—it really does take advantage of the Macintosh operating system—that documents aren't as important as they were in the early days of this column.

One great addition to the Mac is the Kraft Mousestick. This wonderful little gadget attaches between Mac and mouse. The mouse remains as before, but now you have a neat joystick, just right for games and those who think mice mostly useful as cat food. The Kraft Mousestick has switches to make it lock into four-way or eight-way mode and a centering bias adjustment. It works smoothly and unobtrusively; great for Wizardry I and other games where you want to lean back in a big chair. Recommended.

AMPRO LITTLE BOARDS

I had met Don Castella at Atlanta COMDEX. His primary activity is putting together "minimum" systems; and he was somewhat upset by all the space devoted to the Companion (May, page 313) because he was certain that systems built around the Ampro Little Boards were *much* better. Worse, I found later, I must have been one of the few people in western civilization not to know about the Little Boards; certainly my son Alex was surprised that I hadn't heard of them.

The upshot was the visit to Chaos Manor by Castella and Bill Dollar, the president of Ampro. Before they were done, I was impressed.

Little Boards are small single-board computers designed to be the same size as a 5¼-inch disk drive, meaning that you can put together a full Z80 machine, with 64K bytes of memory, disk controller, power supply, etc., and stuff it into a tiny footprint. It's quite a concept, well-designed and well-

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made. Dollar calls his Little Boards "power tools for designers"; it's no bad description.

Don Castella is a tool user. He brought out a fancy system with two floppies and a hard disk; it's still smaller than any single component of Zeke II, the machine I'm writing this on. Don Castella can put together systems ranging from the tiny minimum single-drive unit that sells for about $900, to the fancy thing he brought me (less than $2000 with Xebec hard disk). He has also scoured the earth to find good software. His Little Board systems come with ZCPR, XMODEM, and a whole fleet of other public-domain programs that make life easier for users. One of those, plus a good terminal, would make one heck of a good system for writers.

As it happens, I'd received a new and improved version of WRITE, my favorite text editor, just before Castella arrived; and since WRITE is an 8-bit CP/M program, the obvious thing to do was put WRITE on Castella's machine and see what happened. Therein lies a tale.

I have new software from Viasyn. It's supposed to let the CompuPro 286/Z80 talk to almost *any* disk format. My first idea was to take WRITE off the CompuPro and put it directly on Castella's Little Board box.

No go. I do not have the latest and greatest versions of the new CompuPro Concurrent software. What I have is impressive enough, and indeed it feels good to get back to the hardware state of the art, but just at the moment the experimental software I'm running has a glitch in the 5¼-inch disk department: I can't get it to write small disks that other systems read. The 8-inch drives give no problem, and the CompuPro with Concurrent is *fast* like anything. It's still my mainstay system. Alas, though, it was useless for putting WRITE on Castella's machine.

On the other hand, Ampro Little Board machines can read a variety of disk formats, including Morrow, Kaypro, and lots of different Zenith machines. I certainly have WRITE for the Z-100, and, in fact, Zorro, our Z-100, has 8-inch disks as well as the 5¼-inch he came with. Aha, thought I. The job's simple after all.

Nope. We let the Ampro format disks in Z-100 format. It does that. Zorro had no trouble reading those disks or writing to them; but the Ampro wouldn't read them. I then had Zorro format a disk and copied from the Ampro-formatted to the Zorro-formatted disk. No trouble. Software runs in the Z-100 from either disk; but the Ampro won't read what Zorro wrote. At this point something between despair and disgust set in.

Enter my son Alex, who came over to deliver a new Zenith 19-inch color

(continued)

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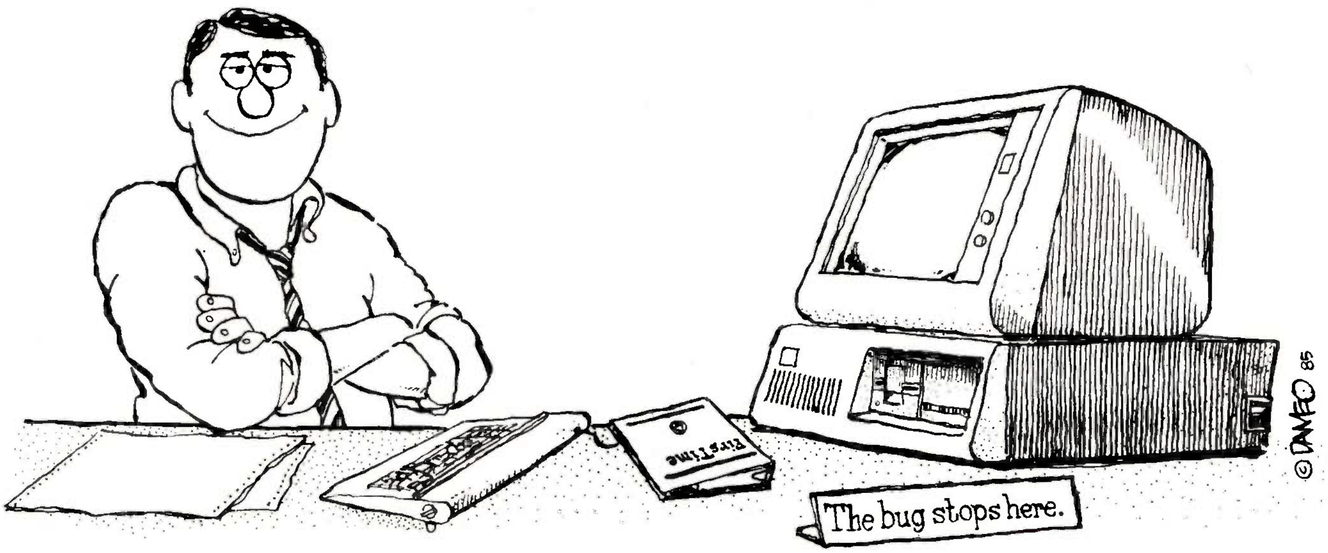

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Inquiry 319

monitor he'd bought me at a closeout sale. I explained the problem.

"Why don't you use Disk Maker?" he asked.

"To do what?"

"To put the files in Little Board format."

"Because I didn't know Disk Maker *knew* about the Little Board format."

"Well, it does," said Alex, and he proceeded to prove it. Disk Maker I, incidentally, is a special-purpose computer that can translate just about any disk format to just about any other. Ours is an S-100 board that resides in Zorro the Z-100 and is connected to its own box of both 48- and 96-tpi (tracks per inch) 5¼-inch drives; it can also take stuff off Zorro's 8-inch drives. Disk Maker I is *wonderful*.

Anyway, Alex put a lot of my favorite files into Little Board format, and we had no trouble putting them into the new Ampro; and they all run fine. Castella brought a new Ampex terminal to go with the Ampro computer. I'd never seen one before. It has a *large* (14-inch) amber screen, good keyboard (except that the Backspace key is in the wrong place), and emulates several other terminals, including a TeleVideo 950. I like it; good keyboard, good character set, and it talks to the Ampro at 38k baud with no hitches; that scrolls about as fast as my memory-mapped video.

We used a copy of WRITE configured for the Telewidget, and it ran like a bomb, except for one glitch: in order to blank out the twenty-fifth, or status, line of the Telewidget, WRITE fills it with spaces. The Ampex terminal automagically blanks out the status line (unless you ask for it); but if you do load anything into that status line, it's shown in reverse video. This means that the Ampex shows those spaces as a bright line. Of course, the simple remedy is to bring up the machine, load WRITE, and turn the terminal off and then back on. It hardly matters: by the time you read this, WRITE should have an Ampex option in the configuration program.

Anyway: the Ampro computer, Ampex terminal, and Xebec Owl hard

(continued)

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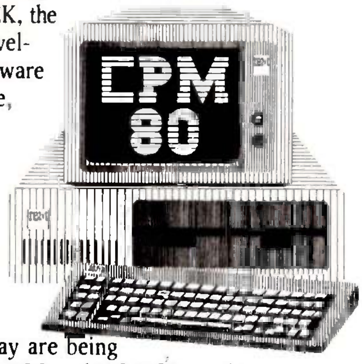

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disk make one heck of a writing machine, much fancier than my first computer and a lot cheaper, too. Moreover, if you don't like the Ampex terminal, choose one you do like. If you're not ready for a hard disk, get one with floppies. Systems built around the Ampro Little Boards have a great deal of flexibility.

Ampro also has a 186 board; I've held it in my hand, but I haven't seen it work. I strongly suggested to Bill Dollar that they ought to make an 8/16 board, with Z80, 8086, and 8087; and that they either build RAM (random-access read/write memory)-disk boards or make a deal with SemiDisk

(continued)

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so that you can get a Little Board system with battery-backed RAM disk (sometimes known as memory drive). That would *really* put "power tools" in designers' hands.

While Dollar and Castella were here, I came up with the notion of a minimum engineer's computer: something to take the place of the formerly ubiquitous slide rule. The ideal would be small, light, and have both heavy math and word-processing capabilities. I can see how to design one out of Ampro Little Boards; but I don't really do system designs. I sure hope somebody does. I've wanted one of those machines ever since I described the pocket computers in our novel *The Mote in God's Eye*.

QUIKSCREEN

Mrs. Pournelle's reading-instruction program consists largely of screen after screen of material, followed by some queries, followed by massive visual rewards for getting things right. It's simple enough to outline the program; but the screen management is a bit tricky.

Not anymore. Quikscreen by Robert Pirko and Jim Baen lets me build images in memory, then move them to any part of the IBM PC screen. It works with color or monochrome, windows or scrolling or both, and it's wonderful. You get standard BASICA source code that can be compiled with Microsoft's BASCOM; it's already linked with precompiled machine-language code that actually does the work. A full-screen change takes about a sixtieth of a second, meaning that it's simple to do animations on the PC using Quikscreen.

Quikscreen's documents are better than adequate; better yet, there are floods of example programs in source code.

I don't see how anyone doing BASIC programs for the IBM PC can do without Quikscreen. Highly recommended.

XYWRITE

I stubbornly continue to do my writing on an ancient Z80 largely because WRITE doesn't exist for PCompatibles. When I do editing on an IBM PC, I use WordStar 3.3.

A few months ago, though, my colleague Stefan Possony converted his establishment to a Corona PCompatible and abandoned WordStar for a new editor program called XyWrite. He was more than happy with it and particularly enjoyed its ability to handle footnotes and bibliographic stuff.

Jim Baen publishes science fiction and high-tech nonfiction books distributed by Simon and Schuster and has been one of my favorite editors

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> *The plan is to put stuff on* BIX *when there's not room in the magazine itself;* BIX *information will also be more current.*

for years. The other day we were discussing this and that on the phone, and XyWrite came up.

"Do you like it?" I asked.

"I sure do. It's as if WordStar died and went to heaven," Jim said.

The upshot is that I took out my copy and brought it up on the Kaypro 286i, which runs it just fine; so just this afternoon I took the program downstairs and handed it to Don Hawthorne, our new editorial assistant. Don has never used *any* text editor before. "Have an editor," I said. "See if you can get it running on the PC."

An hour later he was deep in the tutorial and seemed to be making out just fine. More next month, but it looks like XyWrite is here to stay.

BIX

This column is going in late. One reason for that is BIX, the BYTE Information Exchange, which is a kind of super conferencing party. I've been having a ball playing with it. The conferencing software isn't perfect—yet—and I had a few frustrations in starting up. Most of those were fixed as a result of my experience. BIX is already about as easy to use as any conferencing system I know, and by the time you read this, there ought to be lots of new features.

We're working on the details, but the plan is for a number of us to put stuff on BIX when there's not room in the magazine itself. BIX information will also be a lot more current. My mail stack is growing impossibly large. It's obviously physically impossible to interact with each of thousands of readers, but I'm hoping that the BIX system will let me deal with lots more reader comments and questions than I get to now.

Come join the party.

Winding Down

I'm out of space, and there's still a ton of stuff. Metacomco has a new Cambridge LISP 68000. The Zenith ZVM-136 color monitor is good enough for word processing when fed the right stuff, as for instance by the CompuPro S-100 PC Video board that makes your CompuPro 8/16 system compatible with 75 percent or more of PC software. I've got a Z-49 terminal; if you like Zenith terminals, you'll love this one.

There are two games of the month this time. The first hasn't even been published yet, but it should be out by the time you read this: it's the Expert Games Workshop Toolbox, a set of game-playing programs from Borland International. Mine came Federal Express with a note on letterhead "From the *disk* of Philippe Kahn." You get Turbo Pascal *source code* for expert chess and bridge players. I put the chess player up on the Kaypro 286i, and I guarantee you won't easily beat it. I made the mistake of using a standard opening, the Ruy López, and the machine nearly blasted my socks off. It's *fast* in openings. Pretty speedy in the mid-game, too.

Since you get source code, you can incorporate the Borland algorithms into games of your own design. Borland has another best-seller here.

The other game of the month has been BIX, which is so addictive that one day when the net wasn't working properly, I found myself moping. Ye gods. . .

Everything else has to wait. Next month, I'm going to be organized. ■

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE *Publications, POB 372, Hancock, NH 03449. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.*

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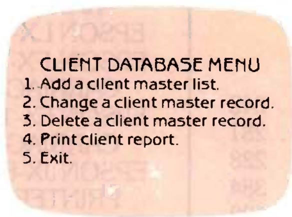

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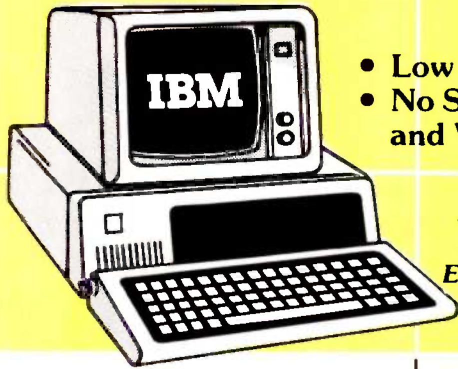

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C·H·A·O·S M·A·N·O·R M·A·I·L

Editor's note: Due to space limitations, we are able to publish only a sampling of the great amount of mail Jerry receives each month.

A FORTH FAN

Dear Jerry,

It seems to me that you are quick to place the blame for the failures of Valdocs on the fact that it was written in FORTH. First of all, as you have pointed out, Valdocs was written in STOIC, not FORTH. STOIC and FORTH are related only in that they are both threaded interpreted languages. Their kernels, however, are quite different in terms of available words, and even some of their basic control structures differ in implementation.

In your March column you pointed out that John Dvorak said that no good, fast programs had been written in FORTH and that he had Valdocs in mind when he made that statement. Apparently, both you and Mr. Dvorak labor under the same illusion.

FORTH per se is not to be blamed for the lack of speed and power apparent in any software that is written in it. Rather, the capability of the hardware to support a language like FORTH and the capacity of the programmer to use FORTH effectively are the measures of the worthiness of the use of FORTH for a specific task.

As far as I'm concerned, any FORTH code running on a Z80 processor is doomed to be slow, particularly if most of the kernel is written in high-level FORTH. To handle FORTH efficiently, a processor must support multiple hardware stacks and have a relative indirect-addressing mode. The Z80 has only one hardware stack pointer and no relative indirect-addressing mode. Therefore, at least one stack must be emulated in software, which is ghastly inefficient. The relative indirect-addressing mode must also be emulated. If the implementation of FORTH on the Z80 is the classical FIG (FORTH Interest Group)-style implementation, matters are made even worse by virtue of the use of indirect threading (the only slower method is token threading) and placing the link fields in the dictionary *after* the name field, as opposed to before (which means that the dictionary search code must traverse the name of the word whenever it needs to link back to the previous word—a slow process at best, especially on the Z80, and even more so if the TRAVERSE code is in high-level FORTH as opposed to machine code).

For processors that support multiple stacks and relative indirect addressing and have FORTH implementations that are designed intelligently (a tight-threaded implementation with link fields before name fields, lots of machine-code primitives, and many good extensions—decompilers, trace features, and so on), FORTH can be the best alternative to assembly language for sheer speed and memory-consumption efficiency.

If I were you, I would do some digging into FORTH before condemning it because someone wrote code in STOIC on a processor that wasn't stack-oriented and it turned out to be slow. Charles Moore's record-keeping system, I understand, is indeed a very good example of what FORTH can do. Also, take a look at Peachtree's accounting software—it's in FORTH, and it's the de facto standard in microcomputer accounting programs. Go to your local arcade and find an Atari machine that was manufactured in 1980 or later. The program in ROM is in GameFORTH, Atari's proprietary version of FORTH. You've been quite kind to Savvy in previous columns. Guess what Savvy was written in? Yup, you guessed it.

I also urge you to look into MacFORTH and/or Neon. MacFORTH is from Creative Solutions Inc., who have been doing 68000 FORTH implementations since 1979, and it is very good. Neon is from Kriya Systems Inc., known for typing tutor programs written in FORTH. Neon is Kriya's FORTH system (for the Macintosh) with extensions that make it an object-oriented system à la Smalltalk.

Better yet, perhaps, acquire HyperFORTH for your Stride Micro system. It's my understanding that HyperFORTH is called that for a good reason. I believe that if you examine the available FORTH implementations for *any* processor that has at least two hardware stacks and an honest-to-goodness relative indirect-addressing mode, you will find that FORTH is faster and more compact than any other language available with the possible exception of some of the better C compilers.

By the way, when are you going to give us the scoop on Modula Corp.'s MacModula-2? For $90 I suppose I couldn't go too far wrong, but I'd rather hear what you have to say about it first.

PAUL F. SNIVELY

Sigh: what we have here is another instance of the "generic language" versus "language implementation" problem. You want to make the case that FORTH can do some really neat stuff; I want to make the point that so far no one has used FORTH to write a good operating system for microcomputers.

FORTH is certainly plenty good for controlling robots. Chuck Moore says, and I believe him, that FORTH is also an excellent toolbox for a journeyman problem solver to attack problems with. I'm certain that one could design a computer to run FORTH in the same way that Lilith was designed to run Modula-2, and the results would be impressive.

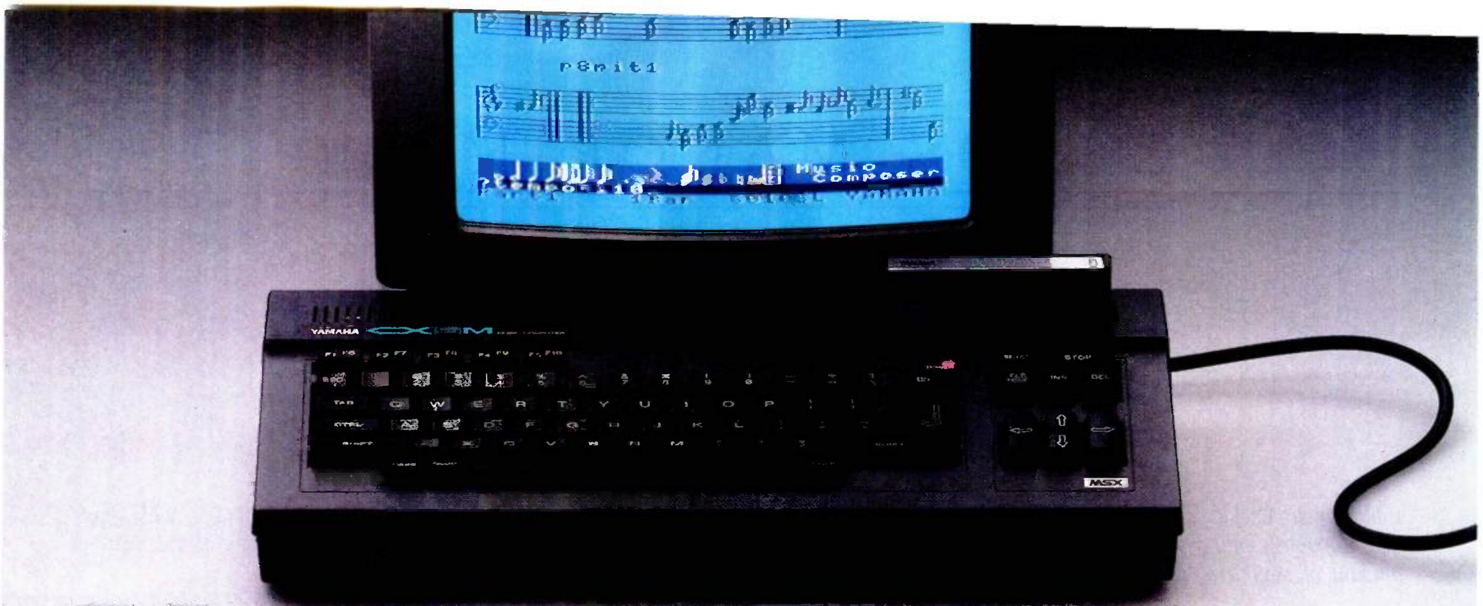
I'm also certain that it was a terrible mistake for the people at Epson America to hitch their wagon's success to Rising Star's ability to write Valdocs for the Z80 in FORTH, and your letter confirms that certainty. You say FORTH per se wasn't to blame, and I can agree; but what I haven't seen are the counterexamples. I have a potful of stories of eager FORTH lovers promising elaborate programs to be written in fabulously short times; alas, the end of the story is always the same: "fabulous" should have been taken literally.

As to the relationship between FORTH and STOIC, I pass; I'm insufficiently familiar with either to have much right to an opinion, and people whose judgment I respect tell me that STOIC really is a variety of FORTH; in fact, yours is the first word I've had to the contrary.

I will probably try HyperFORTH when the Stride 440 is set up. We'll see what happens.

In any event, thanks for an informative letter.

If you like Modula-2, you'll like MacModula-2.—Jerry ■



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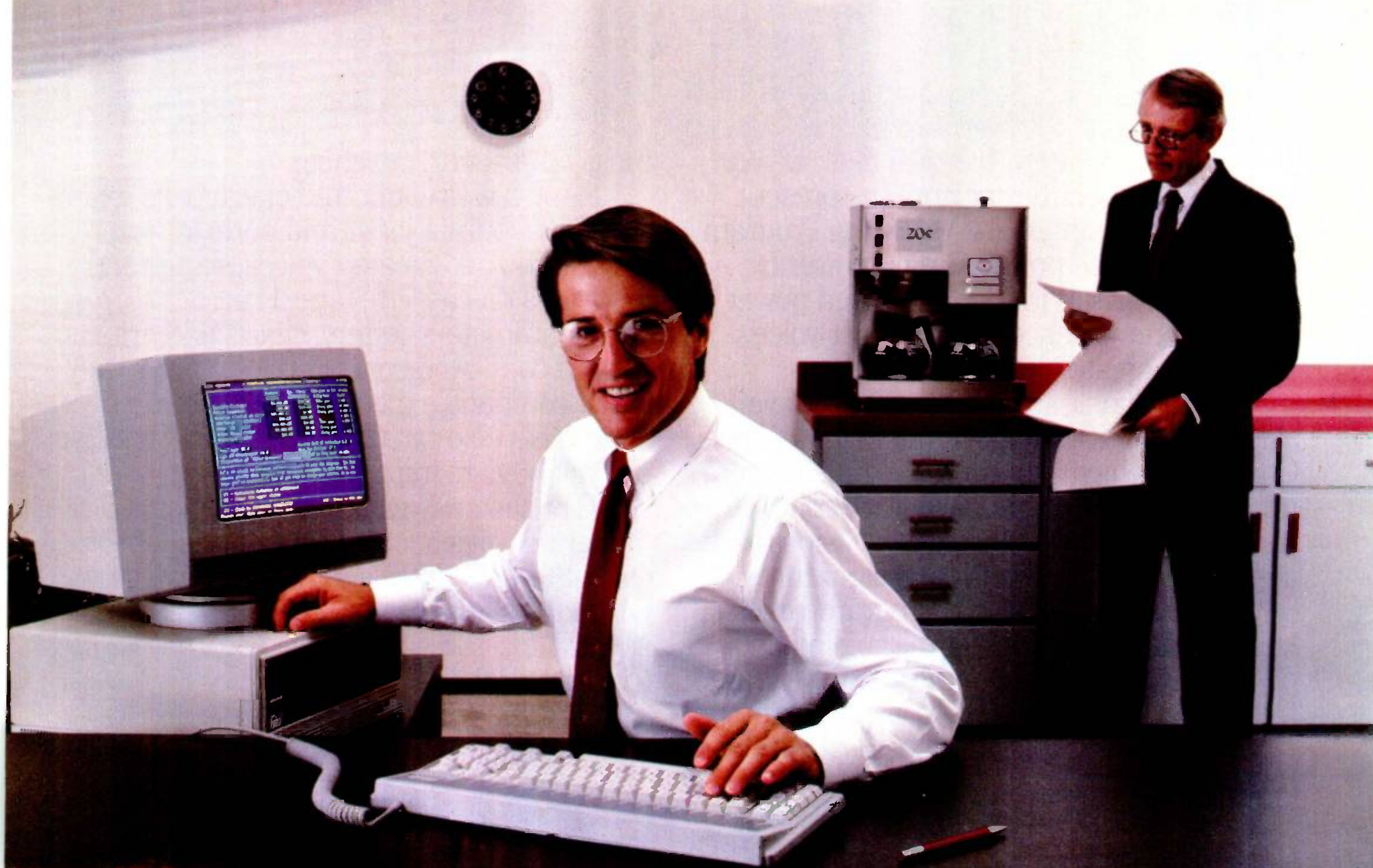

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BY BRUCE WEBSTER

Although I am now writing my fourth column, my first one has yet to see print. It's a little frustrating, both because of the time lag between composition and publication and because I haven't received any reader feedback yet. Phil Lemmons and I have had several discussions about what direction the column should take, but we're also interested in hearing from you. If you have any opinions about this column, please take a minute to send me a note c/o BYTE, 425 Battery St., San Francisco, CA 94111. Or, if you're a BIX subscriber, join the conference "ask.webster" and leave a note under the topic "feedback." Thanks.

PRODUCT OF THE MONTH: AMIGA

Last month, I made a few comments about the future of the home computer market, based on rumors I had heard about the Amiga from Commodore. In essence, I said that if what I had heard was true, the Amiga might be the heir to the Apple II in the home/educational/small business marketplace.

Since writing that, I have seen the Amiga. I have watched demonstrations of its abilities; I have played with it myself; and I have gone through the technical manuals. My reaction: I want to lock myself in a room with one (or maybe two) and spend the next year or so discovering just what this machine is capable of. To put it another way: I was astonished. Hearing a description of a machine is one thing; seeing it in action is something else, especially where the Amiga is concerned.

I can tell you that the low-resolution mode is 320 by 200 pixels, with 32 colors available for each pixel (out of a selection of 4096). But that does not prepare you for just how stunning the colors are, especially when they are properly designed and combined. It also doesn't tell you that you can redefine that set of 32 colors as the raster-scanning beam moves down the screen, letting you easily have *several hundred* colors on the screen simultaneously.

It also doesn't tell you how blindingly fast the graphics hardware is. If you've seen some of Commodore's television commercials demonstrating the Amiga's capabilities, or if you've looked at the machine yourself, you have some idea as to what the machine can do. If you haven't, I'm not sure I can adequately describe it.

Having seen the graphics on the Amiga, I have to smile when I hear people lump it together with the Atari 520ST. The high-resolution mode on the ST is 640 by 400 pixels with 2 colors (out of 512); on the Amiga, it is 640 by 400 pixels with 16 colors (out of the 4096), and you can redefine those 16 colors as the raster-scanning beam goes down the screen. Also, the graphics hardware supporting all those colors is much faster. Little wonder, then, that a friend of mine, a game developer with several programs on the market, came back from the Amiga developers' seminar with plans to return the Atari ST development system at his house and to turn his attentions to the Amiga instead.

As I guessed last month, the real strength of the Amiga is its totally open architecture. An 86-pin bus comes out of one side of the machine, giving any add-on hardware complete control of the machine. What's more, 512K bytes of the 68000's 16-megabyte address space have been set aside for expansion hardware, 4K bytes each for 128 devices. A carefully designed protocol tells hardware manufacturers what data they should store in ROM (read-only memory) so that the Amiga can automatically configure itself when booted. This is a far cry from the closed-box mentality of the Macintosh, which has forced many hardware vendors through weird contortions just to get their devices to talk consistently to the Mac without crashing.

The memory map is well thought out. The Amiga comes with 256K bytes of RAM (random-access read/write memory); an up-

(continued)

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grade to 512K bytes doesn't require a motherboard swap. All you do is plug a cartridge into the front of the machine. But it doesn't stop there. Commodore designed the Amiga to accept and automatically take advantage of up to *8 megabytes* of RAM through the expansion bus. At least one company I know of is coming out with a $400 unpopulated RAM box that plugs into the Amiga and can hold up to 2 megabytes of RAM, which would cost you only another $350 at current 256K-byte DRAM (dynamic RAM) prices. Thus, for about $750—the price for which Apple has been selling its 512K-byte upgrade—you can add 2 megabytes to your Amiga. You are able to do that four times, giving yourself an 8.5-megabyte system for about $5000. And, unlike large memory upgrades on the Mac and the IBM PC AT, all that RAM is immediately usable by the operating system.

Another area in which the Amiga has a possible jump on the competition is in IBM compatibility. The 86-pin bus gives whatever is sitting out there complete control of the machine (if it wants control). The disk-controller hardware can already handle external 5¼-inch disk drives (although they need their own power supply); the keyboard is sufficiently populated (function keys, keypad, cursor keys) to support most MS-DOS programs; and the screen resolutions (320 by 200, etc.) are, by an amazing coincidence, identical to those for most IBM graphics cards. How hard would it be to build a box with the necessary CPU (central processing unit) and ROMs that would turn the Amiga into an IBM-compatible machine? Not very hard, I would think—certainly not as hard as it has been for the folks at Dayna Communications to get MacCharlie, which attempts to make the Mac run MS-DOS software, up and running.

As you can see, I consider the Mac and the Amiga to be direct rivals. The Mac will have the advantages of a well-established software/hardware base and a more refined user interface. The Amiga, though, has the advantages listed above and the overall advantage of Commodore learning from Apple's mistakes. Perhaps the most important thing that Commodore has learned is how to encourage developers. The standard development environment is Lattice C (with assembler, linker, and debugger) running directly on the Amiga itself. The underlying software (ROM routines, operating system, etc.) is not as finely developed as that on the Mac, but neither is it as complex or as rigid. The Mac environment forces developers to write programs that all look alike. The Amiga environment gives developers tools to use and the freedom to choose how to use them. Also, the Amiga has more sheer power than the Mac. Because of that, I think that many developers are going to switch from the Mac to the Amiga.

The real casualty in all this is the Apple II. The IIc may be hit hard by the Atari ST; the IIe will almost certainly be clobbered by the Amiga. Last December, I paid $2100 for an Apple IIe with 128K bytes of RAM, an RGB (red-

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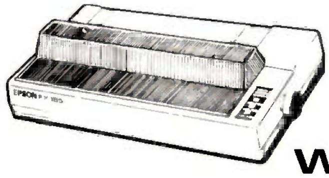

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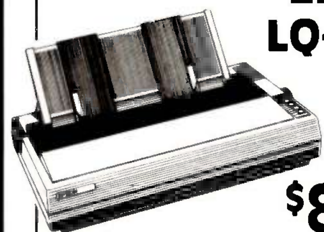

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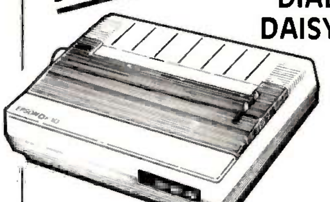

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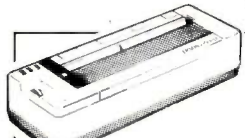

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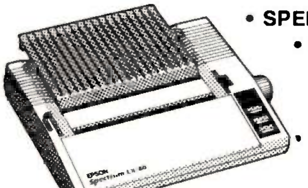

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green-blue) monitor, and two disk drives (holding a total of 280K bytes). This December, I'll be able to buy an Amiga with 512K bytes of RAM, an RGB monitor, and a single disk drive (holding 880K bytes, or three times the total storage on my IIe) for the same amount or less. And, of course, there will be absolutely no comparison whatsoever as far as speed and performance are concerned.

I guess I'm just really struck by how many things the folks at Commodore did right. Here are two simple—but important—illustrations. First, the mouse ports. The Amiga has two of them, up front on the right side of the box—two smart moves right there. There's more, though. The Amiga has the hardware and software support to let you plug in a mouse (it comes with a two-button mouse), a switch-type joystick (like those used by Atari and the Commodore 64), a pot-type joystick (like the one used by the Apple II), or a light pen. The key word here is flexibility: The designers didn't decide what type of input device you have to use—instead, they gave you lots of options.

Illustration #2 is the four types of video output: RF (radio frequency) modulated (for a regular television set); composite video (for a color monitor); and RGB and RGBi (for RGB monitors, both analog and digital). The video signal going out has been conditioned so that you can tape it on a videocassette recorder (VCR) without any problems. What's more, Commodore is coming out with a genlock interface that will accept a video signal from a VCR, a laser disc, a video camera, etc., and make it the background color for your display. This opens up all sorts of possibilities for interactive video systems. It also means that with an Amiga and two VCRs you can have do-it-yourself video titles, animation, and so on.

Reading this, you may think that the Amiga is a perfect machine. Of course it's not perfect. The ROM/system routines are nowhere as extensive nor as finely crafted as those on the Macintosh, which, despite whatever problems they might have, have set a standard that will not be equaled for a long, long time. Design trade-offs, the bane of any computer company, show up here and there. And I'm sure that more problems and weaknesses will show up as people start pounding away on the Amiga for prolonged periods of time. But even so, I want one.

I realize that I am probably raving a bit too much. The Amiga is not the answer to the world's problems; it will not stop war, nor will it feed the hungry. Since I am writing this before the machine has been formally released—much less on dealers' shelves—I run the risk of making a total fool of myself. After all, by the time this sees print, the Amiga could have turned out to be something of a flop. But I think not. I think that people will be so startled by what this machine can do and—more important—what it can become, that they'll buy it in large numbers.

More C Compilers

My education in C inches forward, inspired by my next Programming Project article (a go-playing program for the

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Mac written in C) and the desire to do some development on the Amiga. I've received several C compilers to look at but have had a chance to work with only a few. Here are some comments from a C novice.

Lattice C appears to be a popular compiler for the IBM PC; at least, it's the one that's mentioned most often in the Info-IBMPC digest section on ARPANET. Digital Research chose it as the initial development language for its GEM interface, and, as mentioned, Commodore picked it for development work as well. I thought it would be a good one to look at for the MS-DOS environment.

I had few problems getting the working disks set up. The main stumbling block was figuring out what the different memory models were and which one I wanted. Some digging through the index and the manual itself provided the information needed. I ended up with two disks: a system/compiler disk for drive A and a linker/library disk to be copied onto a RAM disk (drive C). That left drive B free for source and code files. One ironic note: Lattice C doesn't come with an editor, so I put a copy of Turbo Pascal 3.0 (only 39K bytes in size) onto the system/compiler disk and used that as the editor.

The manual has a nice tutorial to get you started, which I used. Unfortunately, some problems did arise. The tutorial claimed that the object file would be automatically placed on drive B; instead, it showed up on drive A. This caused some confusion for a minute or two, until I figured out what had happened. After a while, the compile/link process got tedious enough to impel me to create a file named CC.BAT:

```
erase %1.obj
lc -ms b:%1
if not exist %1.obj goto end
copy %1.obj b:
erase %1.obj
c:link c:c+b:%1, b:%1,,c:lc
:end
```

This file made it much easier to use. All I have to type is

```
A>cc benchmark
```

and CC.BAT automatically does the compilation, linking, deletion of unwanted files, and so on. I have a nearly identical file, CCR.BAT, that has the statement %1 on the line before the label :end. This executes the resulting .EXE file after the linking step is done.

All in all, Lattice C has been an easy system to set up and use. However, I have yet to write a large program using it, so I'll have to reserve final judgment until I've been able to put it through its paces. I've also received two other C implementations for MS-DOS, Aztec C and Toolworks C; more on those as I get a chance to use them.

AZTEC C ON THE MACINTOSH

As I have mentioned in previous columns, a number of C compilers for the Macintosh are available. The one I've

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been using the most is Megamax C. However, Aztec C (from Manx Software Systems) showed up in the mail, and I've taken some time to look at it.

Aztec C uses a UNIX-like shell for the user interface, avoiding the delays inherent in the Finder/Desktop interface. It uses filenames to emulate subdirectories; for example, the file sieve.c within the subdirectory test/ is just a file with the name test/sieve.c. UNIX commands such as ls (list files), cd (change directory), and rm (remove files) are supported, as is I/O (input/output) redirection.

The shell seems to work pretty well in and of itself. However, I've had some problems with it on my Bernoulli Box. I need to make one of the Bernoulli Box partitions the start-up drive before running the shell, or else Aztec C never finds the "system disk." Also, I've gotten some fatal system errors when recompiling a program without first deleting the object file (<name>.o) created by the previous compilation. This reflects a problem I've found with several Mac software packages: They've been tested with only a few (if any) hard-disk drives and often have problems with some of the new ones. Moral: If you have a mass-storage device, check out any software you want on it ahead of time—or be sure that the store you bought it from will give you a refund if it doesn't work.

I haven't had a chance to wring out Aztec C, nor am I entirely sure that I'm qualified to do so. However, once I get the go-playing program up and running in Megamax C, I plan to convert it to all the other Macintosh C implementations. At that time, I can give you some good, hard comparison data. In the meantime, table 1 gives a few benchmarks.

ClickOn, ClickArt, and More

A company called T/Maker Graphics has come out with several useful utilities for the Macintosh. One of them, ClickOn Worksheet, is a nifty little desk accessory that you install on your system disk. When you call it up via the Apple (desk accessory) menu, you have a spreadsheet at your disposal. The spreadsheet—50 rows by 20 columns—has a surprising number of functions for such a small, inexpensive program. You have table lookup, conditional calculations, and more than 20 mathematical and financial functions (compounded yield, straight-line depreciation, average, minimum, standard deviation, etc.). You also have cutting and pasting, replication of formulas, variable-width columns, and the like. In short, you've got a pretty decent spreadsheet, one that can handle the needs of most individuals and small businesses.

But wait, there's more! With a few quick commands, you can produce graphs—bar charts, stacked bar charts, line graphs, and pie charts—of the spreadsheet data. What's more, you can then copy those charts into the clipboard or scrapbook and paste them into your MacWrite/MacPaint/MS Word files. And, of course, if you order now (or if you order anytime, for that matter), they will throw in 12 ready-to-use worksheets set up for such diverse tasks

(continued)

Table 1: *Selected benchmarks for the Macintosh (512K bytes with Bernoulli Box), the Compaq Portable (640K bytes with dual floppy-disk drives), and the Compaq 286 (2 megabytes with dual floppy-disk drives). The Aztec C and Megamax C code file sizes include code to record the actual timing—two function calls to the system routine TickCount and code to write out the values.*

Language	Compilation	Linking	Execution	Normalized	Size
MacASM (long-word fill)	1.1	—	2.9	1.0	
Aztec C	15.4	12.6	6.3	2.2	5144
register vars	15.3	14.9	4.1	1.4	5102
Megamax C	3.0	26.7	6.3	2.2	5578
register vars, imprv	7.8	25.9	4.1	1.4	5536
Turbo Pascal (3.01)	<1.0	—	11.3	3.9	11,678
Compaq 286	<0.1	—	2.9	1.0	
Lattice C (2.151)	36.6	42.3	10.6	3.7	20,018
Compaq 286			2.6	0.9	

as home budgeting, auto loans, and stock portfolios.

This is really a gem of a program, one that demonstrates the excellent qualities of the Macintosh. It has a few weak spots—it took me a while to get used to "folding over" the spreadsheet to see rows and columns that were off the screen—but even so, it would be a steal at twice the price. If it weren't for the Amiga, this would have gotten my product-of-the-month award. My recommendation: Unless you need the heavy-duty guns of an expensive spreadsheet like Multiplan, consider ClickOn Worksheet for all your calculating needs.

T/Maker Graphics also has a series of ClickArt packages for the Mac. The original package, entitled ClickArt, is sim-

(continued)

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Steve Wozniak calls it revolutionary, adding "If I had thought of the SwyftCard while creating the Apple II, I would have built it in." Fomenting revolutions comes naturally to SwyftCard inventor Jef Raskin, whose previous efforts to make computers simple and useful include creating the Macintosh™ project at Apple.

SwyftCard creator Jef Raskin and Apple II creator Steve Wozniak

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ACCORDING TO WEBSTER

ply a collection of clip art for MacPaint, in the same vein as several other packages on the market. Your best bet is to get a look at it to see if it includes anything you really want.

The second package, Publications, is a more specialized collection of images. It contains formats and clip art for preparing memos, newsletters, programs, and related items. For example, it has MacPaint images with borders set up for two- and three-column pages. You make a copy of the appropriate image, fill it in with text and images, and erase the borders. As you might guess, it also has collections of art sized especially for the two- or three-column layout. In addition, it has a variety of clip art for memos, calendars, titles, the usual zany little items, and so on. I used it to create a two-column family newsletter . . . you know, the type you get around Christmas that brags about the parents' promotions and the kids' awards. I was able to put it together in just a few hours, and it came out looking very good (although it never got sent out). If you're doing this kind of work, you should take a good look at ClickArt/Publications.

The third package, Letters, contains 13 large (24- to 48-point) fonts that you can install on your system disk. Besides that, it has nine MacPaint images with large (72-point and up) stencil (blank outline) fonts. These letters, numbers, and symbols have to be lassoed one at a time and moved into place, then filled, if desired. That's what I did for the title across the top of the newsletter; some editing with FatBits made the letters merge into one another and produced a nice effect. Unless you've got a specific need, though, I'm not sure that ClickArt/Letters is worth the price.

The last package, Effects, is probably the most useful of the four, because it lets *you* do some amazing things rather than just provide you with predrawn images. Effects is a desk accessory that you install into MacPaint. When you run it, it disables the rest of the MacPaint functions and draws four new action icons in the upper right corner of the screen. You can then make a box selection (point, click, and drag) and perform one of those functions on the area selected. The Undo menu item still lets you recover from any effects that you didn't want.

The four functions are Rotate, Slant, Perspective, and Distort. All of them involve selecting a rectangular area and manipulating it. The names are descriptive. Rotate (a wheel icon) lets you rotate the image around by any amount; for example, you can finally get text at something other than a 90-degree angle. Slant (the Leaning Tower of Pisa icon) permits you to slant the whole image to the left or the right; the rectangle becomes a parallelogram. Perspective (a road disappearing toward the horizon) lets you make one side (top or bottom) larger than the other; the rectangle becomes a trapezoid. Distort (two hands crumpling a sheet of paper) lets you skew the rectangle entirely, changing any or all sides and angles.

ClickArt/Effects is a good package, but you again must

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decide whether you have a need for it. If you're seriously into MacPaint graphics, all four packages might be a good buy, especially if you can talk the dealer down to a good combined price.

Mac Spell Right

I've received a copy of Mac Spell Right, a spelling checker for MacWrite (version 3.3 or later). Mac Spell Right is from Assimilation Process, the same people who wrote MacWrite, so it's no fluke that the two integrate so well.

When you run MacWrite, it looks for a file entitled Mac Spell Right. If it finds it, it puts up an additional menu on the menu bar. When you use the Spell option, it starts at the current cursor location and checks each word that it finds against the dictionary. If it can't find the word, it stops, displays it, and presents a list of possible spellings. You can then accept the word as is, correct it, add it to the main dictionary (up to 1000 words), or add it to the document dictionary. This continues until you want to quit or you hit the end of the file.

The dictionary, which Assimilation Process says has more than 40,000 words in it, appears to be a good one. Performance against Hayden:Speller (which claims to have only 20,000 words in it) supports that claim. Assimilation Process has done an excellent job of compression, fitting that many words into a file only about 85K bytes in size, which includes the spelling-checker code. My best guess is that they start with a good literal word list, then set flags for each word specifying which endings are allowed. I tried to trick it with imaginary words (good roots, good endings, no such word, like "doorable") but couldn't do it.

There are some problems with using Mac Spell Right. First, since it must be present at the same time as MacWrite, you may have problems on systems without hard disks. You must either thoroughly clean off the MacWrite disk (including throwing away excess fonts) or have a copy sitting on each disk of documents. If you want the optional thesaurus as well, you're in real trouble.

That shouldn't be a concern, though, because the thesaurus isn't worth much. To use the thesaurus in Mac Spell Right, you go through three levels. First, you look up the initial word by paging through a long list of words. If you find it, you then "open" it, and it shows you a bunch of index words. You have to decide which of these is closest to the meaning of the word you were looking up. It then shows you a list of possible synonyms, most of which really aren't synonyms—you have to scan the list and find which ones apply.

As an example, I decided to find synonyms for the word "exhale." It took me a while to get there; I typed "f" to put me at the start of the F-section, then I paged backward until "exhale" showed up. I selected it and got a list of four index words. I chose "ejection," and it then presented me with a list of 145 words, few of which had any relation to "exhale." I then had to use my own judgment to decide which ones did and which one I should use. The entire

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process—moving as quickly as I could—took 96 seconds. By contrast, I picked up a paperback thesaurus and had much better information in less than 20 seconds. Conclusion: Forget Mac Spell Right's thesaurus.

Mac Spell Right is a good checker if you're using MacWrite 3.3 or later. For that matter, it's the *only* checker, since Hayden:Speller currently works only with earlier versions of MacWrite (or with MS Word). So, your choice of word processors pretty much limits your choice of spelling checkers, although Assimilation Process is supposed to have The Right Word (for MS Word) out by the time you read this.

INFORMATION FILTERS

My writing requires that I try to keep up on what's happening in the world—not just in the micro industry, but in telecommunications, technology, science, politics, and society in general. The foot-high stack of unread magazines sitting near me bears mute testimony to how hard it is to do just that. So I am always looking for ways to sift the chaff from the wheat, information filters that screen out what I don't need to see and let the important stuff pass through.

In the past month, I've come across two filters that help me get more wheat and less chaff. First, I've started using the //TRACK function on the Dow Jones Information Service, which I access via MCI Mail. The //TRACK function lets me set up a list of publicly held companies; my list includes firms like Apple, IBM, DEC, Compaq, Tandy, Lotus, and so on. Each time I request a report, //TRACK shows me the current stock information (open/low/high/bid/close/volume) for each company, as well as any news articles pertaining to that company. The articles are especially valuable in finding out what Wall Street thinks of these companies. You can have up to five lists, each holding up to 25 companies. Anyway, //TRACK is proving itself to be a useful filter.

Closer to home, a firm called Omega Research (headed by Brock Meeks) offers an electronic "clipping" service. I signed up as soon as I heard about it, and it, too, is proving to be worthwhile. Once a week, Omega sends me a digest of items dealing with politics, telecommunications, microcomputers, and technology. These have been compiled from on-line databases. The digest comes in a regular ASCII (American Standard Code for Information Interchange) text file that is sent to a computer bulletin board on which I have an account. The digests received so far are about 60K bytes each in size, but they represent several times that amount of reading if I had to track down the items myself.

It appears that, given sufficient interest, this service will be offered to the general public . . . or at least those willing to come up with the money for it. Rates vary based on the number of topics included and the difficulty in obtaining that information. Also, Omega Research will do one-shot research efforts for a negotiated fee. If you have

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MAC SPELL RIGHT $89
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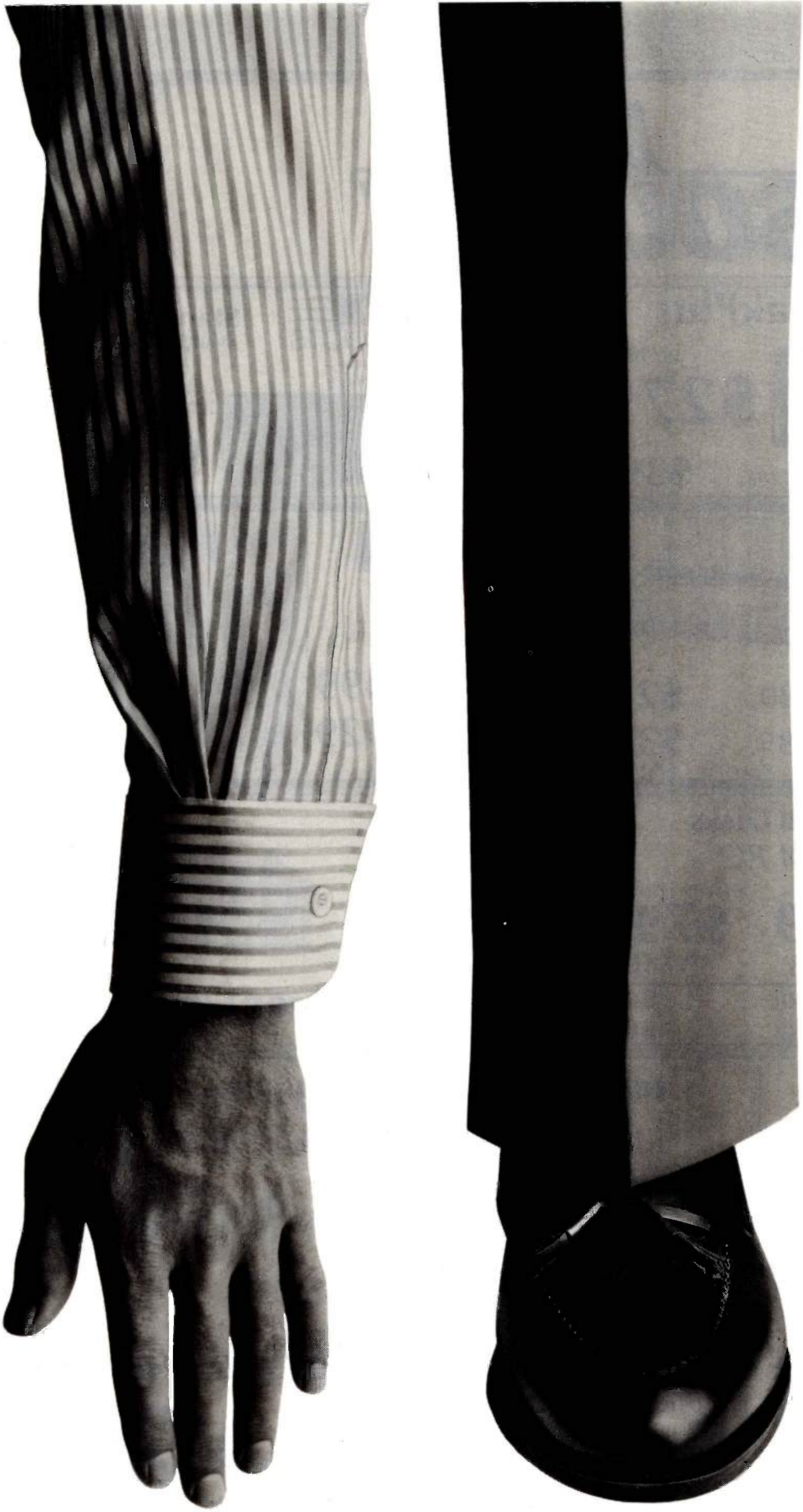
the need for this type of service, it might be worth looking into.

IN THE QUEUE

I've got some more C compilers to look at, as well as ExperLisp and MacFORTH Level III. There's also a syntax-directed editor called FirsTime, designed to help you write correctly formed C programs; I've also got a version for Turbo Pascal. I'll try to get to all those next time.

A Compaq 286 showed up, but it had to be sent back due to hardware problems. I did use it to make the extra benchmark timings in table 1, though, and with a fourfold increase in speed, I can hardly wait to get a fully functional unit back here. (No, that is not a typo: The RAM-to-RAM compilation time under Turbo Pascal was too fast to be measured; there was no discernible pause.) Also, with luck, I may have my hands on an Amiga by the time the next column rolls around.

That's it for now. Be sure to give me your feedback as to what directions you'd like to see this column take. Take care, and I'll see you on the bit stream. ■



Computers As Consultants

Two expert-system shells from the U.K.

BY DICK POUNTAIN

Most of the well-known early expert systems (MYCIN, PROSPECTOR, DENDRAL) were developed in the U.S., although there has been a strong research involvement in expert systems in the U.K. for many years. Much of the research has involved Professor Donald Michie at Edinburgh University, who has championed the technique of inductive inference (see "The Technology of Expert Systems" by Robert H. Michaelsen, Donald Michie, and Albert Boulanger, April BYTE, page 303).

EXPERT-EASE

Two years ago I had the pleasure of reviewing Expert-Ease, an expert-system-shell program for microcomputers derived under license from an inference engine of Michie's called AL/X. [*Editor's note: For more information on* AL/X, *see* AL/X Expert System Using Plausible Inference *by* J. *Reiter, Intelligence Terminals Ltd., Edinburgh University,* 1980.] This program has had a very checkered career; the firm that originally published it ceased trading, and after a period in the wilderness it is being sold in the U.K. by Thorn EMI and in the U.S. by Human Edge Software.

Expert-Ease was the butt of some press criticism when first released because it did not handle "fuzzy logic" (that is, the ability to deal with probabilities rather than certainties) and had no explicit explanation facility (the ability to explain the chain of reasoning that led to a conclusion). Despite the lack of these facilities, I found Expert-Ease to be an interesting and even exciting program because it is capable of inducing its own rules from example "solutions" supplied to it. In other words, it relieves you of the chore of explicitly designing the decision tree it uses to answer queries. As part of my review, I constructed an expert system to identify edible fungi, and the knowledge-acquisition phase consisted of nothing more than typing in descriptions of fungi from a textbook.

Using an algorithm called ID3 (developed by J. R. Quinlan in Sydney, Australia), Expert-Ease produces a decision tree from examples entered into a spreadsheet that has columns containing the values of named attributes. The task of specifying the decision logic is replaced by the still difficult but more "natural" task of identifying a set of significant and discriminatory attributes.

You can inspect the derived decision tree, providing an indirect explanation facility. In addition, the program helps you debug expert systems by highlighting contradictions in the rule tree and pointing out gaps in the knowledge base that must be filled (if possible) by more examples.

TESS

Most of the expert-system shells now coming onto the market seem to be influenced largely by EMYCIN. (EMYCIN stands for Essential MYCIN. MYCIN is a program that was developed at Stanford University to help diagnose blood and meningeal infections.) These shells work on the principle of providing a high-level language in which the human "knowledge engineer" can write the rules that make up the knowledge base. In other words, the engineer is responsible for defining the decision tree.

Until recently, I had no experience with these products, but I have recently been loaned such a product called Tess, from Helix Expert Systems. [*Editor's note: At the time of review, the product was called Tess. It has since been changed somewhat and is being sold under the name* Expert Edge *in the* U.S. *and Europe.*]

Tess is written in C and runs on the IBM Personal Computer (PC), PC XT, or PC AT. The name stands, modestly enough, for "the expert-system shell."

Tess has a number of interesting facilities. It can handle fuzzy logic using Bayesian techniques; it can also be switched to work only with Boolean certainties (this is known as "crisp reasoning" in Tess terminology). It also has a MYCIN-like explanation mode that displays the chain of reasoning that

(continued)

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led to a conclusion.

Tess incorporates arithmetical calculation and testing abilities, which some of these shells lack (see "Insight–A Knowledge System" by Bruce D'Ambrosio, April BYTE, page 345). It offers a choice between an interactive menu-driven way of constructing systems and a user language, Tessul (Tess user language), which allows you to build knowledge bases in batch mode using a standard word processor.

Particularly interesting is the ability to load spreadsheet files into the knowledge base using DIF (data-interchange format) or SYLK (symbolic-link) format. This allows business-oriented expert systems to offer advice based upon current figures.

Tess Basics

Tess is, like Lotus's Symphony, a RAM- (random-access read/write memory) based program. It requires an IBM PC with at least 256K bytes of RAM, but 512K is better because the program stores all its rules in memory. You can store knowledge bases on disk and load them when required, but there is no virtual memory to let the rules "spill over" onto disk. Tess is copy-protected by the Prolok system and requires you to keep the system disk in drive A, so a dual-drive IBM PC is essential.

Built-in utilities purge the memory of redundant rules and perform garbage collection to free up the maximum space, but these must be invoked manually.

The user interface is based on a screen with seven windows that, though variable in size, do not overlap. You can use color if your IBM PC has the necessary adapter, and each window may have a different background. You can alter the size and disposition of the windows either from the main menu or by commands in Tessul.

All the IBM PC display attributes are available in Tess, so you can emphasize text with reverse video, flashing, underlining, etc.

A command window presents the main menu, from which you make selections in the same way you do with Lotus 1-2-3, by moving a cursor with the space bar and backspace, with the cursor keys, or by typing the initial letter of the selection. The Escape key consistently moves you back up the menu tree. Screen updating is very slow throughout the program and responses are not nearly as crisp as in 1-2-3.

The first-level menu offers Advise (consult an expert system), Learn (build or modify a system), Change (alter the system parameters), and Think (a curious name for garbage-collection activities), plus Read and Write for disk operations.

The Change menu lets you alter the system parameters with great flexibility. You can change the default sizes, colors, and positions of all the windows, and replace all the system messages with your own choices. You can also apply passwords, customize the display formats for numeric data, and install any currency symbol (such as $ or £).

The Read option offers a choice of different ways to load Tess. You can load a prewritten system in binary format or compile it from an ASCII (American Standard Code for Information Interchange) file of Tessul commands. You can also load a self-running demonstration system or a spreadsheet data file in DIF.

Decision Rules

A knowledge base in Tess is composed of names, rules, and evidence. Names can have values that are numeric constants, variables or expressions, or nonnumeric strings.

A rule consists of a conclusion, followed by the evidence that leads to that conclusion. Evidence is presented in the form of an IF condition with multiple AND clauses, as in EMYCIN. To achieve the effect of an OR, you must enter the same conclusion again with a different set of evidence. There is no way of expressing negation (i.e., NOT) directly.

Tess answers queries by trying to prove conclusions; to prove a conclusion Tess must prove all the evidence clauses, which may themselves be defined as conclusions of further rules. This type of inference is known as backward-chaining or goal-directed.

Each rule must have a set of probabilities assigned to it, namely, the

(continued)

probability that the conclusion is true, and for each evidence clause, the probability that the evidence is true when the conclusion is true and when it is false. Tess combines these probabilities using the Bayesian theorem when it is trying to prove a conclusion, and it attaches a resultant probability to any answers.

The names used in rules are structured further in a pseudonatural-language fashion by being divided into "subject ¦ verb ¦ object1 ¦ object2," separated in the source code by vertical bars. So a complete rule could look like figure 1.

Names may include spaces for an even more natural look. The division into subject-verb-object is fairly arbitrary and does not imply any understanding of English syntax; subject and verb are compulsory, while objects are optional. Subjects are matched with subjects and objects are matched with objects when searching the knowledge base to prove a conclusion. Verbs are not matched but are used like predicate names to link the items in the knowledge base. Tess recognizes exact matches only.

Some predefined verbs, such as "is equal to" and "is greater than," allow arithmetic comparisons, as shown in figure 2.

Conclusions, evidence, and names can all have texts associated with them, of type Question, Answer, or Help, and these texts are automatically inserted into the dialogue at appropriate points during a consultation. For the example in figure 1, you could associate the question "Are the gills white?" with the first evidence clause and perhaps also a help screen explaining what gills are.

Tess allocates help texts to all the system names, and you can inspect them in the help window by pressing F4 with the cursor on such a name.

Complete rules may be of the types Enquiry, Answer, and Menu. A given rule may be of more than one (or none) of these types.

An Enquiry rule becomes a choice on the menu from which you select at the start of a consultation. It is thus only appropriate for top-level rules, for example, "identify poisonous fungi" and "identify edible fungi."

An Answer rule presents its answer text whenever its conclusion is solved.

A Menu rule presents all its evidence clauses as a menu, from which you must choose one. From then on the system behaves as if this were the only evidence for that rule. This allows the area of enquiry to be selectively narrowed. In the medical example included with the system, a menu offers Infection, Accident, Abdominal, and Psychological as main areas of enquiry, and each choice leads to a different set of rules.

A rule with no type is merely an intermediate goal that the system will never present to the user unless you have built Why? tracing into the system.

As well as building a rule base, you may optionally define a name tree, which organizes names by hierarchical types. Figure 3 shows a tree for the fungus example. This tree provides a limited facility to substitute specific names for general names (rather like instantiation in Prolog). If an Answer text is written as "You may safely eat a ||fungus||," then when a conclusion is reached, ||fungus|| may be replaced by, say, "lepiota" in the given answer. The two levels of brackets reflect two levels in the tree; |fungus| would be replaced by "edible fungus."

You may define synonyms and identities for a given name. A synonym is a name of the same type but different value, e.g., fungusA, fungusB are synonyms for fungus in figure 4. Synonyms could be thought of as typed variable identifiers. An identity is a different name with the same value, for example, an alternative spelling or an abbreviation.

You enter all this information in Learn mode, using a built-in editor that prompts for each piece of information and allows you to traverse the rules and modify them. You can search for a particular rule, name, verb, or noun and may specify merely part of a name to search on. I found it quite easy to use, though slow, due to the number of nested command menus that must be traversed.

```
fungus ¦ may be ¦ amanita IF   gills    ¦ are   ¦ white
                         AND stem     ¦ has   ¦ single ¦ ring
                         AND location ¦ found ¦ beech wood
```

Figure 1: *Complete rules include subjects, verbs, and objects.*

```
company ¦ sound investment
        IF profit% ¦ is greater than ¦ 15
        AND cost of director's car ¦ is less than ¦ 10000
```

Figure 2: *Predefined verbs allow arithmetic comparisons.*

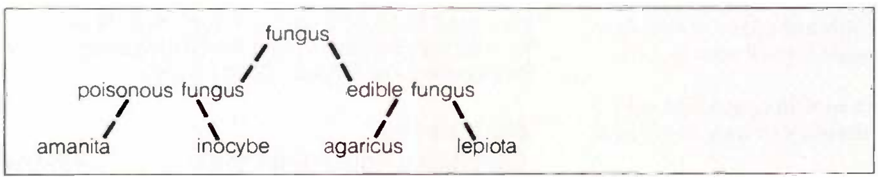

Figure 3: *A name tree organizes names by hierarchical types.*

ADVISE

A system that has been constructed in Learn mode can be consulted by choosing Advise from the main menu.

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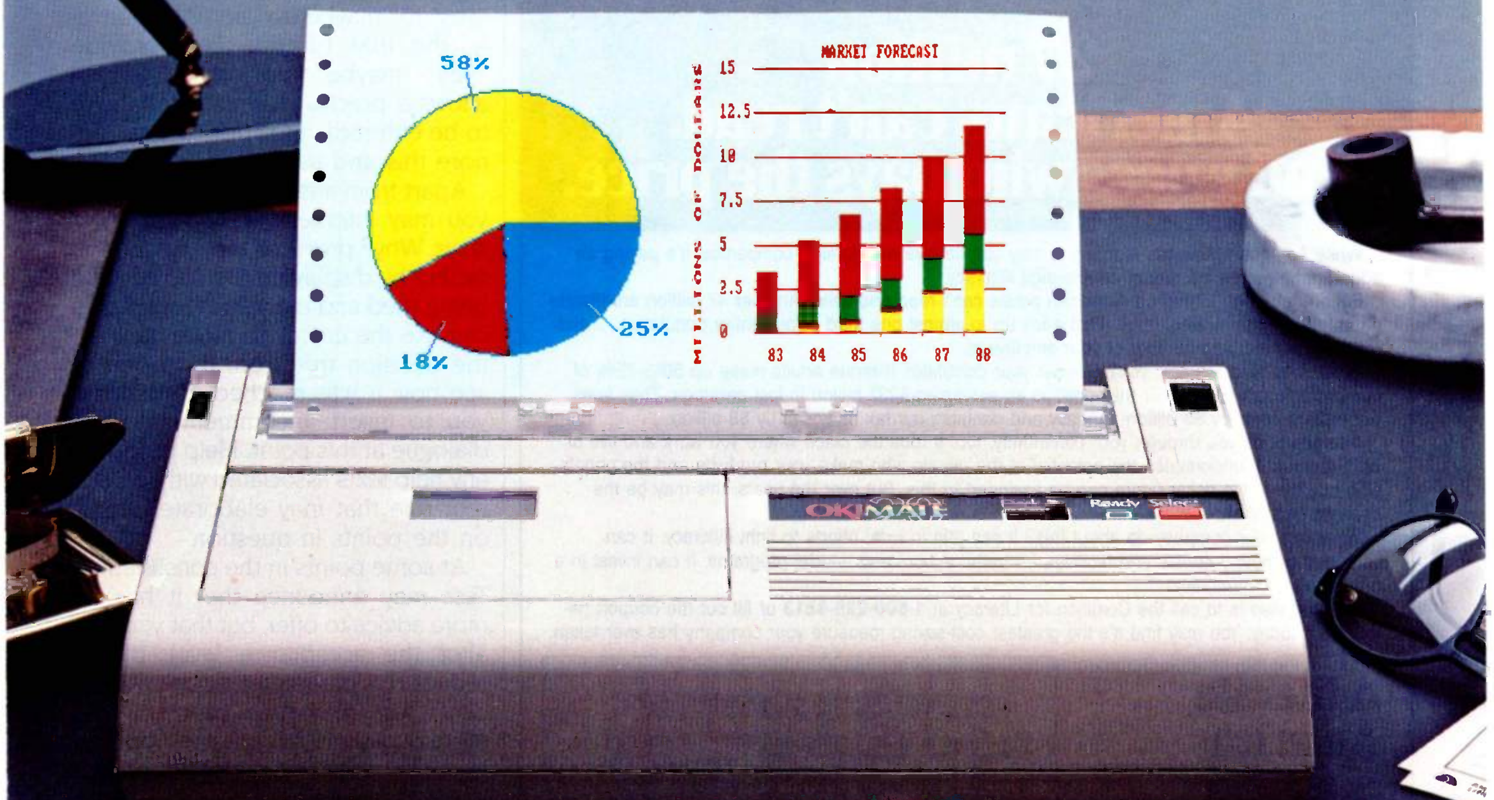

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Tess then presents a menu of possible queries, i.e., the names of all rules that have been declared type Query.

When you choose a query, a message appears on the screen that the acceptance level is 70 percent and then presents questions in the dialogue window.

Answering questions involves entering probabilities, and this is handled in a fashionably graphical way with a screen display of a horizontal scale with a cursor, shaded in deepening tones of gray. The scale starts at "yes," has "maybe" in the middle (50 percent), and ends with "no." By moving the cursor, you can visually select a probability between 0 and 100. The space bar moves you straight from "yes" to "maybe" to "no." Alternatively, the IBM function keys provide "yes," "maybe," "no," "value" (which allows a precise decimal probability to be entered), and "don't know" (ignore this and assign probability 0).

Apart from answering the question, you may intervene in various other ways. Why? provides the explanation facility by displaying the current rule being tried and the values found. You can use the cursor to move back up the decision tree from this point to see how it was reached. But! allows you to insert a comment into the dialogue at this point. Help produces any help texts associated with the current rule that may elaborate further on the points in question.

At some points in the consultation, Tess may announce that it has no more advice to offer, but that you may alter the acceptance level. If you reduce this parameter to, say, 60 percent, Tess may then proceed with more questions, as some new options become worth considering at this level of certainty.

The acceptance level defines the probability above which the conclusions will be presented as confirmed. Similarly, the rejection level is the probability below which a conclusion will be stated as not true; this defaults to 0 percent but may be adjusted also.

When a session ends with a conclusion like "There is a 78 percent prob-

(continued)

ability that the fungus is of species lepiota," you have the option to review the contents of various windows, including replaying the whole dialogue. Dialogues may also be saved from one session to the next.

An extra facility called Tell allows you to answer some questions in advance, to tell Tess to ignore certain questions or answers, and to alter answers already given. It also permits you to divide a session into different areas and direct the focus of the session in other ways.

TESSUL

Tessul is very simple. It contains 39 single keywords, and any legal program statement starts with one of these in uppercase, placed in columns 1 to 11. The format of Tessul programs closely follows the structure of the rules created using Learn, with each command word substituting for a Learn prompt. Indeed, you may opt to save knowledge bases originally created interactively in Tessul, rather than in binary format, to allow editing and modification.

A piece of my fungus system in Tessul is shown in figure 5.

Perhaps it merely reflects my bias as a programmer, but I found working with Tessul files easier than using the friendly Learn facility. The overall structure of the knowledge base became much clearer, and it was very much faster than the maze of menus and prompts.

I tried using the facility to import a DIF file from Lotus 1-2-3, and it appeared to work. I say "appeared to" because I could find no way to verify

(continued)

```
IF fungusA | smells nastier than | fungusB
```

Figure 4: *FungusA and fungusB are synonyms for fungus, but each has a different value and can be thought of as typed variable identifiers.*

NAME	lepiota
SUPERSET	edible fungus
RULE	para
RULETYPE	ANSWER
CONCLUSION	lepiota ¦ identified
ANSWER	The fungus is a parasol mushroom
PRB NO EVD	20,
LEVEL	0
	IF cap ¦ is brown
QUESTION	Is the cap brown?
PRB IF CON	90
PRB IFN CON	40
	AND cap ¦ is shaggy
QUESTION	Is the cap shaggy?
PRB IF CON	90
PRB IFN CON	30
	AND stem ¦ has double ring
QUESTION	Does it have a double ring on the stem?
PRB IF CON	100
PRB IFN CON	10
	AND location ¦ is grass
QUESTION	Did you pick it in grassland?
PRB IF CON	90
PRB IFN CON	50

Figure 5: *Part of the author's fungus system created in Tessul (the Tess user language).*

the fact. Data imported from spreadsheets have to be attached to names of the form R*n*C*n* (e.g., R1C3) to identify the particular cell. I set up some names in the correct form, but I could find no way to inspect the values of these names after loading the file, short of building a whole system around them.

CONCLUSIONS

Tess works, and it certainly beats writing expert systems from scratch in high-level languages. It relieves you of the responsibility for all the really boring stuff like screen formatting, the Bayesian calculations, and the production of dialogue text. The ability to import data and do arithmetic puts it ahead of many of its competitors for business applications.

The main criticisms I had were of the slow screen handling (and hence menu access) and the aforementioned lack of ability to inspect values at run time, which made debugging rather opaque.

What Tess *cannot* do is to give you much help in achieving the proper logical structure for the rule base. You can activate a trace mode that shows you all the matching operations as they happen, and this can be used to check the proof sequence interactively. But expert-system design remains a complex programming problem, albeit one where much of the tedious low-level detail has been dealt with by the shell. This is not specifically a criticism of Tess but a comment on the whole MYCIN-style rule-based approach. I wrote many systems that, when run, asked directly contradictory questions one after the other, such as "Is the cap brown?" *Yes*. "Is the cap white?"

This ultimately reflects nothing more than my incompetence as a knowledge engineer, but the shell didn't help me to get it right.

The difficulty is greatly compounded when you're faced with fuzzy reasoning as well. While devising examples, I discovered just how difficult it was to make sensible estimates of probability that would lead to any answer at all; a lot of my systems refused to commit themselves until the acceptance level was set absurdly low. My favorite system was one that produced the advice that there was an 80 percent chance that I should eat the fungus and a 30 percent chance that it was poisonous. That suggests to me a 100 percent chance that I would live longer by ignoring the advice.

In scientific domains like chemistry or geology it may be possible to evaluate probabilities with great precision. In more everyday domains this is typically not the case, and one must either revert to using crisp reasoning or take the whole thing with a pinch of salt. In short, I believe that this kind of expert-system shell should be seen as an application building tool rather than a tool for end users. ■

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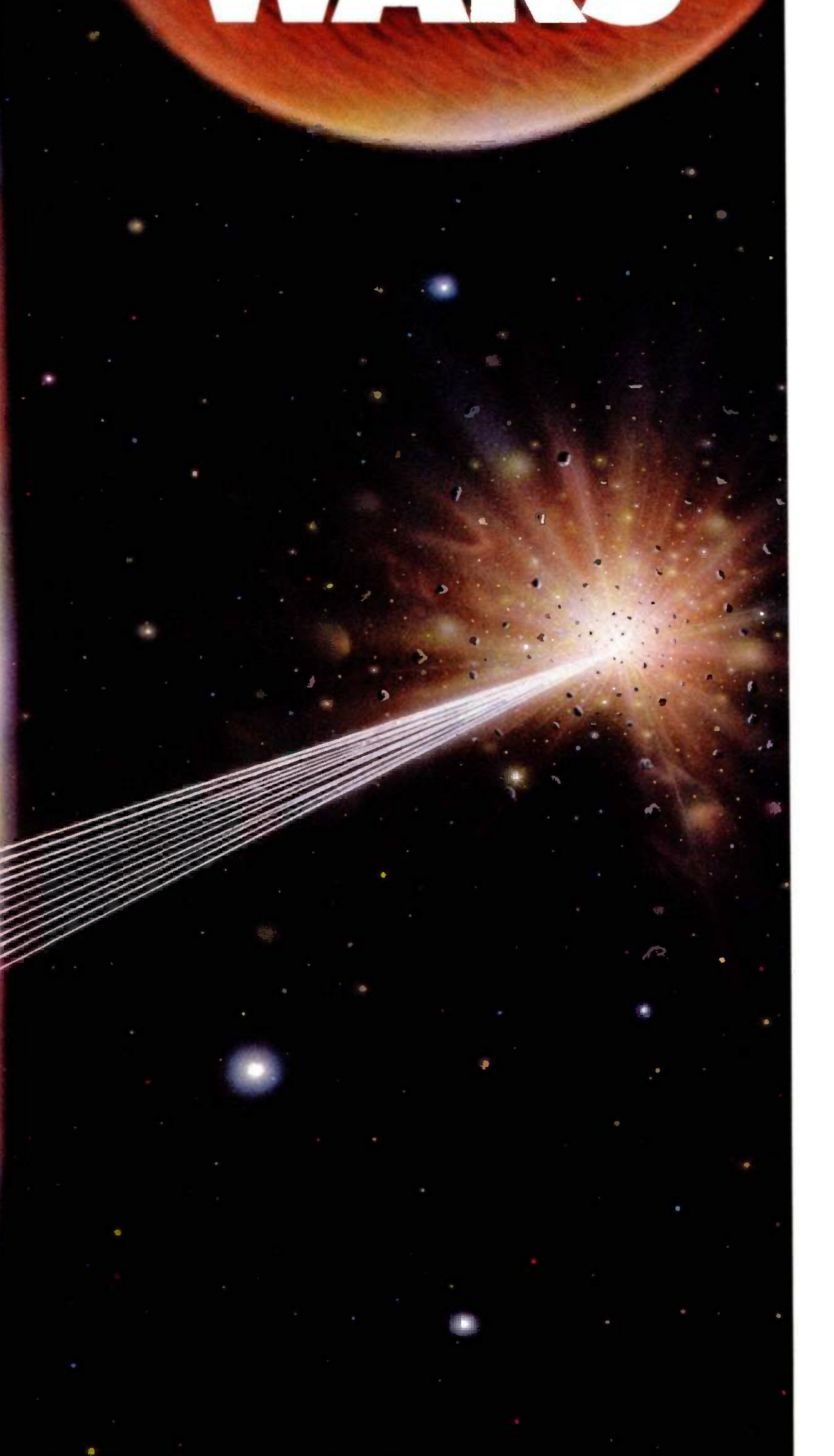

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The Tokyo Microcomputer Show

The NEC PC-98XA, NEC PC-9801U2, 286 XENIX System V, the HP-9807, and a new Hitachi drive

BY WILLIAM M. RAIKE

William M. Raike, who has a Ph.D. in applied mathematics from Northwestern University, has taught operations research and computer science in Austin, Texas, and Monterey, California. He holds a patent on a voice scrambler and was formerly an officer of Cryptext Corporation in the U.S. 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.

The weather bureau just officially declared the start of Japan's six-week rainy season. I wonder how the forecasters can tell; it's been raining for three weeks! The weather seems to bring out the aroma—a little like new-mown hay—of the tatami mats in my apartment, and the cool temperatures are worth cherishing before Tokyo's hot muggy summer. My computer seems to suffer no ill effects in this weather, except it has a tendency to mildew around the display.

The Tokyo Microcomputer Show is held every year around this time (late May). This year, because Gene Smarte, BYTE's managing editor, was in town, I was able to view the show through the eyes of someone unfamiliar with the Japanese computer scene. We saw two major new personal computers from NEC; UNIX was more in evidence than ever before; Hitachi introduced still another semi-astounding disk drive; and Hewlett-Packard's Integral computer, the portable UNIX machine, made its Japanese debut. As usual, though, there were very few IBM Personal Computers to be found.

NEC's New 80286 Machine

It's called the PC-98XA, it runs Japanese-language MS-DOS, and it's not just an IBM PC AT clone. NEC makes no claim about compatibility with the PC AT. The Japanese-language capabilities of the PC-98XA and its powerful graphics make it clear that this machine is oriented toward the Japanese market. NEC is leaving no doubt that it intends to keep its 45 percent share of the Japanese personal computer market. The XA is a logical, well-thought-out adjunct to the company's enormously popular PC-9800 series of machines, and it will run much of the same software. New software packages, or new versions of existing packages (including CAD [computer-aided design] packages), are already available to take advantage of the PC-98XA's powerful graphics features.

The PC-98XA is a single-processor machine that's based on the 80286 processor chip, NEC's version of Intel's 80286. This is the same processor that IBM uses in its PC AT. It runs at 8 MHz (in contrast to the 4.77-MHz speed of the 8088 processor in the IBM PC), and it does a lot of things even faster than the difference in clock speed indicates. The 80286 also contains important memory-management functions, so that it can use larger amounts of memory than most personal computers. For instance, the PC-98XA lets you add up to 7.5 megabytes of RAM (random-access read/write memory). NEC designed this machine so that you can have up to 768K bytes of main memory; it comes with 512K bytes as standard. After you install the 7.5 megabytes of RAM, the remainder can be used as a RAM disk; the operating system treats it like a very large, extremely fast disk drive.

The PC-98XA comes in three models. One has no disk drives; another comes with two built-in 1-megabyte 5¼-inch floppy-disk drives, compatible with the new/old PC-9801M2 machine NEC introduced just a few months ago; and a third has one floppy-disk drive plus a built-in 20-megabyte hard-disk drive. NEC says that the PC-98XA can also read both 640K-byte and 320K-byte floppy-disk formats used with earlier computers in its PC-9801 series.

This machine is still too new for the 20 percent (or more) discounts you can usually find in the Akihabara electronics district. Even so, the list prices aren't all that high considering the computing power you get: The PC-98XA without disk drives sells for the equivalent of $2300, the dual-floppy-disk version sells for $3000, and the 20-megabyte hard-disk version costs only about $4400.

The graphics capabilities of the PC-98XA really make it stand out. Besides its regular memory, this machine comes with 512K bytes of graphics video RAM that lets you display a graphics screen containing 1120 by 750 dots. Each dot can be any of 16

(continued)

colors, and the palette can be selected from 4096 possible colors. (Actually, the graphics page is 1120 by 936 dots, but the extra-high-resolution display units NEC sells to accompany the PC-98XA, both color and black-and-white, display only 750 out of the total 936 lines.) This kind of graphics performance shows that NEC expects the PC-98XA to find a niche in the CAD systems market. The company already has a half-dozen CAD software packages, some mouse-driven, that exploit the PC-98XA's graphics.

The unusually high screen resolution also pays off in the clarity of Japanese characters displayed on the screen. Kanji characters are displayed on the screen in a 24- by 24-dot font; they're a lot clearer than the 16- by 16-dot characters found on most contemporary Japanese personal computers. As you might expect from a machine in this category, its Japanese-language capabilities are extensive. The operating system directly supports full Japanese-language input and output. The hardware includes kanji ROM (read-only memory) that contains both the No. 1 and No. 2 JIS (Japan Industry Standard) character sets for a total of over 7200 characters in addition to the usual alphanumeric and katakana characters. The system also allows you to add up to 188 user-defined characters.

The overall situation regarding applications software for personal computers has been steadily improving in Japan, and that's reflected in the range of programs you can buy for the PC-98XA. NEC has induced dozens of third-party software vendors to write software for the PC-9800 series of computers, and there are already a substantial number of business applications, database managers, Japanese word processors, spreadsheets, and integrated software packages available for the PC-98XA, along with various utilities, languages, etc.

ANOTHER PC-9801?

It's difficult to figure out why NEC introduced still another version of the PC-9800 series at the same time the PC-98XA made its debut and only a few months after the most recent model in the series, the PC-9801M3, went on the market.

The latest member of NEC's PC-9800 stable is the PC-9801U2. Usually, NEC uses a letter designation to refer to versions of its PC-9801 that differ pretty much only in their floppy-disk drives: The F models have 640K-byte floppy-disk drives and the M models have 1-megabyte drives. In this case, the U2 not only has different disk drives but a new processor as well. The U2's 3½-inch microfloppy-

(continued)

> *The U2 has a μPD70116, one of NEC's homegrown microprocessors.*

disk drives hold a hefty 640K bytes each. The main advantage of these drives, other than increased reliability from the less fragile disk media, is their smaller size. NEC is advertising the U2 as a transportable computer, although that seems to have been something of an afterthought: The keyboard doesn't attach to the main unit, there's no built-in or attached display, and they don't offer a case. Evidently you can move the machine around if you get a big enough suitcase. All the advertising blurbs show the PC-9801U2 with an interesting-looking compact orange-plasma display, but it wasn't anywhere to be seen at the show. No doubt NEC will get it to the showrooms in due course.

The microprocessor used in the U2 model is not the same 8086 processor used in all the other PC-9801 computers (and in the U.S. version—the APC III). The U2 has a μPD70116, one of NEC's homegrown microprocessors. It's totally software-compatible with the 8086, but it has somewhat faster execution speed, even though the clock rate is the same (8 MHz).

The U2 suffers from the same limitation on maximum memory size as the F and M models—you can only expand the user RAM up to 640K bytes, unlike the PC-98XA, which is expandable up to 768K bytes, and Fujitsu's machines, which can hold up to a full megabyte.

NEC took a step backward with the U2 by putting in only 128K bytes of standard RAM, and there are only two expansion slots in the whole machine. All in all, I can't think of many good reasons why anybody would want to buy this machine instead of one of its full-size cousins.

286 XENIX System V

UNIX is clearly the wave of the future in Japan for systems at the minicomputer level and higher. The trend is being accelerated by the familiarity of university graduates with the UNIX system, as well as by Japanese frustration with the operating systems coming from some of the major U.S. mainframe manufacturers.

UNIX is certain to make inroads at the microcomputer level, too, where the world of operating systems is currently dominated by both CP/M-86

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XENIX includes a visual shell, record and file locking, and resource-sharing ability.

and MS-DOS. An important sign of commercial progress in that direction was the announcement at this year's Tokyo Microcomputer Show by ASCII Corporation, a prominent Japanese software publisher, that it will release a Japanese-language version of Microsoft's XENIX operating system for 80286-based computers late this summer. (A version of UNIX System III called PC-UX has been available for some months now, but it hasn't been popular.)

I saw ASCII Corporation's 286 XENIX System V running on the PC-98XA at the show and was impressed. XENIX is a UNIX enhancement that includes a visual shell, record and file locking, and some resource-sharing ability, among other things. It also offers substantial MS-DOS compatibility.

Fujitsu has prototyped an 80286 card for its FM-16β, or Beta, machine; it's also scheduled for release sometime this summer. I saw the prototype, also running XENIX, at the show. With the availability of 286 XENIX on the two most popular and powerful personal computers in Japan, we should see a new level of sophistication in top-end Japanese microcomputer systems by this fall.

I had been wondering what my first UNIX machine might be; now it looks like my next computer will be a Fujitsu Beta. I wrote about this outstanding 80186-based machine in the May BYTE Japan (page 355). It will run both CP/M-86 (like the Fujitsu FM-11BS I own now) and MS-DOS, and it offers users the chance to jump on the UNIX bandwagon when XENIX becomes available for it.

The HP-9807

Another UNIX machine at the show was one that has already been featured in BYTE: the Hewlett-Packard Integral portable computer. (See "The HP Integral Personal Computer" by Phillip Robinson, February BYTE, page 98.) It's being sold in Japan as the HP-9807 by YHP (Yokogawa Hewlett-Packard, Hewlett-Packard's Japanese enterprise). Even though I think the machine is interesting, particularly for someone who might want a powerful portable engineering workstation, its sales potential here in Japan is going to be limited by its inability to deal effectively with the Japanese language. At the show, the machine was running some demonstration programs that displayed katakana characters (from the Japanese phonetic alphabet), but that's not enough, particularly for a machine in the Integral's price class.

Hitachi's DK-301 Drive

Hitachi manages at every computer show to exhibit some very impressive OEM (original equipment manufacturer) disk drives. This time, lurking in a corner of the Hitachi booth, there was a small, unprepossessing gadget that looked just like a 5¼-inch hard-disk drive, but smaller. It turned out to be the DK-301, a new 3½-inch Winchester-type hard-disk drive. The whole unit is only 5¾ inches deep, 4 inches wide, and 1⅗ inches high, but the storage capacity is impressive: formatted, it holds 15 megabytes. It's no slouch as far as speed goes, either—the data-transfer rate is 625K bytes per second, which is probably an order of magnitude faster than the floppy-disk drive in your computer. Weighing only about 2.2 pounds, it's not hard to imagine this kind of drive appearing in portable computers in a year or two.

The DK-301 seemed like a nice complement to some of Hitachi's other disk drives, like the 500-megabyte 8-inch hard disk and the 6½-megabyte 5¼-inch floppy-disk drive I've written about in previous issues.

Coming Up

Next month I'll tell you about my new Fujitsu FM-16β, and I'll compare my new machine to the Fujitsu FM-11BS I bought last year. I also plan an update on the NEC PC-9801M2. ■

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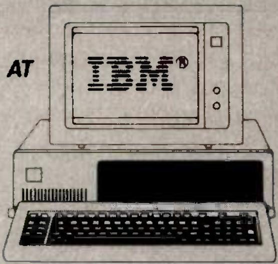

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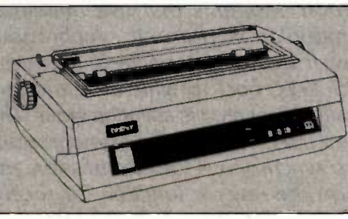

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Conducted by Steve Ciarcia

Disk Drives

Dear Steve,

I am working with a TI-99/4A microcomputer and peripherals. Some of the equipment isn't from TI, and I have problems getting technical manuals, circuit diagrams, and pin-outs from manufacturers. Either they do not want to bother or they are afraid to send them. They are glad to sell equipment, however.

Is there any way to get technical information on disk drives through a technical journal or organization? (Specifically for the TEAC FD50A and Shugart SA400L.)

Elbert B. Childs
Chestertown, MD

Most disk-drive manufacturers offer service and maintenance manuals that contain complete information on the theory of operation and interfacing. The manuals that you require can be obtained from

Shugart Technical Publications
475 Oakmead Parkway, MS 3-14
Sunnyvale, CA 94086
(408) 733-0100

TEAC Corporation of America
7733 Telegraph Rd.
Montebello, CA 90640
(213) 726-0303

As an example, the Shugart OEM manual contains the information required to install, interface, and power the Shugart SA400L floppy disk for applications with a computer system. The service manual provides information necessary to maintain, troubleshoot, and repair the SA400L. The service manual also contains a general description of the interfaces and a section on the theory of operation.

Similar information is contained in the TEAC manuals.—Steve

Modems

Dear Steve,

I have been entertaining thoughts of building a 1200-bps modem from scratch. I've been a hobbyist since before transistors were invented. I know what differential phase-shift keying is, and I think it would be fun to build a flash ADC and digital-phase comparator.

Where do I go to find 212A specifications . . . things like which phase is what bits?

Rich Grise
Richfield, MN

Unlike the Bell 103 and Bell 202 standards that use frequency-shift keying (FSK) for modulating the transmitted signals, the Bell 212A-type modems utilize a four-level phase-shift keying (PSK). This increases the effective data-transmission rate by encoding 2 data bits per baud (a baud is a single modulation of the carrier signal, or bit). Such a technique is required because the bandwidth available on the telephone line is too narrow to accommodate FSK for 1200-bps transmission.

The high bit rate that results from PSK for 212A-compatible modems necessitates greater circuit complexity in both transmitters and receivers, as well as a reduced tolerance for noise and signal distortion. Modems that use multilevel PSK modulation transmit synchronous data over the telephone lines. However, the RS-232C port to which the modem is usually connected is asynchronous. The modem must convert the asynchronous data to synchronous for transmission and perform the reverse function for receiving. To separate the received bits combined into a baud, a timing signal must be recovered by the receiving modem. This is accomplished through a scrambling device in the transmitter and a descrambler in the receiver but has the unwanted aspect of amplifying the effect of transmission errors. Firmware techniques are employed as a part of the process to regain synchronization after errors.

If this level of complexity does not dissuade you, a reference that may help answer these and other questions is Data Communications for Microcomputers *by E. A. Nichols and K. Musson (McGraw-Hill, 1982).*—Steve

Simple LED Display

Dear Steve,

I am an electronics hobbyist interested in building a simple and inexpensive alphanumeric LED display. After reading your article "Build a Scrolling Alphanumeric LED Display" (April 1984, page 32), I was a bit confused. I hope that you might be able to provide me with some information on how to build a simpler display. I would like to build one that is 10 to 20 characters long, is nonscrolling, has characters 2 to 3 inches high, uses a simpler 14-segment display device, and has a switch to select the message to be displayed.

Rick Buncak
Stateline, NV

The project that will satisfy most of your requirements appeared in the October 1979 BYTE on page 58. Entitled "Self-Refreshing LED Graphics Display," it can also be found in the second volume of Ciarcia's Circuit Cellar. *The display described in this article used a multiplexed design to build an 8 by 16 LED array. The same article discusses some simpler arrays as well, which would be good to start with if you're not ready to step up to a full-size display.*

Your local Radio Shack store is often a good source for parts. Two other sources that supply parts by mail order are

Jameco Electronics
1355 Shoreway Rd.
Belmont, CA 94002
(415) 592-8097

Digi-Key Corporation
Highway 32 South
POB 677
Thief River Falls, MN 56701
(800) 346-5144

—Steve ■

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

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

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· SPST keyswitches · 20 pin ribbon cable connection · Low profile keys · Features: cursor controls, control, caps (lock), function, enter and shift keys · Color (keycaps): grey · Weight: 1 lb. · Pinout Incl. · Size: 13⅛"L x 4¼"W x ¾"H

KB54 . . . . **$14.95**

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KB8201 . . . . . . *(1700 available)* **$19.95**

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8 Chips - 21 Minutes

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7400

Part No.	Pins	Price
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SN7403N	14	.29
SN7404N	14	.35
SN7405N	14	.49
SN7406N	14	.59
SN7407N	14	.59
SN7408N	14	.29
SN7409N	14	.35
SN7410N	14	.29
SN7411N	14	.29
SN7412N	14	.49
SN7413N	14	.39
SN7414N	14	.49
SN7416N	14	.49
SN7417N	14	.59
SN7420N	14	.19
SN7421N	14	.59
SN7422N	14	.59
SN7423N	16	.69
SN7425N	14	.39
SN7426N	14	.39
SN7427N	14	.25
SN7428N	14	.59
SN7430N	14	.35
SN7432N	14	.39
SN7433N	14	.49
SN7437N	14	.25
SN7438N	14	.49
SN7439N	14	.79
SN7440N	14	.19
SN7441N	16	.89
SN7442N	16	.45
SN7443N	16	1.25
SN7444N	16	1.25
SN7445N	16	.69
SN7446N	16	.75
SN7447N	16	.75
SN7448N	16	.75
SN7454N	14	.19
SN7459N	14	.35
SN7460N	14	.39
SN7470N	14	.39
SN7472N	14	.39
SN7473N	14	.39
SN7474N	14	.39
SN7475N	16	.45
SN7476N	16	.39
SN7479N	14	4.95
SN7480N	14	.89
SN7482N	14	1.49
SN7483N	16	.55
SN7485N	16	.59
SN7486N	14	.39
SN7489N	16	2.25
SN7490N	14	.49
SN7491N	14	.79
SN7492N	14	.45
SN7493N	14	.45
SN7494N	14	.89
SN7495N	14	.49
SN7496N	16	.49
SN7497N	16	3.25
SN74100N	24	1.95
SN74105N	14	1.19
SN74107N	14	.29
SN74109N	16	.39
SN74116N	24	1.49
SN74121N	14	.45
SN74122N	14	.69
SN74123N	16	.55
SN74125N	14	.49
SN74126N	14	.49
SN74128N	14	.79
SN74132N	14	.59
SN74136N	14	.69
SN74141N	16	.89
SN74142N	16	3.95
SN74143N	24	3.95
SN74144N	24	3.95
SN74145N	16	.65
SN74147N	16	1.29
SN74148N	16	1.29
SN74150N	24	1.49
SN74151N	16	.49
SN74152N	14	.49
SN74153N	16	.99
SN74154N	24	1.49
SN74155N	16	.49
SN74156N	16	.49
SN74157N	16	.49
SN74159N	24	1.95
SN74160N	16	.59
SN74161N	16	.59
SN74162N	16	.59
SN74163N	16	.59
SN74164N	14	.69
SN74165N	16	.69
SN74166N	16	.69
SN74167N	16	2.95
SN74170N	16	1.59
SN74172N	24	4.95
SN74173N	16	.85
SN74174N	16	.59
SN74175N	16	.59
SN74176N	14	.79
SN74177N	14	.79
SN74179N	16	1.49
SN74180N	14	.69
SN74181N	24	1.95
SN74182N	16	1.05
SN74184N	16	2.29
SN74185N	16	2.29
SN74190N	16	.69
SN74191N	16	.69
SN74192N	16	.69
SN74193N	16	.69
SN74194N	16	.69
SN74195N	16	.49
SN74196N	14	.75
SN74197N	14	.75
SN74198N	24	1.19
SN74199N	24	1.19
SN74221N	16	1.19
SN74251N	16	.79
SN74273N	20	1.95
SN74276N	20	2.49
SN74279N	16	.79
SN74283N	16	1.39
SN74284N	16	2.95
SN74285N	16	2.95
SN74365N	16	.55
SN74366N	16	.55
SN74367N	16	.55
SN74368N	16	.55
SN74390N	16	1.49
SN74393N	14	1.49

74LS

Part No.	Pins	Price
74LS00	14	.29
74LS01	14	.29
74LS02	14	.35
74LS03	14	.35
74LS04	14	.39
74LS05	14	.35
74LS06	14	.99
74LS07	14	.99
74LS08	14	.35
74LS09	14	.35
74LS10	14	.35
74LS11	14	.35
74LS14	14	.59
74LS20	14	.29
74LS21	14	.35
74LS26	14	.35
74LS27	14	.35
74LS28	14	.39
74LS30	14	.35
74LS32	14	.39
74LS37	14	.35
74LS38	14	.35
74LS42	16	.49
74LS47	16	.89
74LS51	14	.29
74LS73	14	.39
74LS74	14	.49
74LS75	16	.45
74LS76	16	.39
74LS85	16	.89
74LS86	14	.39
74LS90	14	.55
74LS92	14	.55
74LS93	14	.55
74LS96	16	.89
74LS107	14	.39
74LS109	16	.39
74LS112	16	.45
74LS122	14	.45
74LS123	16	.79
74LS125	14	.59
74LS126	14	.59
74LS132	14	.65
74LS133	16	.59
74LS136	14	.39
74LS138	16	.55
74LS139	16	.59
74LS145	16	1.19
74LS147	16	1.95
74LS148	16	1.79
74LS151	16	.59
74LS153	16	.59
74LS154	24	1.49
74LS155	16	.69
74LS156	16	.69
74LS157	16	.69
74LS158	16	.59
74LS160	16	.69
74LS161	16	.69
74LS162	16	.69
74LS163	16	.69
74LS164	14	.69
74LS165	16	.89
74LS166	16	.89
74LS168	16	1.19
74LS169	16	1.49
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.69
74LS175	16	.69
74LS181	24	2.49
74LS190	16	.89
74LS191	16	.89
74LS192	16	.79
74LS193	16	.89
74LS194	16	.69
74LS195	16	.69
74LS196	14	.89
74LS197	14	.89
74LS221	16	1.09
74LS240	20	1.09
74LS241	20	1.09
74LS243	14	1.09
74LS244	20	1.29
74LS245	20	1.49
74LS251	16	.59
74LS253	16	.59
74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
74LS266	14	.49
74LS273	20	1.49
74LS279	16	.49
74LS280	14	1.95
74LS299	20	2.95
74LS322	20	3.95
74LS323	20	3.95
74LS347	16	.79
74LS353	16	1.09
74LS364	20	1.95
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.49
74LS374	20	1.49
74LS375	16	.69
74LS386	14	.39
74LS393	14	1.19
74LS399	16	1.49
74LS490	16	1.95
74LS533	20	1.95
74LS534	20	1.95
74LS540	20	1.49
74LS541	20	1.49
74LS640	20	2.19
74LS641	20	2.19
74LS642	20	2.19
74LS645	20	2.19
74LS670	16	1.49
74LS688	20	2.95
81LS95	20	1.49
81LS96	20	1.49
81LS97	20	1.49
81LS98	20	1.49

74S/PROMS*

Part No.	Pins	Price
74S00	14	.35
74S02	14	.35
74S04	14	.45
74S05	14	.45
74S08	14	.45
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S37	14	.99
74S38	14	.89
74S64	14	.39
74S65	14	.39
74S74	14	.55
74S85	16	1.99
74S86	14	.55
74S112	16	.55
74S124	16	2.75
74S132	14	1.89
74S133	16	.45
74S135	16	.89
74S136	14	1.39
74S138	16	.89
74S139	16	.89
74S140	14	.69
74S151	16	.99
74S153	16	.99
74S157	16	.99
74S158	16	.99
74S160	16	2.29
74S169	16	4.29
74S174	16	1.09
74S175	16	1.09
74S188*	16	1.75
74S194	16	1.49
74S195	16	1.49
74S196	14	1.49
74S240	20	1.95
74S241	20	1.95
74S242	14	2.19
74S244	20	2.19
74S251	16	.99
74S253	16	.99
74S257	16	.99
74S258	16	.99
74S273	20	2.39
74S280	14	1.89
74S287*	16	1.79
74S288*	16	1.79
74S299	20	5.95
74S373	20	2.49
74S374	20	2.49
74S387*	16	1.95
74S471*	20	4.95
74S472*	20	4.95
74S473*	20	4.95
74S570*	16	2.95
74S571*	16	2.95
74S572*	18	4.95
74S573*	18	4.95

74ALS

Part No.	Pins	Price
74ALS00	14	.59
74ALS02	14	.59
74ALS04	14	.59
74ALS08	14	.59
74ALS10	14	.59
74ALS30	14	.59
74ALS32	14	.65
74ALS74	14	.79
74ALS109	16	.79
74ALS112	16	.69
74ALS138	16	1.25
74ALS240	20	2.25
74ALS244	20	2.25
74ALS245	20	2.59
74ALS373	20	2.59
74ALS374	20	2.59

74F

Part No.	Pins	Price
74F00	14	.69
74F02	14	.75
74F04	14	.89
74F08	14	.75
74F10	14	.75
74F20	14	.69
74F32	14	.75
74F74	14	.85
74F86	14	1.15
74F109	16	.95
74F138	16	1.69
74F139	16	1.69
74F157	16	1.69
74F158	16	1.69
74F240	20	3.75
74F244	20	3.49
74F253	16	1.79
74F257	16	1.79
74F280	14	1.69
74F373	20	4.89
74F374	20	4.59
74F379	16	1.99

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Part No.	Pins	Price
CD4000	14	.29
CD4001	14	.29
CD4002	14	.29
CD4006	14	.89
CD4007	14	.29
CD4008	16	.89
CD4009	16	.59
CD4010	16	.49
CD4011	14	.29
CD4012	14	.29
CD4013	14	.39
CD4014	16	.89
CD4015	16	.39
CD4016	14	.49
CD4017	16	.79
CD4018	16	.79
CD4019	16	.49
CD4020	16	.75
CD4021	16	.75
CD4022	16	.75
CD4023	14	.29
CD4024	14	.69
CD4025	14	.29
CD4026	16	1.59
CD4027	16	.45
CD4028	16	.69
CD4029	16	.79
CD4030	14	.39
CD4034	24	1.79
CD4035	16	.79
CD4040	16	.75
CD4041	14	.69
CD4042	16	.69
CD4043	16	.79
CD4044	16	.79
CD4046	16	.79
CD4047	14	.89
CD4048	16	.59
CD4049	16	.39
CD4050	16	.39
CD4051	16	.79
CD4052	16	.79
CD4053	16	.79
CD4056	16	2.95
CD4059	24	3.95
CD4060	16	.85
CD4066	14	.45
CD4068	14	.35
CD4069	14	.29
CD4070	14	.29
CD4071	14	.29
CD4072	14	.29
CD4073	14	.29
CD4075	14	.29
CD4076	16	.89
CD4077	14	.35
CD4078	14	.35
CD4081	14	.29
CD4093	14	.49
CD4094	16	1.95
CD4098	16	1.95
CD4099	16	1.89
CD40103	16	2.49
CD4503	16	.69
CD4506	16	1.29
CD4507	14	1.19
CD4508	24	1.95
CD4510	16	.85
CD4511	16	.85
CD4512	16	.85
CD4514	24	1.49
CD4515	24	1.49
CD4516	16	.85
CD4518	16	.89
CD4519	16	.85
CD4520	16	.85
CD4522	16	1.69
CD4526	16	1.19
CD4528	16	1.19
CD4529	16	1.69
CD4530	16	1.19
CD4538	16	1.49
CD4541	14	1.49
CD4543	16	1.19
CD4553	16	4.95
CD4566	16	2.95
CD4583	16	2.49
CD4584	14	.59
CD4585	16	1.39
CD4723	16	1.19
CD4724	16	1.19
MC14410	16	8.95
MC14411	24	11.95
MC14412	16	7.95
MC14433	24	17.95
MC14490P	16	4.95
MC14572	16	1.19

RED-HOT RAM & EPROM PRICES

Part No.	Description	Price
21C14	(200ns) CMOS SRAM CMOS USES LESS POWER	.99
27C16	(450ns) CMOS EPROM	9.95
4164N-200	(DRAM)	9/9.95
6116P-4	(200ns) SRAM	3.49
6116LP-4	(200ns) L.P. SRAM	3.69
6264LP-15	(150ns) L.P. SRAM	7.49
MC146818	REAL TIME CLOCK & RAM	7.95
27128-25	(250ns) EPROM	5.95
41256-150	(150ns) DRAM	6.49
68764	(450ns) 21V EPROM	12.95
68766	(350ns) 25V EPROM	14.95

MICROPROCESSOR COMPONENTS

MICROPROCESSOR CHIPS

Part No.	Pins	Function	Price
D765AC	40	Floppy Disk Controller	16.95
D3242	28	Addr. Multiplexer & Refresh Counter	7.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
Z80, Z80A, Z80B, Z8000 SERIES			
Z80	40	CPU (MK3880N)(780C)2.5MHz	2.75
Z80-CTC	28	Counter Timer Circuit	3.49
Z80-DART	40	Dual Asynchronous Rec./Trans.	8.95
Z80-DMA	40	Direct Memory Access Circuit	12.49
Z80-P10	40	Parallel I/O Interface Controller	2.95
Z80-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	11.49
Z80-S10/1	40	Serial I/O (Lacks DTRB)	11.49
Z80-S10/2	40	Serial I/O (Lacks SYNCB)	11.49
Z80-S10/9	40	Serial I/O	11.49
Z80A	40	CPU(MK3880N-4)(780C-1)4MHz	2.95
Z80A-CTC	28	Counter Timer Circuit	3.95
Z80A-DART	40	Dual Asynchronous Rec./Trans.	9.95
Z80A-DMA	40	Direct Memory Access Circuit	12.95
Z80A-P10	40	Parallel I/O Interface Controller	3.95
Z80A-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	11.95
Z80A-S10/1	40	Serial I/O (Lacks DTRB)	11.95
Z80A-S10/2	40	Serial I/O (Lacks SYNCB)	11.95
Z80A-S10/9	40	Serial I/O	11.95
Z80B	40	CPU (MK3880N-6) 6MHz	8.95
Z80B-CTC	28	Counter Timer Circuit	11.95
Z80B-DART	40	Dual Asynchronous Rec./Trans.	19.95
Z80B-P10	40	Parallel I/O Interface Controller	10.95
6500/6800/68000 SERIES			
6502	40	MPU with Clock (1MHz)	4.95
6502A	40	MPU with Clock (2MHz)	5.25
6502B	40	MPU with Clock (3MHz)	7.95
6520	40	Peripheral Inter. Adapter	2.75
6522	40	Versatile Inter. Adapter	4.95
6551	28	Async. Comm. Interface Adapt.	6.95
6800	40	MPU	2.95
6802	40	MPU with Clock and RAM	5.95
6809	40	CPU — 8-Bit (On Chip Oscillator)	6.95
6809E	40	CPU — 8-Bit (External Clocking)	8.49
68B09E	40	CPU — 8-Bit (Ext. Clocking) 2MHz	11.49
6810	24	128x8 Static RAM	2.75
68B10	24	128x8 Static RAM (2MHz)	5.95
6821	40	Peripheral Inter. Adapt (MC6820)	2.75
68B21	40	Peripheral Interface Adapter (2MHz)	4.95
6845	40	CRT Controller (CRTC)	9.95
68B45	40	CRT Controller (CRTC) 2MHz	14.95
6850	24	Asynchronous Comm. Adapter	2.95
6860	24	0-600bps Digital MODEM	6.95
68000L8	64	MPU 16-Bit (8MHz)	19.95
68488P	40	General Purpose Int. Adapter	9.95
68661	28	Enhanced Prog. Comm. Interface (2661)	8.95
8000/80000 SERIES			
8031	40	Control Oriented CPU w/RAM & I/O	12.95
8035	40	MPU — 8-Bit	4.95
8039	40	CPU—Sgl. Chip 8-Bit (128bits RAM)	4.95
8060	40	CPU — 8-Bit NMOS	12.95
8073N	40	CPU w/Basic Micro Interpreter	29.95
8080A	40	CPU	3.95
8085A	40	CPU	3.95
8085A-2	40	CPU-8-Bit N-Channel(5MHz)	10.95
8086-2	40	CPU 16-bit 8MHz	19.95
8087	40	Arithmetic Processor (5MHz)	119.00
8087-2	40	Arithmetic Processor (8MHz)	125.00
8088	40	CPU 8/16-Bit	14.95
8116	18	Dual Baud Rate Generator	9.49
8155	40	HMOS RAM I/O Port-Timer	4.95
8156	40	RAM with I/O Port and Timer	5.95
8202	40	Dynamic RAM Controller	19.95
8203	40	64K Dynamic RAM Controller	29.95
8205	16	Hi Speed 1 out of 8 Binary Decoder	3.95
8212	24	8-Bit Input/Output (74S412)	2.25
8224	16	Clock Generator/Driver	2.19
8228	28	Sys. Cont./Bus Driver (74S428)	3.95
8237-5	40	High Perf. Prog. DMA Cont. (5MHz)	12.95
8238	28	System Controller (74S438)	4.95
8243	24	I/O Expander for 48 Series	3.95
8250A	40	Async. Comm. Element	9.95
8250B	40	ACE (IBM PC or XT Software Compatible)	10.95
8251	28	Prog. Comm. I/O (USART)	3.25
8251A	28	Prog. Comm. Interface (USART)	3.49
8253-5	24	Prog. Interval Timer	6.49
8254	24	Programmable Interval Timer	13.49
8255	40	Prog. Peripheral I/O (PPI)	3.95
8255A-5	40	Prog. Peripheral I/O (PPI) 5MHz	4.25
8257-5	40	Prog. DMA Controller	6.95
8259	28	Prog. Interrupt Control	5.95
8259-5	28	Prog. Interrupt Controller	6.95
8272	40	Sgle/Dble Density Floppy Disk Cont.	16.95
8274	40	Multi-Protocol Serial Cont. (7201)	14.95
8275	40	Prog. CRT Controller	14.95
8279	40	Prog. Keyboard/Display Interface	5.49
8279-5	40	Prog. Keyboard/Display Interface	5.95
8282	20	Octal Latch	6.49
8284	18	Clock Generator/Driver	5.49
8286	20	Octal Bus Transceiver	6.49
8287	20	Octal Bus Transceiver (Inverted)	6.49
8288	20	Bus Controller	13.95
8289	20	Bus Arbiter	24.95
8741	40	8-Bit Univ. Peripheral Interface	19.95
8748	40	HMOS EPROM MPU	19.95
8749	40	MPU 8-Bit (EPROM Version of 8049)	19.95
8751	40	CPU w/4Kx8 EPROM & 128x8 RAM	29.95
8755	40	16K EPROM with I/O	19.95
80186	68	High Integration 16-Bit MPU	19.95
80188	68	High Integra. 16-Bit MPU (8-Bit Data Bus)	49.95
80287	40	Numeric Processor Ext.	195.00
SPECIAL FUNCTION			
MC3470P	18	Floppy Disk Read Amp System	4.95
MM5321N	16	TV Camera Sync. Generator	9.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro. Compatible Time Clock	8.95
MM5369AA/N	8	Prog. Oscillator/Divider (60Hz)	1.79
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95
MC146818	24	Real Time Clock Plus RAM	7.95

DYNAMIC RAMS

Part No.	Pins	Function		Price
1103	18	1024x1	(300ns)	.99
4027	16	4096x1	(250ns)	1.49
4116N-15	16	16,384x1	(150ns)	1.39 — 8/10.95
4116N-20	16	16,384x1	(200ns)	.79-8/6.29
4116N-25	16	16,384x1	(250ns)	.69-8/5.49
4164N-150	16	65,536x1	(150ns)	1.22-9/10.95
4164N-200	16	65,536x1	(200ns)	1.11-9/9.95
MM5261	18	1024x1	(300ns)	.35 — 8/1.95
MM5262	22	2048x1	(365ns)	.35 — 8/1.95
MM5270	18	4096x1	(250ns)	4.95
MM5280	22	4096x1	(200ns) 2107	3.95
MM5298-3	16	8192x1	(200ns)	.59
8118	16	16,384x1	(120ns) (+5V Only Req.)	.99
41256-150	16	262,144x1	(150ns)	6.49
41256-200	16	262,144x1	(200ns)	5.95
4128	16	131,072x1	(250ns)	8.95
STATIC RAMS				
2101	22	256x4	(450ns) 8101L	1.95
2102	16	1024x1	(350ns)	.89
2102-2L	16	1024x1	(250ns) L.P. (91L02)	1.49
2111	18	256x4	(450ns) 8111	2.49
2112	16	256x4	(450ns) MOS	2.49
2114N	18	1024x4	(450ns)	1.29 — 8/9.95
2114N-L	18	1024x4	(450ns) L.P.	1.65 — 8/12.95
2114N-2	18	1024x4	(200ns)	1.39 — 8/10.95
2114N-2L	18	1024x4	(200ns) L.P.	1.69 — 8/13.49
2147HN	18	4096x1	(70ns)	4.49
2148HN	18	1024x4	(70ns)	4.95
TMS4045	18	1024x4	(450ns)	3.95
TMS40L47-45	20	1024x4	(450ns)	1.95
5101	22	256x4	(450ns) CMOS	2.95
MM5257	18	4096x1	(450ns) 4044	4.95
HM6116P-2	24	2048x8	(120ns) CMOS	4.95
HM6116LP-2	24	2048x8	(120ns) L.P. CMOS	6.49
HM6116P-3	24	2048x8	(150ns) CMOS	3.75
HM6116LP-3	24	2048x8	(150ns) L.P. CMOS	3.95
HM6116P-4	24	2048x8	(200ns) CMOS	3.49
HM6116LP-4	24	2048x8	(200ns) L.P. CMOS	3.69
HM6264P-12	28	8192x8	(120ns) CMOS	7.25
HM6264LP-12	28	8192x8	(120ns) L.P. CMOS	7.95
HM6264P-15	28	8192x8	(150ns) CMOS	6.95
HM6264LP-15	28	8192x8	(150ns) L.P. CMOS	7.49
27LS00	16	256x1	(80ns) L.P.	3.95
7489	16	16x4	(50ns) 3101	2.25
74C921	18	256x4	(250ns) CMOS	5.95
74C930	18	1024x1	(250ns) CMOS (6518)	5.95
74S189	16	16x4	(35ns) 93405	2.95
74S289	16	16x4	(35ns) 3101	2.95
82S10	16	1024x1	(50ns) O.C. (93415)	3.95
82S25	16	16x4	(50ns) O.C. (74S289)	2.25
PROMS/EPROMS				
1702A	24	256x8	(1µs)	3.95
TMS2516	24	2048x8	(450ns)	4.95
TMS2532	24	4096x8	(450ns)	5.49
TMS2564	28	8192x8	(450ns)	10.95
2708	24	1024x8	(450ns)	3.95
TMS2716	24	2048x8	(450ns) 3 voltage	7.95
2716	24	2048x8	(450ns)	3.95
27C16	24	2048x8	CMOS	9.95
2716-1	24	2048x8	(350ns)	4.95
27160-5	24	2048x8	(550ns)	3.75
2732	24	4096x8	(450ns)	4.25
2732A-20	24	4096x8	(200ns) 21V	9.95
2732A-25	24	4096x8	(250ns) 21V	5.95
2732A-45	24	4096x8	(450ns) 21V	4.49
27C32	24	4096x8	CMOS	11.95
27C32A-30	24	4096x8	(300ns) 21V (CMOS)	22.95
2764-20	28	8192x8	(200ns) 21V	6.95
2764-25	28	8192x8	(250ns) 21V	5.09
2764A-25	28	8192x8	(250ns) 12.5V	5.95
2764-45	28	8192x8	(450ns) 21V	4.95
27C64	28	8192x8	CMOS 21V	11.95
27128-25	28	16,384x8	(250ns) 128K 21V	5.95
27128A-25	28	16,384x8	(250ns) 128K 12.5V	7.95
27256-25	28	32,768x8	(250ns) 256K (14V)	11.95
68764	24	8192x8	(450ns) 21V	12.95
68766	24	8192x8	(350ns) 25V	14.95
74S188	16	32x8	PROM O.C. (6330-1)	1.75
74S287	16	256x4	PROM T.S. (6301-1)	1.79
74S288	16	32x8	PROM T.S. (6331-1)	1.79
74S387	16	256x4	PROM O.C. (6300-1)	1.95
74S471	20	256x8	PROM T.S. (6309-1)	4.95
74S472	20	512x8	PROM T.S. (6349-1)	4.95
74S473	20	512x8	PROM O.C. (6348)	4.95
74S474	24	512x8	PROM T.S. (DM87S296N)	4.95
74S475	24	512x8	PROM O.C. (6340)	4.95
74S476	18	1024x4	PROM T.S.	6.95
74S478	24	1024x8	PROM T.S.	9.95
74S570	16	512x4	PROM O.C. (6305)	2.95
74S571	16	512x4	PROM T.S. (6306)	2.95
74S572	18	1024x4	PROM O.C. (6352)	4.95
74S573	18	1024x4	PROM T.S. (82S137)	4.95
82S23	16	32x8	PROM O.C. (27S18)	2.95
82S115	24	512x8	PROM T.S. (27S15)	9.95
82S123	16	32x8	PROM T.S. (27S19)	2.95
82S126	16	256x4	PROM O.C. (27S20)	2.95
82S129	16	256x4	PROM T.S. (27S21)	2.95
82S130	16	512x4	PROM O.C. (27S12)	3.95
82S185	18	2048x4	PROM T.S. (TBP24S81)	9.95
82S191	24	2048x8	(80ns)	14.95
DM87S181N	24	1024x8	PROM T.S. (82S181)	9.95
DATA ACQUISITION				
DC10		Mostek DC/DC Converter +5V to −9V		2.95
ADC0801	20	8-Bit A/D Converter (1/4LSB)		14.95
ADC0803	20	8-Bit A/D Converter (±1/2LSB)		4.95
ADC0804	20	8-Bit A/D Converter (1LSB)		3.49
ADC0808	28	8-Bit A/D Conv. w/8-Channel Analog		9.95
ADC0809	28	8-Bit A/D Converter (8-Ch. Multi.)		4.49
ADC0816	40	8-Bit A/D Conv. w/16-Channel Analog		14.95
ADC0817	40	8-Bit A/D Converter (16-Ch. Multi.)		9.49
DAC0806	16	8-Bit D/A Converter (0.78% Lin.)		1.95
DAC0807	16	8-Bit D/A Converter (MC1408-7)		1.49
DAC0808	16	8-Bit D/A Converter (MC1408-8)		2.25
DAC0830	20	8-Bit Up D/A Conv. (.05% Lin.)		5.95
DAC0831	20	8-Bit Up D/A Conv. (.10% Lin.)		4.49
DAC1000	24	10-Bit D/A Conv. Micro Comp. (0.05%)		7.95
DAC1008	20	10-Bit D/A Conv. Micro Comp. (0.20%)		6.95
DAC1022	16	10-Bit D/A Conv. (0.20% lin.)		5.95
DAC1222	18	12-Bit D/A Conv. (0.20% Lin.)		6.95
DAC1230	20	12-Bit Up D/A Conv. (.05% Lin.)		14.95
DAC1231	20	12-Bit Up D/A Conv. (.10% Lin.)		13.95
AY-3-1015D	40	25K Baud UART		4.25
AY-5-1013A	40	30K Baud UART (TR1602)		3.95

Low Profile (Tin) Sockets

Part No.	1-9	10-99	100-up
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.15
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
40 pin LP	.49	.45	.43

Soldertail (Gold) Standard

Part No.	1-9	10-99	100-up
8 pin SG	.39	.35	.29
14 pin SG	.49	.45	.39
16 pin SG	.55	.49	.45
18 pin SG	.65	.59	.51
20 pin SG	.75	.65	.59
22 pin SG	.75	.69	.59
24 pin SG	.79	.69	.65
28 pin SG	.95	.85	.75
36 pin SG	1.25	1.15	.99
40 pin SG	1.39	1.25	1.15

Wire Wrap Sockets (Gold) Level #3

Part No.	1-9	10-99	100-up
8 pin WW	.55	.49	.45
10 pin WW	.69	.65	.59
14 pin WW	.75	.69	.65
16 pin WW	.79	.72	.65
18 pin WW	.89	.85	.75
20 pin WW	1.19	1.09	.95
22 pin WW	1.29	1.19	1.05
24 pin WW	1.35	1.19	1.09
28 pin WW	1.69	1.55	1.39
36 pin WW	1.89	1.79	1.69
40 pin WW	2.29	1.95	1.79

Header Plugs (Gold)

Part No.	1-9	10-99	100-up
14 pin HP	.65	.59	.55
16 pin HP	.69	.65	.59
24 pin HP	1.15	.99	.89

Header Covers

Part No.	1-9	10-99	100-up
14 pin HC	.15	.13	.12
16 pin HC	.16	.17	.15
24 pin HC	.29	.25	.22

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NEW EEPROM

Part No.	Pins	Function	Price
2816A	24	2048x8 16K E²PROM 350ns	12.95

Features: • On-board Address/Data Latches • Auto-Timed Byte Write (on chip timer) • 5V Erase/Write/Read • Optional High Voltage Erase/Program (12V-22V) • Power Up/Down Write Protection • Auto Erase before Write
The 2816A is an ideal nonvolatile memory providing in-system alterability with the same ease and with the same features as 2Kx8 Static RAMs.

Digitalker™

DT1050 — Applications: Teaching aids, appliances, clocks, automotive, telecommunications, language translations, etc. The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences. The "voice" output of the DT1050 is a highly intelligible male voice. The DT1050 consists of a Speech Processor Chip, MM54104 (40-pin) and two (2) Speech ROMs MM52164SSR1 and MM52164SSR2 (24-pin) along with a Master Word list and a recommended schematic diagram on the application sheet.

DT1050 Digitalker™ .... $29.95 ea.
MM54104 Processor Chip..... $12.95 ea.

DT1057 - Expands the DT1050 vocabulary from 137 to over 260 words. Incl. 2 ROMs and specs.
Part No. DT1057............... $21.95 ea.

INTERSIL

Part No.	Pins	Function	Price
FE0202D	40	4 Digit LCD Display for 7211IPL & 7211MIPL	14.95
FE0203D	40	3½ Digit LCD Display for 7106 & 7116	14.95
7045IPI	28	CMOS Precision Timer	14.95
7045EV/Kit	28	Stopwatch Chip, XTL (Evaluation Kit)	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	10.49
7106EV/Kit	40	IC, Circuit Board, Display (Evaluation Kit)	46.95
7107CPL	40	3½ Digit A/D (LED Drive)	10.95
7107EV/Kit	40	IC, Circuit Board, Display (Evaluation Kit)	46.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD	10.95
7201IJS		Low Battery Volt. Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	14.95
7205EV/Kit	24	Stopwatch Chip, XTL (Evaluation Kit)	16.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit	16	Tone Generator Chip, XTL (Evaluation Kit)	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit	14	Freq. Counter Chip, XTL (Evaluation Kit)	8.49
7211IPL	40	4 Digit LCD Display Decoder/Driver (TTL compatible)	7.95
7211MIPL	40	4 Digit LCD Display Decoder/Driver (Microproc. compat.)	8.95
7215IPG	24	4 Func. CMOS Stopwatch CKT	16.95
7215EV/Kit	24	4 Func. Stopwatch Chip, XTL (Evaluation Kit)	19.49
7216AIJI	28	8 Digit Univ. Counter C.A.	31.49
7216DIPI	28	8 Digit Freq. Counter C.C.	21.49
7217IJI	28	4 Digit LED Up/Down Counter C.A.	10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.	9.95
7224IPL	40	LCD 4½ Digit Up Counter DRI	10.95
7226AEV/Kit	40	5 Function Counter Chip, XTL (Evaluation Kit)	99.95

30009 1983 INTERSIL Data Book (1356p.) $9.95

74HC HIGH SPEED CMOS

Part No.	Pins	Price
74HC00	14	.59
74HC02	14	.59
74HC03	14	.89
74HC04	14	.59
74HCU04	14	.69
74HC08	14	.59
74HC10	14	.59
74HC11	14	.69
74HC14	14	.89
74HC20	14	.59
74HC27	14	.59
74HC30	14	.69
74HC32	14	.79
74HC42	16	1.09
74HC51	14	.89
74HC58	14	.89
74HC73	14	.79
74HC74	14	.79
74HC75	16	.99
74HC76	16	.79
74HC85	16	1.69
74HC86	14	.75
74HC107	14	.79
74HC109	16	.79
74HC112	16	.79
74HC123	16	2.29
74HC125	14	1.75
74HC132	14	1.29
74HC137	16	1.59
74HC138	16	1.19
74HC139	16	1.05
74HC147	16	1.29
74HC151	16	.99
74HC153	16	1.09
74HC154	24	2.65
74HC157	16	.99
74HC158	16	.99
74HC160	16	1.39
74HC161	16	1.39
74HC162	16	1.39
74HC163	16	1.39
74HC164	14	1.35
74HC165	16	2.15
74HC166	16	2.49
74HC173	16	1.29
74HC174	16	1.09
74HC175	16	1.09
74HC190	16	1.59
74HC191	16	1.59
74HC192	16	1.49
74HC193	16	1.49
74HC194	16	1.19
74HC195	16	1.19
74HC221	16	2.95
74HC237	16	1.49
74HC240	20	2.29
74HC241	20	2.29
74HC242	14	2.15
74HC243	14	2.15
74HC244	20	2.29
74HC245	20	2.59
74HC251	16	.99
74HC253	16	1.09
74HC257	16	.99
74HC259	16	1.69
74HC266	14	.89
74HC273	20	2.79
74HC280	14	4.59
74HC299	20	5.59
74HC366	16	2.59
74HC367	16	2.59
74HC373	20	2.69
74HC374	20	2.69
74HC390	16	1.59
74HC393	14	1.59
74HC533	20	2.69
74HC534	20	2.69
74HC595	16	3.19
74HC688	20	3.59
74HC4024	14	1.75
74HC4040	16	1.49
74HC4049	16	.89
74HC4050	16	.89
74HC4060	16	1.49
74HC4075	14	.59
74HC4078	14	.59
74HC4511	16	1.95
74HC4514	24	4.19
74HC4538	16	2.59
74HC4543	16	3.75

74HCU04 is unbuffered

74C—C/MOS

Part No.	Pins	Price
74C00	14	.29
74C02	14	.35
74C04	14	.35
74C08	14	.35
74C10	14	.35
74C14	14	.59
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.19
74C48	16	1.79
74C73	14	.69
74C74	14	.59
74C85	16	1.39
74C86	14	.29
74C89	16	5.95
74C90	14	1.09
74C93	14	1.09
74C95	14	1.19
74C107	14	.79
74C151	16	2.19
74C154	24	3.25
74C157	16	1.75
74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.29
74C165	16	1.29
74C173	16	.89
74C174	16	1.19
74C175	16	1.19
74C192	16	1.39
74C193	16	1.39
74C195	16	1.29
74C221	16	1.75
74C240	20	1.95
74C244	20	1.95
74C373	20	2.29
74C374	20	2.29
74C901	14	.59
74C902	14	.79
74C903	14	.59
74C906	14	.59
74C907	14	.89
74C911	28	8.95
74C912	28	8.95
74C915	18	1.19
74C917	28	8.95
74C922	18	4.49
74C923	20	4.95
74C925	16	5.95
74C926	18	5.95
80C95	16	.69
80C97	16	.69

LINEAR

Part No.	Pins	Price
DS0026CN	8	1.95
TL071CP	8	.79
TL072CP	8	1.09
TL074CN	14	1.95
TL081CP	8	.59
TL082CP	8	1.19
TL084CN	14	1.95
LM109K		5.95
LM301CN	8	.39
LM302H		2.49
LM304H		1.95
LM305H		.99
LM307CN	8	.49
LM308CN	8	.69
LM309K		1.25
LM310CN	8	1.95
LM311CN	8	.59
LM312H		2.79
LM317T		1.19
LM317K		3.49
LM318CN	8	1.59
LM319N	14	1.49
LM320K-5		1.35
LM320K-12		1.35
LM320K-15		1.35
LM320K-24		1.35
LM320T-5		.85
LM320T-12		.85
LM320T-15		.85
LM320T-24		.85
LM322N	14	1.49
LM323K		4.95
LM324N	14	.59
LM329DZ		.65
LM331N	8	3.95
LM334Z		1.19
LM335Z		1.29
LM336Z		1.09
LM337MP		1.15
LM337T		1.89
LM338K		6.95
LM339N	14	.69
LM340K-5		1.35
LM340K-12		1.35
LM340K-15		1.35
LM340K-24		1.35
LM340T-5		.75
LM340T-12		.75
LM340T-15		.75
LM340T-24		.75
LF347N	14	1.49
LM348N	14	.89
LM350K		4.79
LF351N	8	.59
LF353N	8	.89
LF355N	8	1.09
LF356N	8	1.09
LM358N	8	.59
LM359N	14	1.79
LM370N	14	4.95
LM373N	14	4.95
LM377N	14	1.95
LM380CN	8	1.09
LM380N	14	.89
LM381N	14	1.79
LM382N	14	1.49
LM384N	14	1.95
LM386N-3	8	.89
LM387N	8	1.39
LM389N	18	1.19
LM391N-80	16	1.19
LM392N	8	.59
LM393N	8	.45
LF398N	8	3.95
LM399H		5.95
LF412CN	8	1.95
TL494CN	16	2.79
TL496CP	8	1.59
NE531V	8	1.79
NE540H (C540H)		2.95
NE544N	14	1.95
NE550A	14	1.95
NE555V	8	.35
XR-L555	8	.69
LM556N	14	.79
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76477	28	3.95

30003 1982 Nat. Linear Data Book (1952 pgs.) . $11.95

Inquiry 178

(continued from page 32)

THE MAC'S OVERHEAD

William Miller makes an interesting point about the speed of the disk system used in the Apple Macintosh (Letters, May, page 22). Indeed, the access times and transfer rates of the Macintosh might well be comparable to the IBM PC. However, Mr. Miller's conclusion that, "Clearly, it is software overhead, not hardware limitations, that accounts for the long waits. . ." could be somewhat misleading.

Any Macintosh owner fortunate enough to have 512K bytes of memory and a RAM-disk program can attest to the fact that, without the limitations of the disk drive, Mac is fast. The Mac's overhead is much more likely due to the fact that many more disk accesses are required for "equivalent" operations. This is the price you pay for a well-organized desktop (anyone can print "A>" in a hurry), default parameters that tailor themselves to the user, and very friendly programs with lots of graphics in the user interface. I, along with a quarter of a million or so other Macintosh owners, feel that it's worth it.

RON RISLEY
Costa Mesa, CA

MAC IMPROVEMENTS

A major revision has been released for the Mac: Using the new so-called "Mini-Finder," apparently developed by Steven Capps, the Mac can now load programs about as quickly as an average MS-DOS and CP/M operating system. The Mini-Finder does limit some aspects of the general Finder desktop (which is also retained as a slower option), but it also adds keyboard commands that allow advanced users to do more faster in file manipulation than the older Finder.

This is a major advance for the Mac. It appears the benefits of the Mini-Finder even extend to hard-disk systems, as the loading speed was satisfactory even on a Lisa 2/10 (Mac XL) on which I evaluated it.

While I think it would be nice to extend the Mini-Finder's speed to the regular Finder desktop (and I also think it is theoretically feasible, with a more sophisticated disk-directory function underlying the icons "behind the scenes," so to speak), I am depressed by the new upgrade.

I think it can now be said that the Mac is satisfactorily fast relative to CP/M and MS-DOS machines in loading disk files for the first time and in saving and manipulating disk files, thanks to this new upgrade.

I wanted to compliment Apple on this new upgrade, since I have been critical of this problem in the past. This leaves only the issue of memory expansion. Rumors now rampant indicate Apple will release a memory-expandable unit with a circuit board that will fit in the original Mac's body by late August, with DMA to a 20-megabyte hard disk. This new board should permit expansion, I've heard, to 1.5 megabytes. With that board and DMA to the 20-megabyte hard disk, my hardware requirements for the Mac to match or exceed the PC will be met. Given the impressive new operating-system upgrade just released, I think we can now say that after 18 months of marketing the Mac, Apple has finally smoothed the rough edges enough to take a run at the PC. This is particularly true given not only the ease of connecting its network but also the high quality of the laser printer. Though expensive, it is a fantastic machine.

The laser printer is probably not one or two but is rather ten to a hundred times nicer than any printer I've ever seen. And it has a fantastically sophisticated interface with the on-screen graphics on the Mac. I should mention there are still idiosyncrasies, given the tabs and "white spaces" in MacWrite texts that line up on screen don't always line up in the proportional output to the laser printer. But even with those drawbacks, evidently caused by the rush to get it to market, it is an awesome machine. You can create almost any document, mixing graphics and text, and print it out with virtually typeset quality. And the ability to share that printer with multiple Macs on a network is equally impressive.

These developments appear to be timely for Apple. Home computers in general, and sales of the Apple II series in particular, appear to be down dramatically. But Apple has earned the right to have its new Mac upgrades and networks looked at closely by any MIS director.

It is no surprise to me that Mac sales were down very little in the first quarter, given the release of the Microsoft series of software at that time. But if Apple can get the expandable Mac out by August 31, despite the company's first-quarter loss this could turn out to be the year it finally seizes the market back from IBM.

Even though the laster printer costs about $7000, multiple users can amortize the costs. (The Apple first-quarter loss was caused primarily by Apple II sales being down, by the way, not by Mac sales being down.)

DON SLAUGHTER
Seattle, WA ■

THIS SAMPLE OF HIGH-DENSITY BAR CODE IS INCLUDED AS PART OF A PRINTING EXPERIMENT.

NEW SYSTEMS

Sharp PC-7000 Portable

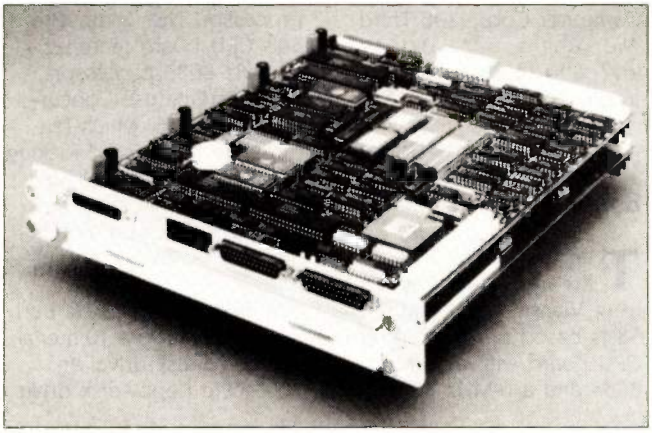
Sharp's PC-7000 IBM PC-compatible system features an 80-character by 25-line illuminated crystal display backlit by an electroluminescent panel. The bit-mapped screen has 640- by 200-dot resolution. The machine has a carrying handle, a sculpted detachable keyboard, and an adjustable display angle. It weighs 18¾ pounds.

The PC-7000 comes with 320K bytes of memory, two built-in 5¼-inch floppy-disk drives, one serial and one parallel port, and MS-DOS 2.11. You can expand the unit's 16-bit 8086 microprocessor memory to 740K bytes and add an 8087 numeric coprocessor. You can also upgrade both memory and coprocessor capacity on the motherboard.

Other options include a 300/1200-bps Hayes-compatible internal modem, RGB color controller, and silent transfer printer that attaches to the base unit. The printer can use plain or thermal paper. It runs at 70 cps in draft mode and 28 cps in near-letter-quality mode.

Suggested list price for the PC-7000 is less than $2000. Contact Sharp Electronics Corp., Systems Division, 10 Sharp Plaza, Paramus, NJ 07652, (201) 265-3856.
Inquiry **620**.

32-bit Board-Level Computers



National Semiconductor's ICM-3216, *based on the* 32016.

National Semiconductor Corporation's ICM (Integrated Computer Modules) line is based on its Series 32000 32-bit microprocessor family. The 9- by 11-inch ICM-3216 uses the 10-MHz NS32016 CPU, the NS32081 FPU, the NS32082 MMU, the NS32201 timing and control unit, and the NS32202 interrupt control unit. It also has four serial ports, a parallel port, an SCSI, a clock/calendar with battery backup, and a 16-bit I/O bus.

Memory is from 1 to 8 megabytes of dynamic RAM. Depending on the size of physical memory, the computer module consists of two or three printed circuit boards: one board for the CPU and computing functions and one or two boards for memory.

Scheduled for availability in 1986 is the ICM-3232, which will use the NS32032 CPU, contain 2 megabytes of on-board memory, and be partitioned into a computing cluster and an I/O processor that uses the NS32016.

ICM products include the MiniBus I/O channel, which is controlled by a VLSI bus interface controller. The memory bus and MiniBus are designed so that CPU, memory, and personality modules stack via DIN connectors, eliminating the need for backplanes.

System V/Series 32000, a port of UNIX System V, is available for the ICM family. It supports demand-paged virtual memory, offers job control, and has record-locking features. Also available are FORTRAN and C compilers, the Series 32000 assembler, and all Series 32000 language support tools.

The 1-megabyte version of the ICM-3216 is priced at less than $3000. The ICM-3232 will be priced at less than $4000. Contact National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051, (408) 721-5000.
Inquiry **621**.

Turbo.Tower Jr. Three-User System

Turbo.Tower Jr. from XMARK Corporation is a multiuser system that includes integrated software programs for office automation and word processing. It features a triple-microprocessor design: an 8-MHz 8088-2, a 4-MHz Z80A, and a 6502.

The system also has 256K bytes of expandable memory, two serial ports and one parallel port, one 10-megabyte hard-disk and one 5¼-inch floppy-disk drive, three CRTs (including one full graphics terminal), a clock/calendar with battery backup, and a draft-/letter-quality graphics printer.

Turbo.Tower Jr. uses the Pick operating system and also supports CP/M and MS-DOS. Its office-automation package includes the Turbo.Word word processor, Turbo.Plan spreadsheet, Turbo.Graph graphics program, Turbo.DBase database, and Turbo.Screen screen/program generator. The optional Turbo.Net module provides communications and networking capability.

You can expand Turbo.Tower Jr. from three to seven users. System cost is $6685. Contact XMARK Corp., 3176 Pullman St., Unit 119, Costa Mesa, CA 92626, (714) 556-9210.
Inquiry **622**.

Nixdorf 8810/25 CPC

Nixdorf Computer Corporation's IBM-compatible 8810/25 CPC (Compact Personal Computer) comes with a built-in 9-inch monitor, a detachable IBM-style keyboard, one Centronics parallel and one RS-232C serial interface, and a thermal graphics printer that you can switch from 80 to 132 columns. You have a choice of two double-sided double-density floppy-disk drives or one floppy-disk drive and a 10-megabyte hard-disk drive. The system uses the Intel 8088 CPU and has two expansion slots.

Standard internal memory

(continued)

Compiled by Dennis Barker and Lynne M. Nadeau

NEW SYSTEMS

is 256K bytes, expandable to 640K bytes. System software includes MS-DOS 2.11, GW-BASIC, and GEM.

A 12-inch color or monochrome monitor is optional. A separate expansion chassis with a maximum of three slots is also available.

Prices for the basic 8810/25 CPC with two floppy-disk drives start at $2500. Systems with floppy- and hard-disk drives start at $3900. Contact Nixdorf Computer Corp., 300 Third Ave., Waltham, MA 02154, (617) 890-3600.
Inquiry **623.**

Viasyn Multiuser Systems

The CompuPro 58 and 86 are two-user systems from Viasyn. The CompuPro 58 is based on a CompuPro CPU board with a 10-MHz 8088 and a 6-MHz 8085 processor. The CompuPro 86's CPU board features a 10-MHz 8086 processor. Both systems use Concurrent DOS 8-16, which features file and record locking, user-account security functions, electronic mail, windowing, full-screen switching, and PC-DOS compatibility.

Standard features on both systems include a 10-megabyte hard-disk drive, an 800K-byte floppy-disk drive, four serial ports, one parallel port, and one Centronics printer port. A 40- or 80-megabyte hard disk, slave processors, a tape backup unit, Viasyn's video board, and an ARCnet-compatible LAN are optional.

The CompuPro 58 and 86 sell for $5895 and $5995, respectively. Contact Viasyn Corp., 26538 Danti Court, Hayward, CA 94545-3999, (415) 786-0909.
Inquiry **624.**

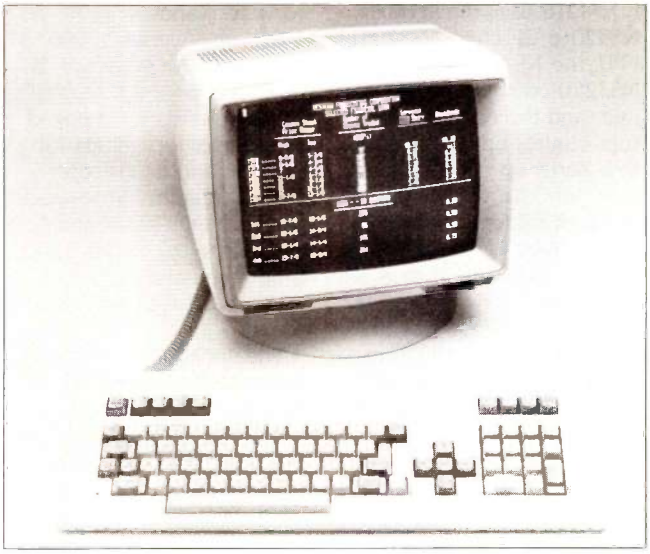
PERIPHERALS

Low-Cost Lear Siegler Terminal

Lear Siegler's ADM 3E terminal provides a standard 14-inch green or amber screen with a 50- to 60-Hz vertical refresh rate. You can tilt and swivel the monitor to a secured position.

The detached DIN standard keyboard features dynamically allocated function-key memory and seven programmable keys that you can shift for 14 nonvolatile functions. A bidirectional printer port with independent bps rate is optional. The on/off and contrast controls are located on the front panel.

The terminal is compatible with the ADM 3A and ADM 5, as well as with the ADDS Viewpoint. The ADM 3E sells for $399. Contact Lear Siegler Inc., Data Products Division, 901 East Ball Rd., Anaheim, CA 92805, (800) 532-7373; in California, (714) 778-3500.
Inquiry **625.**



Lear Siegler's ADM 3E *terminal.*

Data-Acquisition System for the Mac

MacADIOS (Macintosh Analog/Digital Input/Output System) from GW Instruments converts the Apple Macintosh into a laboratory workstation by controlling and monitoring scientific experiments and processes. The system communicates with the Mac at a rate of 500,000 bps. It has four 12-bit analog voltage outputs, eight 12-bit analog voltage inputs, 16 digital inputs, and 16 digital outputs.

MacADIOS has an extensive software package that includes the MacADIOS Manager, a general-purpose data-acquisition program that performs waveform synthesis and data presentation, analysis, and storage. You also have easy control of MacADIOS from Microsoft BASIC and can execute specific tasks from that program.

List price for MacADIOS is $2500. Contact GW Instruments, 3 Ames St., Cambridge, MA 02139, (617) 577-1524.
Inquiry **626.**

Modem for Cellular Phones

Spectrum Cellular Corporation's Bridge/Span data-communications package transmits error-free data between cellular phones and home base at rates up to 300 bps. The Bridge is a mobile modem that plugs into your car's 12-volt cigarette lighter or other voltage source. The Span is the fixed-base modem for installation at a personal computer or mainframe. Both units are Hayes-compatible and can be used as standard modems.

The Bridge and The Span communicate through a special protocol. A Bridge unit can also communicate with another Bridge to provide mobile-to-mobile transmission. The modems are compatible with the Bell 103A series and use the RS-232C interface.

The Bridge and The Span send data in packets. To ensure error-free transmission, they resend the packet if the original is damaged. This solves the data-loss problems that occur during the

(continued)

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Fields Per File	**Unlimited**	128	400
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200 to 700 milliseconds of cell-site handoff. However, the transmission rate of 300 bps decreases with carrier quality, such as when the mobile system is in a garage.

Each unit costs $695. For more information, contact Spectrum Cellular Corp., 2710 Stemmons Freeway, 800 North Tower, Dallas, TX 75207, (214) 630-9825.
Inquiry 627.

Cartridge Tape Memory

Telebyte Technology's Packetape, a 67-megabyte cartridge tape storage device, is compatible with the Pertec standard interface. It is interface- and software-compatible with ½-inch nine-track tape controllers. The recording format provides redundant data-recovery and bad-block management techniques transparent to the user.

You can daisy-chain Packetape units to other compatible ½-inch tape drives that have embedded formatters and are connected to a common tape-controller card. The device can operate in start/stop or streaming mode. Its data-transfer rate is 2 megabytes per minute in streaming mode.

The Packetape system sells for $2990. Contact Telebyte Technology Inc., 270 East Pulaski Rd., Greenlawn, NY 11740, (800) 835-3298; in New York, (516) 423-3232.
Inquiry 628.

Laptop EPROM Programmer

Logical Devices' Shooter has 128K bits of internal memory and can program the 2716 through 27256 single-voltage EPROMs. This laptop EPROM programmer can be integrated with an IBM PC to create an EPROM development center.

Shooter programs larger devices with the intelligent fast algorithm. It programs in stand-alone mode or through its RS-232C port.

Shooter sells for $395. Contact Logical Devices Inc., 1321 Northwest 65th Place, Fort Lauderdale, FL 33309, (800) 331-7766; in Florida, (305) 974-0975.
Inquiry 629.

Brother's Twinriter 5 daisy-wheel/dot-matrix printer.

Daisy-Wheel and Dot-Matrix Printer

The Model HR-35 DD Twinriter 5 from Brother International provides both daisy-wheel and dot-matrix printing in a single unit. It produces dot-matrix print at 140 cps in draft mode and 60 cps in near-letter-quality mode. The daisy wheel prints at 36 cps. The host computer controls the modes. You can combine them within a document to print text and graphics in the same operation.

The printer features bold/shadow printing, subscript/superscript, underlining, proportional spacing, and selectable dot density. Printing width ranges up to 16½ inches. The Twinriter 5 has a Centronics parallel interface with optional converter for RS-232C serial interface and standard 3K-byte buffer memory.

The Twinriter 5 is priced at $1295. Contact Brother International Corp., 8 Corporate Place, Piscataway, NJ 08854, (201) 981-0300.
Inquiry 630.

Storage and Backup for the AT

Control Data's StorageMaster Model 630 Winchester drive mounts in the IBM PC AT system unit and uses the AT's disk controller. It provides 30 megabytes of storage and has an average seek time of 40 milliseconds. All functional software is included.

The StorageMaster 860 ¼-inch cartridge streaming-tape system is compatible with the StorageMaster 500 and 600 series and IBM disk drives. You can use the StorageMaster 860 to copy selected files or an entire disk. Each cartridge stores 60 megabytes of data. Transfer rate in streaming mode is 90K bytes per second.

The 860 system consists of a half-height tape unit, an I/O cable, and a single-board controller that fits into a slot in the AT's system unit. Manuals and a DOS 3.x disk with diagnostics and utilities are included.

The StorageMaster 630 disk drive costs $2795, and the 860 streaming-tape device costs $1795. Contact Control Data Corp., StorageMaster Marketing, 2200 Berkshire Lane N., Plymouth, MN 55441.
Inquiry 631.

Headset Input Device for the Mac

Personics Corporation's View Control System (VCS) is an input device for the Macintosh that moves the cursor to where the operator looks on the screen. The VCS headset receives an ultrasonic signal from the VCS control unit, which sits on top of the Mac. By measuring and comparing the signal received at three points on the headset, the VCS tracks changes in the rotation and angle of the user's head. The system translates movements into cursor commands, as a mouse or light pen would.

Exaggerated head motion is not required. Cursor movement depends on the rate of head movement. By monitoring this rate, the VCS determines if the operator is scanning the screen or zeroing in on a target.

Suggested list price for the VCS is $199. Contact Personics Corp., 2352 Main St., Building 2, Concord, MA 01742, (800) 445-3311; in Massachusetts, (800) 447-1196.
Inquiry 632.

(continued)

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FIBONACCI	*0:53.49*	*1:49.74*
30X30 MATRIX (8087)	*0:08.84*	*0:19.28*
FP OPERATIONS	*0:52.12*	*0:31.75*
FP OPERATIONS (8087)	*0:01.97*	*0:06.21*
SYNTAX CHECKING EDITOR	*YES*	*NO*
MULTIPLE WINDOW EDITING	*YES*	*NO*
EDITOR FILESIZE LIMIT	*MEMORY SIZE*	*64K*
COMPILE ERROR CALLS EDITOR	*YES*	*YES*
LINKER	*YES*	*NO*
PRODUCES .EXE FILES	*YES*	*NO*
EXECUTABLE CODE SIZE LIMIT	*DISK SPACE*	*64K*
DOS ACCESS FROM EDITOR	*YES*	*NO*
DOS ACCESS FROM PROGRAMS	*YES*	*LIMITED*
8087 SUPPORT STANDARD	*YES*	*NO*
COPY-PROTECTED DISK	*NO*	*NO*
COST WITH 8087 SUPPORT	*$80.88*	*$109.90*

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Source: Software Resources, Inc.
Sieve program from BYTE, January 1983.
Fibonacci program from Dr. Dobb's Journal, February 1985.
Matrix program from BYTE, October, 1982.
FP Operations program from BYTE, May 1985.
Turbo Pascal without 8087 uses only 6-byte accuracy for type REAL; M2SDS with or without 8087 uses 8-byte accuracy.
Programs compiled with all checking options on.
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ADD-INS

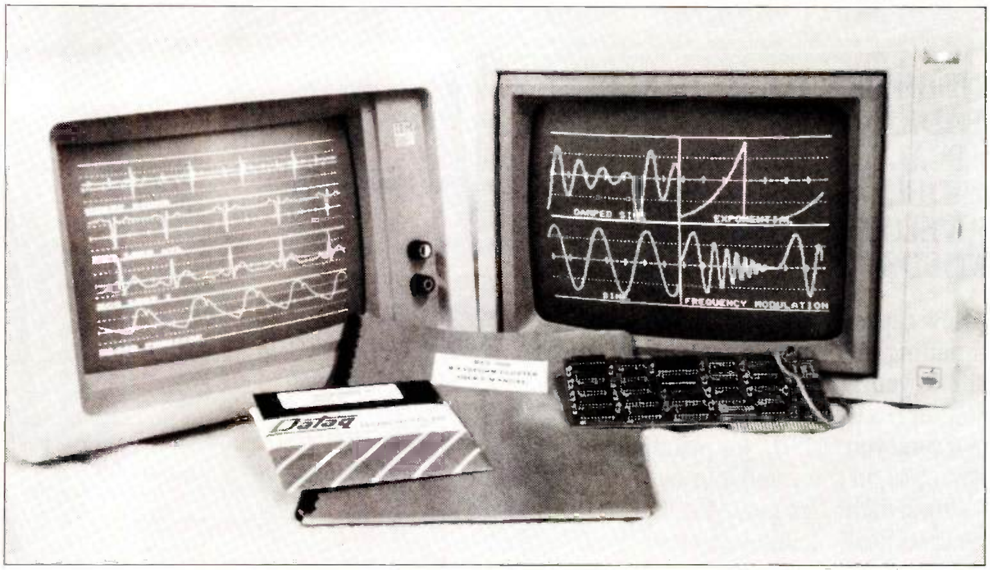
MPC-128 Coprocessor Board

Facilitec's MPC-128 coprocessor board adds building automation and direct digital control for up to 768 points to the IBM PC and compatibles. The board contains more than 100K bytes of firmware that combines all the accepted energy-management strategies with a proprietary controls programming language called Versitec. The prewritten strategies have English prompts for selecting parameters. Versitec lets you operate other custom control programs within the board's 128K bytes of onboard RAM.

The MPC-128 has one RS-422 port and two RS-232C ports. It includes 256 digital inputs, 256 digital outputs, and 256 analog inputs. Its power source is the computer's power supply.

Pricing for the MPC-128 is set at $2500. Contact Facilitec Controls Corp., 1420 Woodswether Rd., Kansas City, MS 64105, (816) 472-0260.

Inquiry **633.**



Dataq Instruments' WFS-200 *graphics-interface package for* IBM PCs *and* Apple IIs.

IBM PC 80286 Processor

TurboAccel-286 from Earth Computers is an 8-MHz 80286 processor card for the IBM PC and compatibles. It uses the Edsun Labs EL-286-88 chip and is designed to improve the PC's performance on computational tasks.

TurboAccel-286 has 512K bytes of memory with expansion capability. It provides for an optional 80287 math coprocessor and has a switch to run the PC's 8088 microprocessor. The board is software transparent because its custom VLSI chip emulates the 8088's signals.

Suggested retail price for TurboAccel-286 is $995. Contact Earth Computers, Box 8067, Fountain Valley, CA 92728, (714) 964-5784.

Inquiry **634.**

Data Acquisition for the Apple II and IBM PC

Dataq Instruments has introduced the WFS-200 family of graphics interface boards for Apple II and IBM PC computers. These boards plot up to eight channels of data on the computer's monitor during acquisition.

The WFS-200 has two display modes programmable by the host computer. You can use the continuous smooth-scroll display mode to show acquired data in a strip-chart-like fashion. You can use the oscilloscope display mode to trigger waveform plotting as a function of user-definable conditions to accommodate higher-frequency data plotting. Input signal plotting capability is DC to 7500 Hz for both display modes.

The WFS-200's nine programmable display formats let you divide the computer's monitor into four display windows. The board features a plot throughput rate of 15,000 points per second (IBM PC version) and monitors the entire data-acquisition process from signal source through analog-to-digital conversion.

List price for the Apple II version of WFS-200 is $695; the IBM PC version is $795. Contact Dataq Instruments Inc., 100 Lincoln St., Akron, OH 44308, (216) 434-4284.

Inquiry **635.**

Apple Memory Expansion

Applied Engineering's RAMWorks card expands the Apple IIe's internal memory from 128K bytes to 1 megabyte. The card supports AppleWorks and SuperCalc 3a.

Z-RAM, a product similar to RAMWorks, is for the Apple IIc. It has 512K bytes of RAM and a Z80 coprocessor. Z-RAM lets the IIc run CP/M software and Ashton-Tate's dBASE II.

RAMWorks costs $179 for the 64K-byte version, $249 for 128K bytes, $299 for 256K bytes, $399 for 512K bytes, and $649 for 1 megabyte. Z-RAM costs $449 for 256K bytes and $549 for 512K bytes. Contact Applied Engineering Inc., POB 798, Carrollton, TX 75006, (214) 241-6060.

Inquiry **636.**

Inmos Color Look-Up Table

Inmos has announced the IMSG170 Color Look-Up Table. This VLSI graphics IC is intended for use in color display systems. It is currently available in 35- and 50-MHz versions and is housed in a 28-pin package.

ADD-INS

The G170 can display 266,144 colors. It generates RGB analog signals from three on-chip 6-bit digital/analog converters and is compatible with the RS 170A video standard. The G170 operates from a single 5-volt power supply and has a maximum power dissipation of 750 milliwatts.

Pricing for 1000 pieces is $79 for the 50-MHz IMSG170S-50 and $57 for the 35-MHz IMSG170S-35. For more information, contact Inmos Corp., POB 16000, Colorado Springs, CO 80935, (303) 630-4000.
Inquiry **637.**

Model DASH-16 Data-Acquisition Board

The Model DASH-16 from MetraByte is a plug-in data-acquisition board for the IBM PC, XT, AT, and compatibles. It provides 12-bit A/D conversions at speeds up to 50,000 per second. Data transfer to the PC is performed in a DMA mode that lets the DASH-16 take data in the background while the computer performs other tasks.

You can operate the DASH-16 in 16-channel single-ended input or 8-channel fully differential modes. The board includes switch-selectable input ranges or lets you install a resistor to provide virtually any input range. It also lets you initiate conversions by software command, an on-board interval timer, or an external trigger.

The DASH-16 includes two channels of multiplying 12-bit D/A converter, an on-board three-channel counter chip, 4 digital input bits, and 4 digital output bits. The Utility Software Package lets you operate the board from BASIC. Other software consists of a graphics package, installation and calibration routines, and sample programs. A FORTRAN-compatible library is optional.

The DASH-16 costs $945 and the FOR-16 FORTRAN library is $95. Contact MetraByte Corp., 254 Tosca Dr., Stoughton, MA 02072, (617) 344-1990.
Inquiry **638.**

SOFTWARE • IBM PC

Program Modifies Machines for Handicapped

Rev. Bradley Murray, an instructor in computer science at Loyola College, has designed a program that modifies IBM PCs and compatibles for people who have limited use of their hands and arms. The package eliminates the need to press two keys simultaneously. Instead of having to hit Shift and 7 at the same time to produce an &, for example, the user can type the two keys sequentially. The program also works with the Ctrl and Alt keys.

Although he has not been able to test it on a wide variety of applications software, Rev. Murray said the program works with many popular packages, including Word, WordPerfect, MultiMate, dBASE III, and R:base. The current version will not operate with software that modifies certain interrupt vectors (SideKick, for example), but a version for this class of programs is in the works.

Besides the IBM PC and PC XT, the program works with the Tandy 1000 and machines from Compaq, Zenith, and AT&T. It costs $10. Contact Rev. Bradley Murray S.J., Loyola College, 4501 North Charles St., Baltimore, MD 21210.
Inquiry **639.**

All the Curves That Fit

FitAll is a nonlinear least-squares curve-fitting program for the IBM PC and compatibles. It can fit virtually any function to a set of data points. FitAll will make two-dimensional graphs of the original data, the calculated curve superimposed on the data, and the residuals. The software automatically scales graphs or lets you specify the axis limits and tick-mark spacing.

The program can handle 250 data points, 5 independent values, 10 parameters, and 10 constants. FitAll is menu-driven. You can use predefined functions or devise up to 11 of your own.

With a printer and a graphics screen-dump utility, the package can produce tables containing the original data, the data and the corresponding calculated values, and the resolved parameter values and their standard deviation. Tables printed to a disk file can be incorporated into reports.

FitAll is supplied as Turbo Pascal 2.0 source code and can be copied. It supports an 8087 coprocessor. Requirements are an IBM PC XT or true compatible with at least 128K bytes of RAM, one disk drive, and a color/graphics adapter; PC-DOS or MS-DOS 1.0 or later; and Turbo Pascal 2.0 or later.

The program costs $45. Contact MTR Software, POB 13, Islington A, Toronto, Ontario M9A 4X1, Canada.
Inquiry **640.**

Artificial-Intelligence Package

An artificial-intelligence program for the IBM PC and compatibles, small-X combines simple syntax with a set of tests and actions for the development of rule-based expert systems. Typical applications can combine AI decision-making, classification, diagnosis, and prediction facilities with graphic, database, text-processing, and analysis techniques.

The package is an interpreter with a set of tools for entering, executing, debugging, saving, and loading its programs. It can control and exchange data with other MS-DOS applications and can manipulate integers, real numbers, strings, and lists. Up to 250 rules can be stored in 64K bytes of memory; small-X requires 128K bytes and one disk drive.

The price of $249 includes the software, a manual (which you can buy alone for $30), example expert systems, and a demonstration script. Contact Institute for Scientific Analysis Inc., Suite 106A, 36 East Baltimore Pike, Media, PA 19063, (215) 566-0801.
Inquiry **641.**

(continued)

SOFTWARE • IBM PC

Wang Word Processing on the PC

Wang Laboratories has opened the VS minicomputer environment to IBM users with a version of its word-processing software for the PC. The IBM edition is fully compatible with other Wang products. You can edit documents made with this package on a Wang Professional Computer without any conversions.

The software comes with a Wang keyboard oriented toward word processing. It performs both IBM and Wang functions.

The product runs on a PC with two disk drives or a PC XT with a floppy-disk drive and a hard-disk drive. Other requirements are a minimum of 256K bytes of memory, PC-DOS 2.0 or 3.0, and a monochrome, color, or composite video monitor with an appropriate controller.

Wang Word Processing for the IBM PC costs $695. Contact Wang Laboratories Inc., One Industrial Ave., Lowell, MA 01851, (617) 459-5000.
Inquiry 642.

COBOL Couple

Micro Focus has released two packages for COBOL programmers: CO-Math, a library of mathematical functions, and VS COBOL, a compiler.

Among the math functions CO-Math contains are exponentiation, power, square root, natural log, $\log_{10}$, sine, cosine, arcsine, and arctangent XY. A graphics interface called CO-Graphics provides access to the VDI (virtual device interface) routines supplied by Graphic Software Systems.

The math library costs $200.

VS COBOL is a high-speed compiler that generates 8086 native code. Micro Focus said the product compiles twice as many lines per minute as its Level II compiler. The package is a synthesis of four variants: IBM's OS/VS COBOL and VS COBOL II, the vendor's Level II COBOL, and ANSI '85 COBOL.

VS COBOL supports the full 12-module ANSI '74 standard as well as Micro Focus extensions that fully support the IBM PC screen attributes. Users can select from any combination of the COBOL dialects supported during syntax checking. The compiler flags nonselected syntax.

The price of VS COBOL is $1200. Contact Micro Focus, 2465 East Bayshore Rd., Palo Alto, CA 94303, (415) 856-4161.
Inquiry 643.

SOFTWARE • APPLE

CAD/CAM for PCB Designers

Quik Circuit is a CAD/CAM system for designers of printed-circuit boards. The setup consists of software, a 512K-byte Macintosh, and an Imagewriter printer for $4300. The software alone sells for $695.

You enter the PCB layout on the screen using the mouse; layout area is 24 by 20 inches. The screen shows both sides of the board (dark traces on the component side, lighter traces on the solder side). You can zoom in on areas as small as 0.4 by 0.25 inch. After editing and modifying the design, you send it to an Imagewriter or to a pen plotter; the system works with several plotters, including Houston Instrument's DMP-41 and DMP-51 and Roland DG's DXY-880.

Bishop Graphics has established a network of PCB manufacturers equipped to produce boards from designs generated with Quik Circuit. The system calculates and displays production specs, which are sent to the manufacturer in order to get a price quote. If you're satisfied with the estimate, you can transmit your design to the fabricator through a modem. Bishop says the PCB builder can produce the board directly from the Quik Circuit design "in a matter of days."

For more information, contact Bishop Graphics Inc., 5388 Sterling Center Dr., POB 5007, Westlake Village, CA 91359-5007, (818) 991-2600.
Inquiry 644.

Quik Circuit, a CAD/CAM system from Bishop Graphics.

A Finder for the Apple IIe, IIc

Nite Owl's Developer Disk #1 contains programs and information designed to aid in the development of friendly software for the Apple IIe and IIc computers. This double-sided disk contains the Nite Owl Run Time program, which enhances ProDOS with a program selector capable of indexing subdirectories with a single key press and TYPEing text files.

Other enhancement programs on the disk condense high-resolution graphics pictures into files half the size of normal hi-res pictures, provide commands for entering and editing Applesoft string data, and let the user set the ProDOS date register for proper dating of disk files.

The flip side of the disk contains a tutorial on ProDOS and Applesoft.

Developer Disk #1 costs $19.95 and comes with an instruction manual. School

SOFTWARE • APPLE

and commercial licenses are available. Contact Nite Owl Productions, 5734 Lamar Ave., Mission, KS 66202, (913) 362-9898.
Inquiry **645.**

Schematic Designer

Schematic Entry is the first release in Advanced Engineering Solutions' series called ParaGenesis, a quartet of packages for electrical engineers. The CAE program runs on the 512K-byte Macintosh with external drive and can send files and drawings to an Imagewriter or LaserWriter or to an Apple, Hewlett-Packard, or Houston Instrument plotter.

As you design a circuit, Schematic Entry compiles a database of parts, pins, and nets, which is used to generate schematic plots and lists of components, interconnects, and design checks. Among the package's features are a library of TTL functions; a discrete library consisting of transistors, diodes, crystals, motors, and so on; and a library editor that lets you generate and label custom graphics symbols that are automatically appended to the component libraries.

Schematic Entry costs $300. (An evaluation package costs $25.) Three utilities are available: Netlist ($200), a netlist to Gerber format so you can port a design to other CAE systems or mainframes; List of Materials ($100), which lets you document the components with commercial part numbers; and Plotter Drivers ($200), which lets you link up with plotting devices. The vendor offers a service whereby it plots your design with its Houston Instrument DMP-41.

Contact Advanced Engineering Solutions Inc., Suite 302, 75 Manhattan Dr., Boulder, CO 80303, (303) 499-2910.
Inquiry **646.**

LISP for the Mac

MacScheme, an implementation of LISP for the 512K-byte Macintosh, conforms to the standards for Scheme, a LISP dialect. It supports Common LISP's most important attributes, including lexically scoped variables, first-class procedures (closures), macros, and generic arithmetic (both floating-point and infinite-precision integer). It also supports continuations.

This dialect offers run-time error detection and debugging. The Smalltalk-like interface features multiple scrolling windows; all windows can be edited. The editor helps with syntax by highlighting matching parentheses and suggesting proper indentation. You can edit in one window while computation goes on in another.

MacScheme is sold, without copy protection, for $125. Contact Semantic Microsystems, Suite 543, 1001 Bridgeway, Sausalito, CA 94965.
Inquiry **647.**

SOFTWARE • OTHER COMPUTERS

MIDI Sequencer, Patch Programs for Commodore 64

Dr. T's Music Software's MIDI sequencer for the Commodore 64 can be used as a 16-track tape recorder capable of playing back on all 16 MIDI channels. The keyboard Controlled Sequencer works with the Sequential, Passport, or compatible interface.

Sequences can be recorded in real time from the synthesizer keyboard or entered one note at a time from the computer keyboard. You can record keyboard events only or record program wheel and pedal changes. The sequencer can reassign the MIDI channel as it records and play back the sequence events on the new channel as they are received.

The sequencer provides a complete set of editing functions. You can insert program changes at precise points in sequences and move, copy, transpose, invert, or time-reverse part or all of any sequence.

Dr. T's says that musicians report they can get about three complete songs or 10 complete bass parts into memory at one time. The sequencer can be synchronized to drum machines and to tape.

The Keyboard Controlled Sequencer retails for $125.

Dr. T's also sells two Commodore programs for making and storing patches. The DX7 Patch Librarian works with Yamaha's synthesizer and lets you display, edit, and print patch parameters. A single disk can hold 800 patches. The program sells for $75 and requires a Sequential, Passport, Music-data, or compatible MIDI interface.

The CZ Patch Librarian works with Casio's CZ-101, CZ-1000, and CZ-5000 synthesizers. It lets you display all patch parameters on one screen. Parameters can be changed using either the Commodore keyboard or the Casio. Files of 16 patches can be stored on disk. The CZ package requires the same interface as the DX7 version. It retails for $65. Contact Dr. T's Music Software, Customer Information, 24 Lexington St., Watertown, MA 02172, (617) 926-3564.
Inquiry **648.**

Amiga Tools

The C-Leaner utility runs on the Commodore Amiga and is designed to help optimize existing C programs by analyzing source code and suggesting improvements. It also makes suggestions on how to make a C compiler produce more efficient code (for example, recommending use of variables in registers). The tool is similar to the UNIX lint utility.

C-Leaner checks for improper argument types and conversion errors. The package contains a library definition for the UNIX library routines; you can make additions to the library or make your own definitions. For input, C-Leaner takes one or more source-code modules. It outputs a list of each function processed, possible improvements, and detected errors.

Tardis Software also has toolkits for the Amiga. Tool Pak 1 contains five programs for analyzing text files, searching for ASCII

(continued)

strings, generating hexadecimal/ASCII dump output from any arbitrary input file, building libraries from one or more input files, and producing cross-references of 68000 assembler files.

Tool Pak 2 consists of a "beautifier" for C source code and a program that takes C source code and generates a listing of all variables, type point of definition, and points of reference.

All three programs sell for $49.95 each. Versions are available for the Macintosh and the Atari 520ST. Contact Tardis Software, 2817 Sloat Rd., Pebble Beach, CA 93953, (408) 372-1722.
Inquiry **649**.

Two-Pass Macro Assembler

Phoenix Computer Products says its Pasm86 macro assembler transforms source code into object code in half the time it takes Microsoft's Assembler (MASM). Pasm86 reportedly assembles a 600-line test file in 6 seconds; Phoenix says MASM takes 13 seconds. Pasm86 operates on any 8088, 80186, or 80286 machine running MS-DOS or PC-DOS 2.0 or later.

The assembler lets you include local symbols within procedures, define symbols on the command line, and obtain listings of error lines only. It also can assemble modules made by MASM. The program issues warnings when questionable statements are used; warning messages can be enabled or disabled.

A two-pass assembler, Pasm86 defines the relative offsets for each line of source in the first pass; in the second pass, it generates the listing, object, and cross-reference files. The assembler generates Microsoft object modules that can be linked using Phoenix's Plink86 or other linkage editors.

Pasm86 sells for $295. Contact Phoenix Computer Products Corp., Suite 220, 1416 Providence Highway, Norwood, MA 02062, (617) 762-5030.
Inquiry **650**.

Lumena Graphics on the Tandy 2000

Lumena, the Time Arts graphics tool designed for professional artists, is now available for the Tandy 2000. It features multiple pen and brush sizes; user-defined brushes; 8 solid and 28 mixed colors; two screen buffers (with the capability to overlay screens); automatic creation of circles, boxes, polygons, and curves; and eight fonts.

Lumena lets you magnify picture areas for precision work, rotate picture elements, and move, copy, duplicate, or scale portions of pictures. The program operates with a mouse or a graphics tablet. It costs $299.95. Contact Tandy Corp./Radio Shack, 1800 One Tandy Center, Fort Worth, TX 76102, (817) 390-2129.
Inquiry **651**.

8051 Cross Compiler

The Intel 8051 Cross Compiler from Specialized Systems Consultants lets programmers write and debug C programs on a UNIX host and then cross-compile to the target microprocessor. The package consists of a compiler, assembler, and linker and is available for the AT&T UNIX PC.

The Cross Compiler features an appropriate subset of UNIX C that can be directly compiled under UNIX, embedded assembly language, C code embedded as comments in the assembly listing, and sources for the driver, optimizer, and run-time library. It generates reentrant code that can be embedded in ROM and supports variables in all address spaces. Register declarations use real registers.

The 8051 Cross Compiler costs $3500. For more information, contact Specialized Systems Consultants, POB 55549, Seattle, WA 98125, (206) 367-8649.
Inquiry **652**.

DC-Circuit Analyzer

SourceView Software's DC Circuit Analysis for MS-DOS machines solves circuits with up to 25 branches and 12 nodes (excluding ground node). Branch elements can be resistors, current sources, voltage sources, or controlled voltage sources. The user can change the circuit's individual parameters and have the program recalculate the results. The software displays four different computations: node voltages, branch voltages, branch current, and branch power.

DC Circuit Analysis sells for $49.50. It requires 256K bytes of memory. Contact SourceView Software International, 835 Castro St., Martinez, CA 94553, (415) 228-6220.
Inquiry **653**.

Diagnostic Tool for C Programs

PC-Lint from Gimpel Software is a lint-like utility that analyzes C programs and reports on bugs and glitches. The package, which runs under MS-DOS, looks across multiple modules and notifies you of type inconsistencies across modules, parameter-argument mismatches, irregularities in library usage, value-return inconsistencies, uninitialized variables, and variables declared but not used.

Among PC-Lint's features are full support of the Kernighan and Ritchie standard, one-pass operation, and special lint-style comments to suppress errors. The program comes with user-modifiable standard library descriptions for most popular compilers.

PC-Lint requires minimum memory of 128K bytes. It costs $139. Contact Gimpel Software, 3207 Hogarth Lane, Collegeville, PA 19426, (215) 584-4261.
Inquiry **654**.

WHERE DO NEW PRODUCT ITEMS COME FROM?

The new products listed in this section of BYTE *are chosen from the thousands of press releases, letters, and telephone calls we receive each month from manufacturers, distributors, designers, and readers. The basic criteria for selection for publication are: (a) does a product match our readers' interests? and (b) is it new or is it simply a reintroduction of an old item? Because of the volume of submissions we must sort through every month, the items we publish are based on vendors' statements and are not individually verified. If you want your product to be considered for publication (at no charge), send full information about it, including its price and an address and telephone number where a reader can get further information, to* New Products Editor, BYTE, 425 Battery St., San Francisco, CA 94111.

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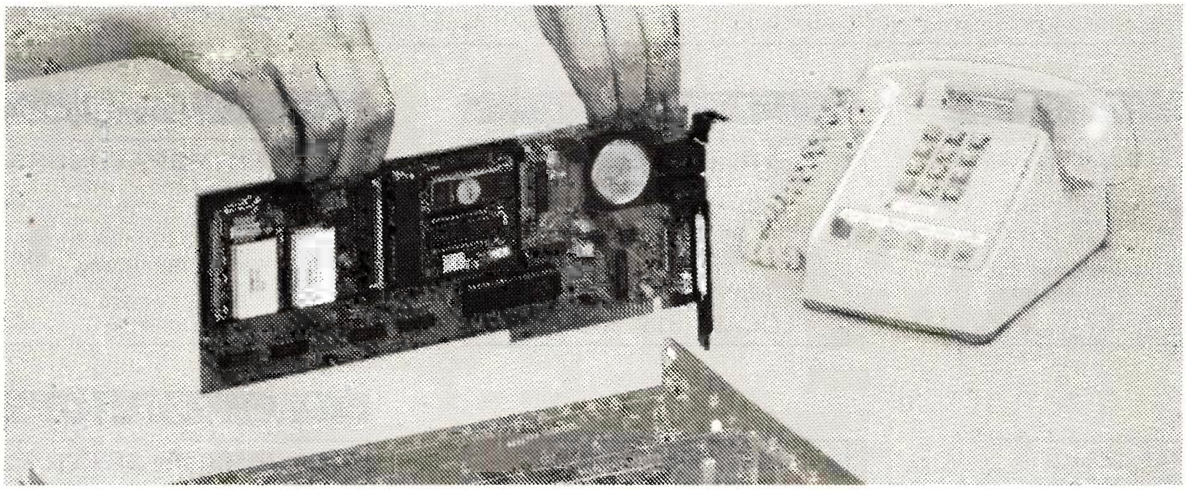

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Selectively reformat mainframe ASCII report data into spreadsheets, databases. Lotus, dBASE, Multiplan, Visicalc, word processors. Cut & Paste, edit, merge, transpose. **$95.**
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- Loads ANY ASCII data into Lotus™!
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See our ad in July BYTE, page 387 for more details.

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(619) 481-1477

Inquiry 737

CORRECTION NOTICE

The price of our DT 2801 was misquoted as $895 instead of the correct price of $995 in the August issue of this publication. We apologize for any inconvenience this may have caused our distributors or customers.

DATA TRANSLATION

Subscription Problems?

We want to help!

*If you have a problem with your BYTE subscription, write us with the details. We'll do our best to set it right. But we **must** have the name, address, and **zip** of the subscription (new and old address, if it's a change of address). If the problem involves a payment, be sure to include copies of the credit card statement, or front and back of cancelled checks. Include a "business hours" phone number if possible.*

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**Based on multiples of 100 each.
Boxed in 10's with heavy-duty cardboard sleeves, user ID labels, reinforced hubs (where appropriate) and write-protect tabs.**

Introducing Wabash Pinnacle Series Diskettes.

Two years ago, if you'd told me I'd be writing this ad, I would have laughed.

At that time, Wabash diskettes were synonymous with "s—t".

Just saying that quality control was poor would be charitable.

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

That was yesterday.

Kearney-National Inc., a $202-million division of a much larger company, came into Wabash.

Out went the old management, the old methods, the old production techniques...and in went a lot of new people, ideas, production lines and some really imaginative thinking.

The end result.

Today, I'm proud to offer you the Wabash Pinnacle Series of diskettes at the prices shown.

This isn't evolution in diskette manufacturing: it's revolution.

Here's what you get.

Wabash Pinnacle diskettes are
...certified 100% Error Free
...are coverd by a LIFETIME WARRANTY
...meet or exceed all industry specifications (by quite some distance)
...and are simply the best value in diskettes available today.

The torture test.

Considering Wabash's earlier dubious reputation, I wasn't exactly a true believer when their Director of Marketing came into my office with samples.

So I took a box at random, selected a disk, bent the thing every which way and slipped it into my IBM-PC.

It formatted. It booted. It stored and retrieved data.

That wasn't enough.

I gave samples of the diskettes to Curt Rostenbach and, in turn, to Tom Streit, both hackers of long experience and members of the Waukegan (Illinois) Apple Users Group.

Tom really went at it.

He took a quartz-halogen lamp, aimed it at the diskette until it started to smoke (and melt)...and then formatted, booted the diskette and stored and retrieved data!

The same terribly (and intentionally) mutilated diskette ran on an ITT Corona and IBM.

Curt was nicer.

He simply bent the diskette every which way...and it still formatted, booted and ran on his Apple.

The best buy I've ever seen.

DISK WORLD!, Inc. sells more flexible magnetic media by mail-order than anyone else in the world.

I, as President of the corporation, won't tolerate a product with a failure rate of more than 1/1000th of 1 percent.

I also don't like companies who try to milk a "quality" or "premium" image for a higher price like Dysan and Verbatim did...until they failed.

As President of DISK WORLD!, Inc., my motto is simple: "the best diskette for the least amount of money."

Wabash is it.

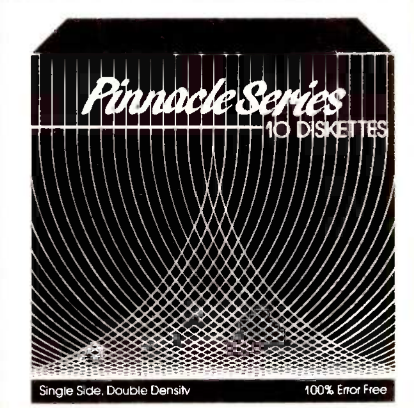
Right now, there is no better value than the Wabash Pinnacle Series of diskettes.

Granted, you have to buy a hundred at a time, but so what? Split the order with friends, relatives, co-workers or even your worst enemies.

The key thing is to get the most diskette for the money.

And this is it.

(Incidentally, as a corporation, we put our money where our



mouth is. Our first order for Wabash Pinnacle Diskettes was 1.5-million units.)

That's an awful lot of faith and confidence.

But, then again, I have the diskette that Tom Streit literally melted...and kept on running.

The truth about $1.00 or less diskettes.

More and more ads are popping up offering diskettes for $1.00 or less.

By the same token, more and more people who were selling used cars a few months ago are now selling diskettes by mail.

We did a little survey of current ads for diskettes advertised for a dollar or less and did some analysis of the market and here's what we found as it applies to 5.25" DSDD diskettes "supposedly" selling for a dollar or less.

VENDOR:	ADVERTISED LOW PRICE:	ACTUAL PRICE PER 100:	ACTUAL MFGR.:
Unitech	.89 ea.	.92 ea.	Unspecified.
Datatech	.99 ea.	.99 ea.	Unspecified.
Computer Club	.95 ea.	98 ea.	Unspecified.
	.99 ea.	1.02 ea.	Unspecified.
Communications & Electronics	.49 ea.	80 ea.	Unspecified.
Precision Data	.89 ea.	.93 ea.	Unspecified.
Diskette Connec.	.93 ea.	.93 ea.	Unspecified.
Comp Soft Serv.	.77 ea.	.77 ea. + shpg.	Unspecified.
Computer/Computer	.99 ea.	.99 ea.	Unspecified.
DISK WORLD	.89 ea.	.92 ea.	Wabash Datatech

The real truth about $1.00 or less diskettes.

It costs all diskette manufacturers about the same to produce a diskette. Some may charge more because they want to project a "premium quality" image, ala the late, lamented Dysan who bought their basic media from 3M.

Some charge less because they sell a sub-standard product...and we're not foolish enough to name names here.

But here's the truth about the $1.00 or less diskette market.

It falls into four categories.

1. The DISK WORLD's of the universe who simply are so big that they can buy first quality product in massive quantities and choose to pass on the savings to you. (Precision Data and Diskette Connection on **BRAND NAME** products also fall into this category.)

2. The people who buy "cosmos"...stuff from major manufacturers that usually hits quality control standards, but is cosmetically blemished and thus can't be packaged and sold under the manufacturer's own name.

3. "Duplicator Quality". Uncertified media, usually below manufacturer's own standards and frequently below ANSI and IBM standards. Sold on an "as-is" basis with the understanding that the manufacturer's name will never be divulged. Usually about a 20% reject rate...as compared to DISK WORLD's standard of less than 1/1000th of 1% reject/return rate. Next to garbage, this is the source of most diskettes advertised at a dollar or less.

They may work...and then again they may not. (Frankly, the odds at the Blackjack table in Las Vegas are more in your favor.)

4. Garbage. Stuff that shouldn't be sold at all. But some manufacturers are hurting for cash, so they sell it anyway. (After all, they want to meet their payroll. Look what happens when you don't: you become a Dysan or Verbatim. Lots of history, but no money.) More and more garbage is being dumped into the market as manufacturers become pressed for cash and are motivated into selling anything and everything they can manufacture. (Read the article in FORBES about Verbatim and its "Bonus" brand.)

Finally, the Taiwanese counterfeiters are moving into the act. Perfect duplicates of the packaging of major manufacturers with one exception: the quality isn't there.

The Critical Factor.

Only DISK WORLD!, Inc. offers fully brand-identified, LIFETIME-WARRANTY product for less than a dollar.

Every one else offering 5.25" product for less than a buck doesn't tell you who makes it.

We do.

And that ought to tell you a lot right there.

Ordering & Shipping Instructions

SHIPPING: Wabash Pinnacle Diskettes are sold in multiples of 100 only. Shipping charges are $3.00 per 100, regardless of type or size.

PAYMENT: VISA, MASTERCARD and PREPAID orders accepted. Corporations rated 3A2 or better and government and quasi-government open accounts are accepted on a NET 15 basis.

C.O.D. orders are subject to a $5.00 special handling charge. (Sorry for the increase, but too many people have been refusing C.O.D. orders or using bad checks. It's a classic example of a few "bad eggs" making life more expensive for everyone else.)

APO, FPO, AK, HI & PR ORDERS: Include shipping as shown **and** an additional 5% of the total amount of the order to cover PAL and insurance.

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TAXES: Illinois residents only, add 7%.

MINIMUM ORDER: $35.00

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PCXT **99.00**

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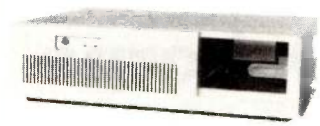

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- Use our power supply FC-5192 and keyboard FC 527

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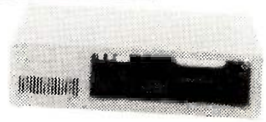

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- IBM® PC/XT identical dimension
- Righthand side on-off switch position
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- 7 & 8 slot rear panels. Good for 0.75" or 1" apart slot connectors
- Use FC 135 40 power supply

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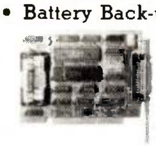

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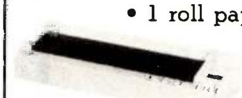

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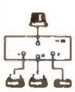

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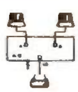

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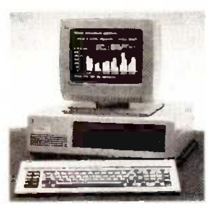

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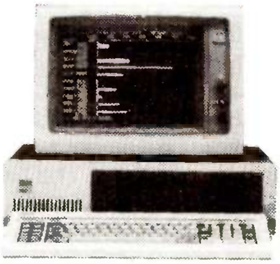

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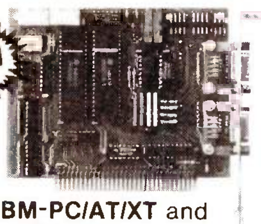

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Trouble is, most of them aren't manufacturers.

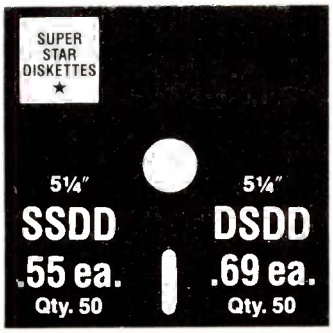
Rather they are fabricators or marketers, taking other company's components, possibly doing one or more steps of the processing themselves and pasting their labels on the finished product.

The new Eastman Kodak diskettes, for example, are one of these. So are IBM 5¼" diskettes. Same for DYSAN, Polaroid and many, many other familiar diskette brand names. Each of these diskettes is manufactured in whole or in part by another company!

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

We would go out and find smaller companies to manufacture a diskette to our specifications...specifications which are higher than most...and simply create our own "name brand" diskette.

Name brand diskettes that offered high quality at low prices.



Super Star diskettes are sold in multiples of 50 only. Diskettes are shipped with white Tyvec sleeves, reinforced hubs, user ID labels and write-protect tabs.

Boy, did we get lucky. Our Super Star Diskettes are the same ones you've been using for years...without knowing it.

In our search for the low priced, high quality diskette of our dreams, we found something even more interesting.

We found that there are several manufacturers who don't give a hoot about the consumer market for their diskettes. They don't spend millions of dollars in advertising trying to get you, the computer user, to use their diskettes.

Instead, they concentrate their efforts on turning out the highest quality diskettes they can...because they sell them to the software publishers, computer manufacturers and other folks who (in turn) put their name on them...and sell them for much higher prices to you!

After all, when a software publisher or computer manufacturer or diskette marketer puts their name on a diskette, they want it to work time after time, everytime. (Especially software publishers who have the nasty habit of copy-protecting their originals!)

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

Well, that's the story.

Super Star diskettes don't roll off the boat from Pago-Pago or emerge from a basement plant just east of Nowhere.

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

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

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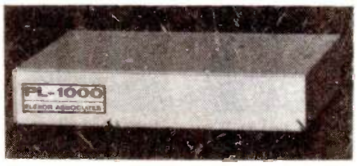

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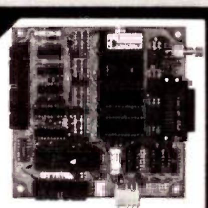

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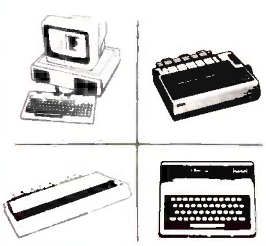

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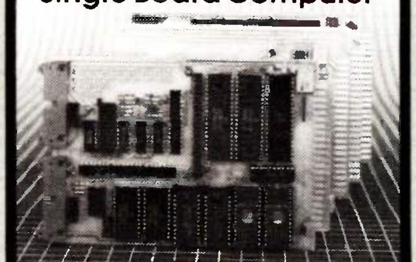

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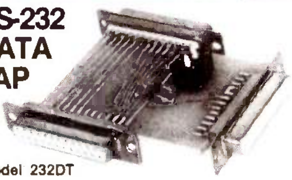

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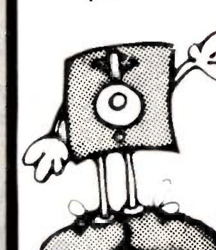

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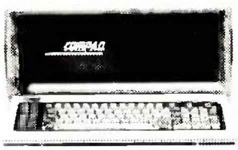

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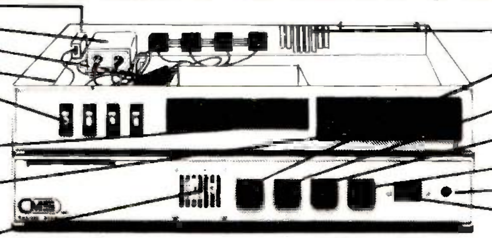

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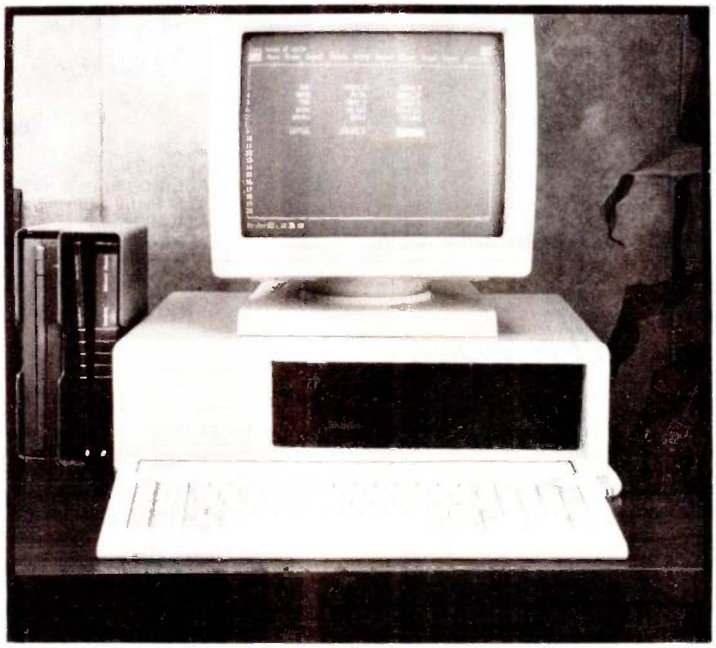

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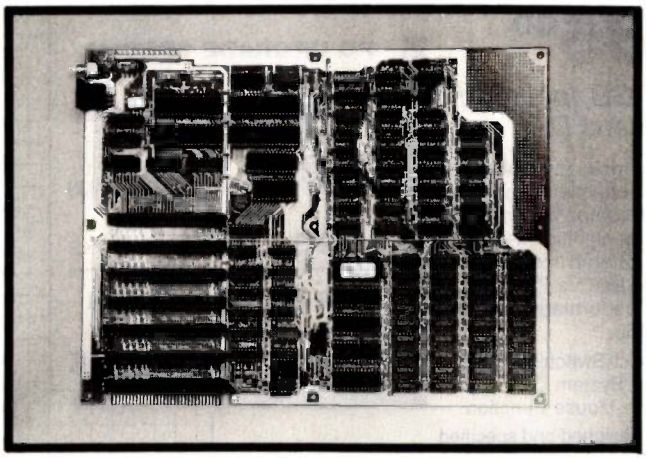

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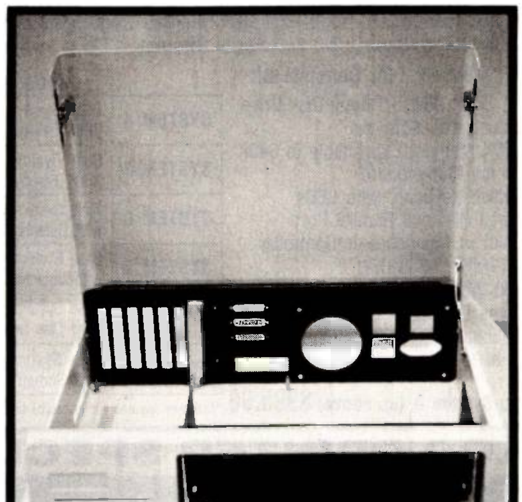

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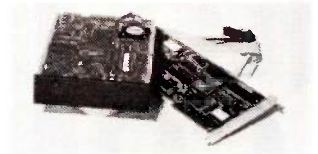

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4001	.22	4029	.75	4060	.85	4506	1.10
4002	.22	4030	.39	4066	.39	4507	1.10
4006	.79	4031	3.25	4069	.28	4508	1.90
4007	.22	4032	2.15	4070	.35	4510	.79
4008	.95	4034	1.91	4071	.28	4511	.79
4009	.39	4035	.79	4072	.28	4512	.79
4010	.39	4037	1.95	4073	.28	4514	1.18
4011	.24	4040	.75	4075	.28	4515	1.79
4012	.24	4041	.75	4076	.75	4516	1.19
4013	.36	4042	.65	4077	.35	4518	.85
4014	.75	4043	.85	4078	.35	4520	.75
4015	.39	4044	.69	4081	.29	4555	.95
4016	.35	4046	.80	4082	.29	4556	.95
4017	.65	4047	.89	4085	.95	4566	1.35
4018	.79	4048	.80	4086	.95	80C95	1.50
4019	.39	4049	.35	4093	.45	80C97	.49
4020	.69	4050	.34	4094	2.95	MC14408	12.95
4021	.69	4051	.75	4098	1.85	MC14409	12.95
4022	.69	4052	.75	4099	1.85	MC14410	9.95
4023	.25	4053	.75	4501	.69	MC14411	11.95
4024	.59	4055	3.95	4502	.95	MC14412	12.95
4025	.25	4056	2.95	4503	.49	MC14419	4.95
4027	.45			CALL FOR 74HC			

74C00

74C00	$ .29	74C74	$.65	74C161	$1.15	74C373	$2.35
74C02	.29	74C85	1.89	74C175	1.15	74C374	2.35
74C04	.29	74C90	1.15	74C240	1.89	74C901	.59
74C08	.35	74C93	1.15	74C244	1.89	74C922	4.45
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LM304H	1.89	LM709H	1.90	LM3916	2.95		
LM305H	.95	LM710	.68	MC4024	3.75		
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LM307N	.40	LM715	3.95	RC4131	3.75		
LM308CN	.85	LM723N	.55	RC4136	1.19		
LM310CN	1.65	LM723H	.75	RC4151	3.75		
LM311CN	.62	LM733	.98	CA3023	2.75		
LM312H	1.75	LM739	1.85	CA3039	1.25		
LM318CN	1.45	LM741CN	.33	CA3046	1.25		
LM318H	1.55	LM741H	.40	CA3059	2.85		
LM319N	1.19	LM741N	.29	CA3060	2.85		
LM320 (see VRs)		LM747	.65	CA3065	1.69		
LM324N	.55	LM748	.55	CA3080	1.10		
LM339N	.95	LM1014	1.15	CA3081	1.60		
LM340 (see VRs)		LM1303	1.90	CA3082	1.60		
LM348N	.95	LM1310	1.45	CA3083	1.55		
LM356CN	.65	MC1330	1.65	CA3086	.80		
LM359	1.75	MC1349	1.85	CA3089	2.95		
LM360N	2.95	MC1350	1.15	CA3096	3.45		
LM370N	4.95	MC1358	1.85	CA3130	1.29		
LM373N	3.95	MC1372	6.75	CA3140	1.15		
LM376N	3.75	LM1414	1.55	CA3146	1.79		
LM377N	1.90	LM1558H	2.99	CA3160	1.49		
LM380CN	.65	LM1800	2.35	LM13080	1.25		
LM380N	1.05	LM1812	8.10	LM13600	1.45		
LM381N	1.59	LM1830	3.40	LM13700	1.45		
LM382N	1.35	LM1871	5.45	LF347	2.19		
LM383N	1.95	LM1872	5.45	LF351	.60		
LM384N	1.75	LM1877	3.20	LF353	.99		
LM386N	.89	LM1889	1.90	LF355	1.10		
LM387N	1.29	LM1896	1.75	LF356	1.10		
LM389N	1.15	ULN2001	1.95	LF357	1.39		
LM392N	.69	ULN2003	1.49	TL071CP	.79		
LM723N	.48	XR2206	3.75	TL072CP	1.35		
LM723H	.55	XR2207	2.90	TL074CN	1.90		
NE531	2.85	XR2208	2.40	TL081CP	.59		
NE555	.29	XR2211	3.75	TL084CN	1.90		
NE556	.65	LM2877P	2.00	TL494	4.10		
NE558	1.49	LM2878P	2.25	TL496	1.65		
NE561	23.50	LM2900	.83	TL497	3.20		
NE564	2.85	LM2901	.99	MC3423	1.49		
LM565	.95	LM2903	.69	MC3453	4.95		
LM566	1.45	LM2907	2.45	MC3456	1.29		
LM567	.85	LM2917	2.85	MC3459	3.75		
NE570	3.85	LM3900	.55	MC3469	6.25		
NE571	2.90	LM3905	1.15	MC3470	7.95		

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8116	10.50	2513-001U	9.50	AY38910	7.95
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7400

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7402	.18	7448	.68	74126	.44	74179	1.34
7403	.18	7450	.19	74128	.49	74180	.75
7404	.18	7451	.19	74132	.45	74181	1.75
7405	.23	7453	.19	74136	.75	74182	1.15
7406	.49	7454	.19	74141	.85	74184	2.25
7407	.49	7459	.25	74142	2.95	74185	2.25
7408	.24	7460	.37	74143	3.70	74190	.67
7409	.19	7470	.29	74144	2.95	74191	.67
7410	.19	7472	.29	74145	.59	74192	.67
7411	.24	7473	.33	74147	1.49	74193	.67
7412	.38	7474	.33	74148	1.19	74194	.67
7413	.34	7475	.38	74150	1.09	74195	.67
7414	.49	7476	.34	74151	.55	74196	.75
7416	.49	7479	4.60	74152	.67	74197	.86
7417	.49	7480	.69	74153	.53	74198	1.15
7420	.19	7482	.95	74154	1.19	74199	1.15
7421	.35	7483	.45	74155	.69	74221	1.19
7422	.45	7485	.55	74156	.59	74251	.75
7423	.58	7486	.35	74157	.59	74273	1.65
7425	.29	7489	1.95	74158	1.65	74276	1.89
7426	.29	7490	.35	74159	1.58	74279	.75
7427	.29	7491	.65	74160	.79	74283	1.40
7428	.55	7492	.45	74161	.69	74284	2.90
7430	.19	7493	.35	74162	.69	74285	2.90
7432	.29	7494	.85	74163	.69	74290	1.49
7437	.25	7495	.50	74164	.69	74298	1.49
7438	.29	7496	.69	74165	.69	74365	.55
7439	.58	7497	2.70	74166	.85	74366	.55
7440	.19	74100	1.50	74167	2.75	74367	.55
7441	.79	74107	.24	74170	1.25	74368	.55
7442	.45	74109	.37	74172	4.75	74390	1.45
7443	1.15	74116	1.45	74173	.69	74393	1.33
7444	1.15	74121	.29	74174	.69	74490	2.25
7445	.68	74122	.44	74175	.69		

74LS00

74LS00	$ .22	74LS113	$ .38	74LS247	$ .74
74LS01	.22	74LS114	.39	74LS248	.98
74LS02	.22	74LS122	.45	74LS249	.98
74LS03	.22	74LS123	.65	74LS251	.59
74LS04	.24	74LS124	2.75	74LS253	.59
74LS05	.25	74LS125	.49	74LS257	.59
74LS08	.27	74LS126	.49	74LS258	.59
74LS09	.28	74LS132	.59	74LS259	2.95
74LS10	.25	74LS136	.39	74LS260	.59
74LS11	.33	74LS138	.59	74LS261	2.49
74LS12	.33	74LS139	.59	74LS266	.55
74LS13	.39	74LS145	1.19	74LS273	1.45
74LS14	.59	74LS148	1.38	74LS275	3.29
74LS15	.33	74LS151	.55	74LS279	.59
74LS20	.26	74LS153	.55	74LS283	.68
74LS21	.29	74LS154	1.49	74LS290	.88
74LS22	.29	74LS155	.69	74LS293	.78
74LS26	.29	74LS156	.69	74LS295	.98
74LS27	.29	74LS157	.69	74LS298	.88
74LS28	.29	74LS158	.69	74LS324	1.75
74LS30	.25	74LS160	.69	74LS347	1.95
74LS32	.29	74LS161	.69	74LS348	1.95
74LS33	.53	74LS162	.69	74LS352	1.25
74LS37	.35	74LS163	.69	74LS353	1.25
74LS38	.39	74LS164	.69	74LS363	1.29
74LS40	.25	74LS165	.90	74LS365	.48
74LS42	.44	74LS166	1.90	74LS366	.48
74LS47	.74	74LS168	1.15	74LS367	.45
74LS48	.74	74LS169	1.15	74LS368	.45
74LS51	.25	74LS170	1.40	74LS373	1.39
74LS54	.29	74LS173	.67	74LS374	1.33
74LS55	.29	74LS174	.67	74LS375	.69
74LS73	.39	74LS175	.67	74LS377	1.38
74LS74	.39	74LS181	1.95	74LS385	1.95
74LS75	.39	74LS190	.85	74LS386	.45
74LS76	.39	74LS191	.85	74LS390	1.15
74LS78	.39	74LS192	.78	74LS393	1.15
74LS83	.59	74LS193	.78	74LS395	1.15
74LS85	.69	74LS194	.69	74LS399	1.47
74LS86	.39	74LS195	.69	74LS424	2.95
74LS90	.54	74LS196	.79	74LS668	1.75
74LS92	.54	74LS197	.79	74LS670	2.29
74LS93	.54	74LS221	.89	81LS95	1.45
74LS95	.74	74LS240	.95	81LS96	1.45
74LS96	.89	74LS242	.95	81LS97	1.45
74LS107	.39	74LS243	.95	81LS98	1.45
74LS109	.39	74LS244	1.25	25LS2521	2.65
74LS112	.39	74LS245	1.45	25LS2569	3.50

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74S05	.45	74S113	.55	74S175	1.19	74S373	2.09
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SB180-1 *w/8K ROM monitor. . $369.00*
SB180-5 *w/8K ROM monitor, BIOS source and Z-system $418.00*

#2: *"I need speed."*

Solution:
THE Z8 FORTH SYSTEM/CONTROLLER

The Z8 FORTH System/Controller is only 4" by 4½" and includes a custom masked Z8 version of the FORTH language with a full screen editor, cassette I/O driver primitives, EPROM programmer primitives, and other utility words. It also contains up to 4K bytes of RAM or EPROM, an RS-232 serial port with selectable baud rates, and two parallel ports. Additional Z8 peripheral boards include memory expansion, a smart terminal board, serial and parallel I/O, real time clock an A/D converter, and an EPROM programmer. It's perfect for data reduction and high speed control applications.

BCC21 *w/utilities . . . $225.00*

#3: *"Let me have an entire development system on one board."*

Solution:
THE BCC52 SYSTEM/CONTROLLER

The BCC52 is a new stand alone single board microcomputer which is bus compatible with the Micromint BCC11 /BCC21 Z8 System/Controllers and expansion boards. The BCC52 features the Intel 8052AH-BASIC microprocessor which includes a ROM resident 8K byte floating point BASIC interpreter with extensions for process control work. It contains sockets for up to 48K bytes of RAM/EPROM, an "intelligent" 2764/128 EPROM programmer, 3 parallel ports, a serial terminal port, and a serial printer port.

BCC52 . . . *$239.00*

For a System Controller suited to your needs, give us a call.

#4: *"Give me lots of economical computing power."*

Solution:
THE BCC11 BASIC SYSTEM/CONTROLLER

The Z8 BASIC System/Controller is nearly identical to the FORTH System/Controller but contains a tiny BASIC interpreter, up to 6K bytes of RAM and EPROM, an RS-232 serial port with switch selectable baud rates, and two parallel ports. Add a power supply and terminal to start programming in BASIC or machine language. Programs can be transferred to 2732 EPROMS with the optional EPROM programmer for auto-start applications. It can also use any of the expansion boards mentioned under the Z8 FORTH System/Controller.

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Additional information on peripheral boards and OEM pricing is available.

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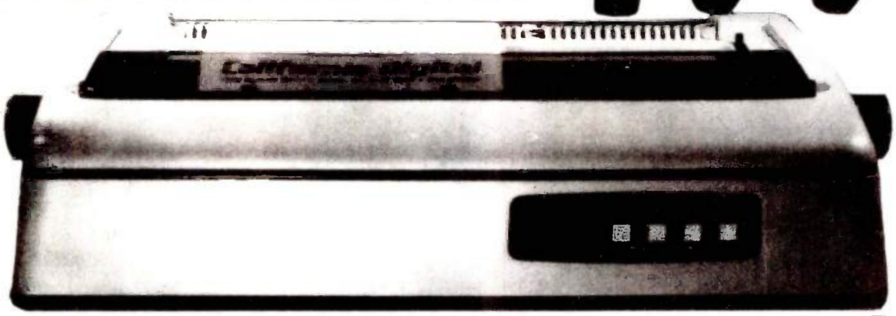
LETTER QUALITY F-10 DAISY WHEEL PRINTER $499



The TEC F-10 Daisy Wheel printer is the perfect answer to a reasonablly priced 40 character word processing printer. While this printer is " extremely" similar to C.Itoh's F-10/40 Starwriter printer. Legal counsel for the C.Itoh Company have advised us that we should refrain from referring to the TEC printer as a Starwriter.

This 40 character per second printer auto installs with Wordstar and Perfect Writer. Features extensive built-in word processing functions that allow easy adaptability and reduced software complexity. Industry standard Centronics interface provides instant compatibility with all computers equiped with a parallel printer port. The TEC F-10 accepts paper up to 15 inches in width.

These printers were originally priced to sell at over $1400. Through a special arrangment California Digital has purchase these units from a major computer manufacturer and is offering these printers at a fraction of their original cost.

Options available include sheetfeeder, tractor feed, buffered memory and an assortment of printer cables for a variety of computers.

$99 TEAC 55B 48 TPI

	One	Two	Ten
Five Inch Double Sided Drives			
TEAC FD55B half height	99	95	89
TEAC FD55F 96 TPI, half ht.	119	115	109
CONTROL DATA 9409 PC	169	159	155
SHUGART SA455 Half Height	99	95	89
SHUGART SA465 ½ Ht. 96TPI	99	95	89
TANDON 100-2 full height	129	125	119
TANDON 101-4 96TPI full ht.	199	189	179
MITSUBISHI 4851 half height	139	135	129
MITSUBISHI 4853 96/TPI½ Ht.	155	149	139
MITSUBISHI 4854 8" elec.	295	285	275
QUME 142 half height	119	105	99
Eight Inch Single Sided Drives			
SHUGART 801R			
SIEMENS FDD 100-8	119	115	109
TANDON 848E-1 Half Height	369	359	349
Eight Inch Double Sided Drives			
SHUGART SA851R	495	485	475
QUME 842 "QUME TRACK 8"	319	319	313
TANDON 848E-2 Half Height	459	447	435
REMEX RFD-4000	219	219	209
MITSUBISHI M2896-63 ½ Ht.	459	449	409

FREE PROBE

California Digital is offering this $12.95 value 12 MHz. Logic Probe absolutely FREE with any purchase over $50.

The Logic Probe is a LED applied instrument that operates from circuits under test and gives instantaneus logic level indications.

To receive your FREE Logic Probe your order must be placed by MAIL before the end of this month, payment must accompany your order and the free logic Probe must be requested.

DUAL SHUGART SUBSYSTEM $239

The dual Shugart subsystem features two SA465 (96 tpi) 5¼" double sided disk drives. Also supplied within the subsystem is 50 watt power supply and a shielded signal cable.

PLOTTER $219

The Comrex Comscriber I is the ideal solution to make short work of translating financial and numeric data into a graphic presentation Many ready to run programs such as Lotus 1-2-3 Visi-on and Apple business graphics already support this plotter

The Comscriber I features programmable paper sizes up to 8½ by 120 inches. 6 inch per second plot speed and 0.004 step size Easy to implement Centronics interface allows the Comscriber I immediate use with the printer port of most personal computers

The Comscriber I is manufactured for Comrex by the Enter Computer Corporation The plotter is marketed by Heath Kit and also sold under Enters own Sweet P Label This is your opportunity to purchase a plotter which was originally priced at $795 for only $219

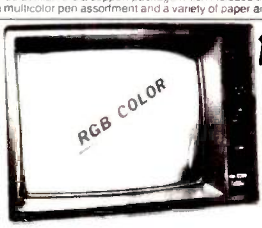
Also available is a support package which includes demonstration software, interface cable a multicolor pen assortment and a variety of paper and transparency material

Shugart 604 WINCHESTER $99

These 6.7 Megabyte drives are new units recently released by the Shugart division of Xerox. The Shugart 604 is fully 506 industry compatible. Each drive is tested before shipment and is supplied with a 90 day warranty. SHU-604

Five Inch Winchester Hard Disk Drives			
FUJITSU M2235AS	27 Meg.	899	859
RODIME RO-208	53 Meg.	1589	1493
MAXTOR XT10140	140 Meg.	3895	3785
SHUGART 712	13 Meg. ½ Ht	495	465
SHUGART 604	6.7 Meg.	99	89
TANDON 502	10 Meg.	419	395
TANDON 503	19 Meg.	695	675
SEAGATE 225	25 Meg.	695	625

NEC RGB COLOR MONITOR $219



The NEC JC-1401D is a 13 medium/high resolution RGB monitor suitable for use with the Sanyo MBC-550/555 or the IBM/PC. The monitor features a resolution of 400 dots by 240 lines. Colors available are Red Green Blue Yellow, Cyan, Magenta, Black and White

The NEC monitor carries the Litton Monroe label and was originally scheduled for use in their Office of the Future equipment. A change in Monroe s marketing strategy has made these units excess inventory which were sold to California Digital. We are offering these new RGB monitors at a fraction of their original cost Sanyo compatible NEC-1401/S; IBM P C Computer compatible NEC-1401/PC

PRINTERS

MATRIX PRINTERS

Star Gemini-SG10 120 char/sec	STR-SG10	239.00
Star Gemini-SG15, 100 char./sec 15 paper	STR-SG15	389.00
Star Gemini Delta 10, 160 Char/sec	STR-D10	359.00
Citizen MSP/10FT 160 char/sec.	CIT-MSP10	289.00
Toshiba P1351, 192 char/sec letter quality	TOS-1351	1495.00
Okidata 182A serial & parallel 9½" paper	OKI-182A	257.00
Okidata 192A parallel interface, 160 char/sec	OKI-192A	345.00
Okidata 84P parallel 15" paper	OKI-84P	789.00
Epson LX-80 10" 120 Char/sec.	EPS-LX80	239.00
Epson FX80FT, 10" 160 char /sec with graphtrax	EPS-FX80	369.00
Epson RX100 + 15" withGraphtrax	EPS-RX100	389.00
Epson FX100FT 15" 160 char./sec with graphtrax	EPS-FX100	489.00
Epson LQ1500, 15" corespondence quality	EPS-LQ1500	895.00
Epson JX80 Color printer	EPS-JX80	519.00
Prowriter 8510 parallel 9½" paper	PRO-8510P	329.00
Dataproducts B-600-3, band printer 600 LPM	DPS-B600	6985.00
Printronix P300 high speed printer 300 lines per minute	PTX-P300	3995.00
Printronix P600 ultra high speed 600 lines per minute	PTX-P600	5795.00

WORD PROCESSING PRINTERS

Starwriter F10 parallel, 40 char/sec	PRO-F10P	499.00
NEC8810 55 char/second serial interface	NEC-8810	1659.00
NEC8830 55 char/sec, par'l interface	NEC-8830	1659.00
NEC3550 popular printer designed for the IBM/PC	NEC-3550	1599.00
NEC2050 designed for IBM/PC 20 char/sec. par'l.	NEC-2050	689.00
Silver Reed EXP500, 14 char/sec par'l interface	SRD-EXP500	319.00
Silver Reed EXP550 17 Char/sec par'l interface	SRD-EXP550	429.00
Diablo 630 40 char/sec serial	DBL-630	1569.00
Diablo 620, proportional spacing, horz.& vert tab, 20 cps	DBL-620	769.00
Juki 6100, 18 char /sec	JUK-6100	399.00
Juki 6300, 40 char./sec	JUK-6300	699.00
Comrex CR2, 5k buffer, proportional spacing, par'l.	CRX-CR2P	395.00

TERMINALS

Freedom 100, split screen, detatchable keyboard	LIB-F100	495.00
Qume 102 green phosphor terminal	QUM-102	539.00
Ampex Dialogue 125 green screen	APX-D125G	675.00
Ampex Dialouge 175 amber screen, two page, func. keys	APX-D175A	719.00
Wyse 50, 14" green phosphor	WYS-50	495.00
Wyse 300, Eight color display, split screen	WYS-300	1159.00
Zenith 29 terminal, VT52 compatible detatch ble keyboard.	ZTH-Z29	765.00
Televideo 910 Plus, block mode	TVI-910P	575.00
Televideo 925, detatchable keyboard, 22 function keys	TVI-925	759.00
Televideo 950, graphic char..split screen, 22 func	TVI-950	950.00
Televideo 970, 14" green, 132 column, European	TVI-970	1095.00

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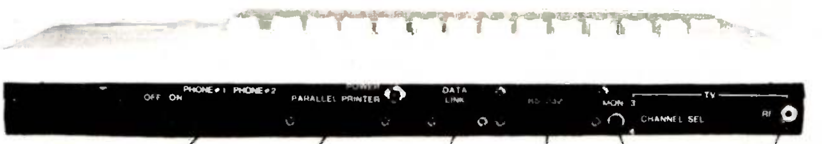


The Xerox Sunrise 1810 is by far the best value we have ever seen in a micro computer. This is a self contained battery and AC operated portable. The Sunrise was originally priced at $2995. Xerox has since elected to drop the computer from their product list. California Digital has purchased all the remaining inventory and is making the unit available at a fraction of its original cost.

This portable features a built in 80 column liquid crystal display, along with both RF monitor and television outputs. The internal 300/1200 baud modem includes an auto dial telephone assembly. The units has both centronics parallel and a serial port programmable to 19,200 baud.

The self contained micro cassette is capable of capturing data from the keyboard as well as doubling as an recorder for dictating messages.

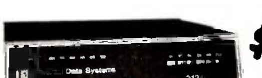
An optional dual floppy disk drive module, pictured above, is available for only $219. (when purchased with the Sunrise 1810). Also available, for $59 is an 80 column printer that mounts in the drive module. The Sunrise features a CP/M operating system which allows the operator to use any CP/M program in Xerox 5¼" disk format and over 5000 CP/M programs available in public domain.

1200 BAUD MODEMS

UNIVERSAL DATA

$119

The UDS-212LP is a compact desktop modem designed to obtain all its operating power entirely from the telephone line thus eliminating the need to con-
ct to an external AC power source. NOT Hayes compatible but
ideal 1200 baud modem to connect to any CRT terminal or
mputer when accessing dial up data bases
.e Universal Data Div. of Motorla original suggested list price on
212/LP was $ 495. but California Digital is offering at only $119.



$159

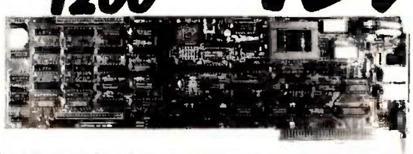
e Universal Dala 212A is manufactured for the minicomputer
rket. This modem is both 300 and 1200 baud auto answer. An
ustrial quality modem originally priced at $595. NOT Hayes
npatible.

SMARTEAM 1200

$189

Team 212A offers all the features of the Hayes Smart Modem
0 for a fraction of the price. Now Is your opportunity to purchase
200 baud modem at the price of a 300 baud modem.
ifornia Digital is so confident of your complete satisfaction that
will allow the return the Team 212A and apply the full credit
ards the purchase of any other modem.

UltraLink 1200 $159



The UltraLink is a Hayes compatible 300/1200 modem designed for the IBM/PC market place. The UltraLink adds a voice/data demension to your PC. Manufacturers original suggested price on this modem is $795. California Digitals price is only $159.

MODEMS

Universal Data 212LP, 1200 duplex, line powered.	UDS-212LP	119.00
Universal Data 212A, 300/1200 baud, industrial.	UDS-212A	159.00
Universal Data 103JLP, line powered, auto answer.	UDS-103LP	29.00
Hayes Smartmodem 2400 baud modem	HYS-2400	599.00
Fujitsu 2400/1200 baud auto everything.	FUJ-1935D	439.00
Team 1200 Hayes Compatible, 300/1200 baud.	TEM-SM1200	189.00
UltraLink 1200 data and voice on same line.	UTL-1200A	159.00
CTS 212AH 1200 baud, auto dial	CTS-212AH	239.00
Terminal software for CTS 212AH	CTS-212SFT	35.00
Prometheus 1200 super features	PRM-P1200	319.00
Prometheus 1200B internal PC	PRM-P1200B	279.00
Signalman Mark 12, 1200 baud, Hayes compatible.	SGL-MK12	239.00
Signalman Mark VI, 300 baud internal PC	SGL-MK6	59.00
Hayes Smart Modem 1200 baud, auto dial	HYS-212AD	389.00
Hayes 1200B for use with the IBM/PC, 1200 baud.	HYS-1200B	369.00
Hayes Smartmodem, 300 baud only, auto dial	HYS-103AD	199.00
Hayes Chronograph, time & date	HYS-CHR232	199.00
Penril 300/1200 industrial quality	PEN-12AD	395.00

XEROX/XT

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$1985

Includes:

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

This 10 Megabyte XT system was manufactured for the XEROX Corporation by Toshiba. The XEROX / XT operates all IBM software including Lotus 1-2-3 and Flight Simulator.

Built into the XEROX / XT Computer is a RS-232 serial port, Centronics parallel printer port, RGB and composit monitor output. The XEROX / XT also includes 256K/Byte of memory expandable to 640K, and a high resolution 14" RGB color monitor. The computer provides three IBM expansion slots for adding a modem or other boards. XEROX has also included a mouse along with operating software. Complete with 90 day warranty.

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JADE RGB w/Par Port	$99
JADE RGB w/Par & Ser	$199
JADE Mono 720x348	$149

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For IBM PC		For IBM PC-AT	
64K	$349	128K	$529
256K	$399	512K	$629
512K	$449	1 MB	$729
1 MB	$549	2 MB	$929
2 MB	$749	4 MB	$1599

TALLTREE JRAM-2/JRAM-3 2 MB Card

2 MB JRAM-2 w/o memory	$199
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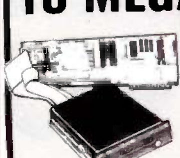
2 MB JRAM-2	$599
256K JRAM-3	$329
1 MB JRAM-3	$499
2 MB JRAM-3	$629

10 MEGABYTE Hard Disk For Your IBM PC $469



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Teac 55B	$99

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KB5150 Improved	$159
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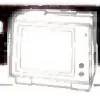
High Resolution Video Monitors



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ProModem 1200 RS-232	$299
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64K RAM Chip Kit for PC	$9
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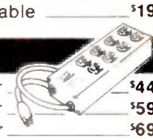

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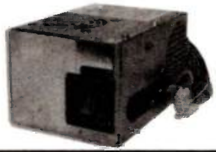

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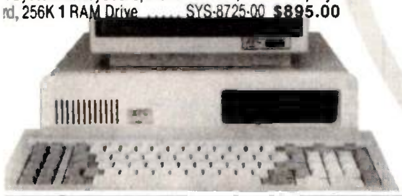

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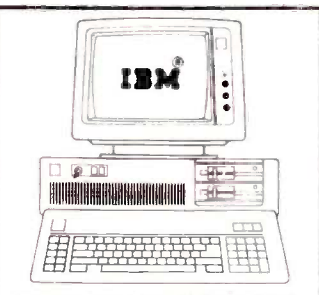

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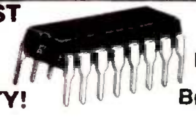

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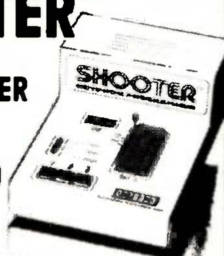

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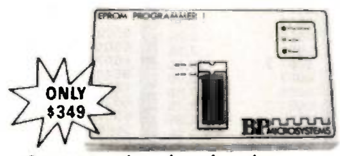

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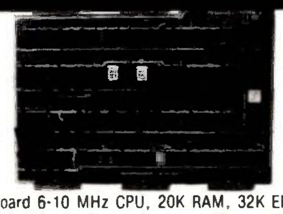

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- PIN COMPATIBLE WITH 8088
- SUPERSET OF 8086/8088 INSTRUCTION SET
- LOW POWER CMOS

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- ★ COMPUTER MANAGED INVENTORY - VIRTUALLY NO BACK ORDERS!
- ★ VERY COMPETITIVE PRICES
- ★ FRIENDLY STAFF
- ★ FAST SERVICE - MOST ORDERS SHIPPED WITHIN 24 HOURS!
- ★ WE ACCEPT VISA AND MASTERCARD

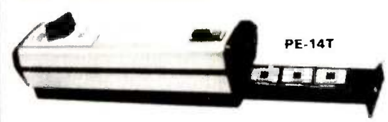
MasterCard VISA

EPROMS

2708	1024x8	(450ns)	3.95
2716-6	2048x8	(650ns)	2.29
2716	2048x8	(450ns)(5V)	2.49
2716-1	2048x8	(350ns)(5V)	3.95
TMS2532	4096x8	(450ns)(5V)	3.95
2732	4096x8	(450ns)(5V)	2.49
2732A	4096x8	(250ns)(5V)(21V PGM)	2.69
2732A-2	4096x8	(200ns)(5V)(21V PGM)	4.95
27C64	8192x8	(250ns)(5V)(CMOS)	7.95
2764	8192x8	(450ns)(5V)	2.29
2764-250	8192x8	(250ns)(5V)	2.49
2764-200	8192x8	(200ns)(5V)	4.95
TMS2564	8192x8	(450ns)(5V)	8.95
MCM68766	8192x8	(350ns)(5V)(24 PIN)	17.95
27128	16384x8	(250ns)(5V)	3.49
27C256	32768x8	(250ns)(5V)(CMOS)	15.95
27256	32768x8	(250ns)(5V)	9.95

5V=Single 5 Volt Supply 21V PGM=Program at 21 Volts

SPECTRONICS CORPORATION EPROM ERASERS



Model	Timer	Capacity Chip	Intensity (uW/Cm²)	Unit Price
PE-14	NO	9	8,000	$83.00
PE-14T	YES	9	8,000	$119.00
PE-24T	YES	12	9,600	$175.00

8000

8035	1.95
8039	2.95
8080	2.95
8085	2.95
8087-2	139.95
8087	109.00
8088	7.95
8088-2	9.95
8155	2.95
8155-2	3.95
8748	9.95
8755	19.95
80286	129.95
80287	185.00

8200

8203	34.95
8205	3.29
8212	1.49
8216	1.49
8224	2.25
8237	4.95
8237-5	6.95
8250	6.95
8251	1.95
8251A	2.49
8253	1.95
8253-5	2.49
8255	1.95
8255-5	2.49
8259	2.49
8259-5	2.95
8272	4.95
8279	2.95
8279-5	3.49
8282	3.95
8284	2.95
8286	3.[illegible]
8288	4.95

Z-80

Z80-CPU 2.5 MHz 1.79

4.0 MHz

Z80A-CPU	1.89
Z80A-CTC	1.95
Z80A-DART	5.95
Z80A-DMA	5.95
Z80A-PIO	1.95
Z80A-SIO/0	5.95
Z80A-SIO/1	5.95
Z80A-SIO/2	5.95

6.0 MHz

Z80B-CPU	4.95
Z80B-CTC	8.95
Z80B-PIO	8.95
Z80B-DART	14.95
Z80B-SIO/0	12.95
Z80B-SIO/2	12.95
Z8671 ZILOG	19.95

6500

1.0 MHz

6502	2.79
65C02 (CMOS)	12.95
6507	9.95
6520	1.95
6522	4.95
6526	26.95
6532	6.95
6545	6.95
6551	5.95
6561	19.95
6581	34.95

2.0 MHz

6502A	2.95
6520A	2.95
6522A	5.95
6532A	11.95
6545A	7.95
6551A	6.95

3.0 MHz

6502B	6.95

6800

1.0 MHz

6800	1.95
6802	4.95
6803	9.95
6809	5.95
6809E	5.95
6810	1.95
6820	2.95
6821	1.95
6840	6.95
6843	19.95
6844	12.95
6845	4.95
6847	11.95
6850	1.95
6883	22.95

2.0 MHz

68B00	4.95
68B02	5.95
68B09E	7.95
68B09	7.95
68B21	4.95
68B45	8.95
68B50	3.95
68B54	7.95

CLOCK CIRCUITS

MM5369	1.95
MM5369-EST	1.95
MM58167	12.95
MM58174	11.95
MSM5832	2.95

CRT CONTROLLERS

6845	4.95
68B45	8.95
6847	11.95
HD46505SP	6.95
MC1372	2.95
8275	26.95
7220	19.95
CRT5027	12.95
CRT5037	9.95
TMS9918A	19.95

DISK CONTROLLERS

1771	4.95
1791	9.95
1793	9.95
1795	12.95
1797	12.95
2791	19.95
2793	19.95
2797	29.95
6843	19.95
8272	4.95
UPD765	4.95
MB8876	12.95
MB8877	12.95
1691	6.95
2143	6.95

BIT RATE GENERATORS

MC14411	9.95
BR1941	4.95
4702	9.95
COM8116	8.95
MM5307	4.95

UARTS

AY5-1013	3.95
AY3-1015	4.95
TR1602	3.95
2651	4.95
IM6402	6.95
IM6403	9.95
INS8250	6.95

SOUND CHIPS

76477	3.95
76489	8.95
SSI-263	39.95
AY3-8910	12.95
AY3-8912	12.95
SP1000	39.00

CRYSTALS

32.768 KHz	.95
1.0 MHz	2.95
1.8432	2.95
2.0	1.95
2.097152	1.95
2.4576	1.95
3.2768	1.95
3.579545	1.95
4.0	1.95
4.032	1.95
5.0	1.95
5.0688	1.95
6.0	1.95
6.144	1.95
6.5536	1.95
8.0	1.95
10.0	1.95
10.738635	1.95
12.0	1.95
14.31818	1.95
15.0	1.95
16.0	1.95
17.430	1.95
18.0	1.95
18.432	1.95
20.0	1.95
22.1184	1.95
24.0	1.95
32.0	1.95

CRYSTAL OSCILLATORS

1.0MHz	5.95
1.8432	5.95
2.0	5.95
2.4576	5.95
2.5	4.95
4.0	4.95
5.0688	4.95
6.0	4.95
6.144	4.95
8.0	4.95
10.0	4.95
12.0	4.95
12.480	4.95
15.0	4.95
16.0	4.95
18.432	4.95
20.0	4.95
24.0	4.95

MISC.

TMS99531	9.95
TMS99532	19.95
ULN2003	.79
3242	7.95
3341	4.95
MC3470	1.95
MC3480	8.95
MC3487	2.95
11C90	13.95
2513-001 UP	6.95
AY5-2376	11.95
AY5-3600 PRO	11.95

74LS00

74LS00	.16	74LS165	.65
74LS01	.18	74LS166	.95
74LS02	.17	74LS169	.95
74LS03	.18	74LS173	.49
74LS04	.16	74LS174	.39
74LS05	.18	74LS175	.39
74LS08	.18	74LS191	.49
74LS09	.18	74LS192	.69
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS37	.26	74LS256	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.59	74LS259	1.29
74LS48	.69	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.24	74LS279	.39
74LS75	.29	74LS280	1.98
74LS76	.29	74LS283	.59
74LS83	.49	74LS290	.89
74LS85	.49	74LS293	.89
74LS86	.22	74LS299	1.49
74LS90	.39	74LS322	3.95
74LS92	.49	74LS323	2.49
74LS93	.39	74LS364	1.95
74LS95	.49	74LS365	.39
74LS107	.34	74LS367	.39
74LS109	.36	74LS368	.39
74LS112	.29	74LS373	.79
74LS122	.45	74LS374	.79
74LS123	.49	74LS375	.95
74LS124	2.75	74LS377	.79
74LS125	.39	74LS378	1.18
74LS126	.39	74LS390	1.19
74LS132	.39	74LS393	.79
74LS133	.49	74LS541	1.49
74LS136	.39	74LS624	1.95
74LS138	.39	74LS640	.99
74LS139	.39	74LS645	.99
74LS145	.99	74LS669	1.29
74LS147	.99	74LS670	.89
74LS148	.99	74LS682	3.20
74LS151	.39	74LS683	3.20
74LS153	.39	74LS684	3.20
74LS154	1.49	74LS688	2.40
74LS155	.59	74LS783	22.95
74LS156	.49	81LS95	1.49
74LS157	.35	81LS96	1.49
74LS158	.29	81LS97	1.49
74LS160	.29	81LS98	1.49
74LS161	.39	25LS2521	2.80
74LS162	.49	25LS2569	2.80
74LS163	.39	26LS31	1.95
74LS164	.49	26LS32	1.95

HIGH SPEED CMOS

A new family of high speed CMOS logic featuring the speed of low power Schottky (8ns typical gate propagation delay), combined with the advantages of CMOS: very low power consumption, superior noise immunity, and improved output drive.

74HC00

74HC: Operate at CMOS logic levels and are ideal for new, all-CMOS designs.

74HC00	.59	74HC148	1.19
74HC02	.59	74HC151	.89
74HC04	.59	74HC154	2.49
74HC08	.59	74HC157	.89
74HC10	.59	74HC158	.95
74HC14	.79	74HC163	1.15
74HC20	.59	74HC175	.99
74HC27	.59	74HC240	1.89
74HC30	.59	74HC244	1.89
74HC32	.69	74HC245	1.89
74HC51	.59	74HC257	.85
74HC74	.75	74HC259	1.39
74HC85	.35	74HC273	1.89
74HC86	.69	74HC299	4.99
74HC93	1.19	74HC368	.99
74HC107	.79	74HC373	2.29
74HC109	.79	74HC374	2.29
74HC112	.79	74HC390	1.39
74HC125	1.19	74HC393	1.39
74HC132	1.19	74HC4017	1.99
74HC133	.69	74HC4020	1.39
74HC138	.99	74HC4049	.89
74HC139	.99	74HC4050	.89

74HCT00

74HCT: Direct, drop-in replacements for LS TTL and can be intermixed with 74LS in the same circuit.

74HCT00	.69	74HCT166	3.05
74HCT02	.69	74HCT174	1.09
74HCT04	.69	74HCT193	1.39
74HCT08	.69	74HCT194	1.19
74HCT10	.69	74HCT240	2.19
74HCT11	.69	74HCT241	2.19
74HCT27	.69	74HCT244	2.19
74HCT30	.69	74HCT245	2.19
74HCT32	.79	74HCT257	.99
74HCT74	.85	74HCT259	1.59
74HCT75	.95	74HCT273	2.09
74HCT138	1.15	74HCT367	1.09
74HCT139	1.15	74HCT373	2.49
74HCT154	2.99	74HCT374	2.49
74HCT157	.99	74HCT393	1.69
74HCT158	.99	74HCT4017	2.19
74HCT161	1.29	74HCT4040	1.59
74HCT164	1.39	74HCT4060	1.49

74F00

74F00	.69	74F74	.79	74F251	1.69
74F02	.69	74F86	.99	74F253	1.69
74F04	.79	74F138	1.69	74F257	1.69
74F08	.69	74F139	1.69	74F280	1.79
74F10	.69	74F157	1.69	74F283	3.95
74F32	.69	74F240	3.29	74F373	4.29
74F64	.89	74F244	3.29	74F374	4.29

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CMOS

4001	.19	14419	4.95
4011	.19	14433	14.95
4012	.25	4503	.49
4013	.35	4511	.69
4015	.29	4516	.79
4016	.29	4518	.85
4017	.49	4522	.79
4018	.69	4526	.79
4020	.59	4527	1.95
4021	.69	4528	.79
4024	.49	4529	2.95
4025	.25	4532	1.95
4027	.39	4538	.95
4028	.65	4541	1.29
4035	.69	4553	5.79
4040	.69	4585	.75
4041	.75	4702	12.95
4042	.59	74C00	.29
4043	.85	74C14	.59
4044	.69	74C74	.59
4045	1.98	74C83	1.95
4046	.69	74C85	1.49
4047	.69	74C95	.99
4049	.29	74C150	5.75
4050	.29	74C151	2.25
4051	.69	74C161	.99
4052	.69	74C163	.99
4053	.69	74C164	1.39
4056	2.19	74C192	1.49
4060	.69	74C193	1.49
4066	.29	74C221	1.75
4069	.19	74C240	1.89
4076	.59	74C244	1.89
4077	.29	74C374	1.99
4081	.22	74C905	10.95
4085	.79	74C911	8.95
4086	.89	74C917	8.95
4093	.49	74C922	4.49
4094	2.49	74C923	4.95
14411	9.95	74C926	7.95
14412	6.95	80C97	.95

7400/9000

7400	.19	74147	2.49
7402	.19	74148	1.20
7404	.19	74150	1.35
7406	.29	74151	.55
7407	.29	74153	.55
7408	.24	74154	1.49
7410	.19	74155	.75
7411	.25	74157	.55
7414	.49	74159	1.65
7416	.25	74161	.69
7417	.25	74163	.69
7420	.19	74164	.85
7423	.29	74165	.85
7430	.19	74166	1.00
7432	.29	74175	.89
7438	.29	74177	.75
7442	.49	74178	1.15
7445	.69	74181	2.25
7447	.89	74182	.75
7470	.35	74184	2.00
7473	.34	74191	1.15
7474	.33	74192	.79
7475	.45	74194	.85
7476	.35	74196	.79
7483	.50	74197	.75
7485	.59	74199	1.35
7486	.35	74221	1.35
7489	2.15	74246	1.35
7490	.39	74247	1.25
7492	.50	74248	1.85
7493	.35	74249	1.95
7495	.55	74251	.75
7497	2.75	74265	1.35
74100	2.29	74273	1.95
74121	.29	74278	3.11
74123	.49	74367	.65
74125	.45	74368	.65
74141	.65	9368	3.95
74143	5.95	9602	1.50
74144	2.95	9637	2.95
74145	.60	96S02	1.95

74S00

74S00	.29	74S163	1.29
74S02	.29	74S168	3.95
74S03	.29	74S174	.79
74S04	.29	74S175	.79
74S05	.29	74S188	1.95
74S08	.35	74S189	1.95
74S10	.29	74S195	1.49
74S15	.35	74S196	1.49
74S30	.29	74S197	1.49
74S32	.35	74S226	3.99
74S37	.69	74S240	1.49
74S38	.69	74S241	1.49
74S74	.49	74S244	1.49
74S85	.95	74S257	.79
74S86	.35	74S253	.79
74S112	.50	74S258	.95
74S124	2.75	74S280	1.95
74S138	.79	74S287	1.69
74S140	.55	74S288	1.69
74S151	.79	74S299	2.95
74S153	.79	74S373	1.69
74S157	.79	74S374	1.69
74S158	.95	74S471	4.95
74S161	1.29	74S571	2.95

DATA ACQ / INTERFACE

DATA ACQ		INTERFACE	
ADC0800	15.55	8T26	1.29
ADC0804	3.49	8T28	1.29
ADC0809	4.49	8T95	.89
ADC0816	14.95	8T96	.89
ADC0817	9.95	8T97	.59
ADC0831	8.95	8T98	.89
DAC0800	4.49	DM8131	2.95
DAC0806	1.95	DP8304	2.29
DAC0808	2.95	DS8833	2.25
DAC1020	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

VOLTAGE REGULATORS

TO-220 CASE

7805T	.49	7905T	.59
7808T	.49	7908T	.59
7812T	.49	7912T	.59
7815T	.49	7915T	.59

TO-3 CASE

7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49

TO-92 CASE

78L05	.49	79L05	.69
78L12	.49	79L12	.69

OTHER VOLTAGE REGS

LM323K	5V	3A	TO-3	4.79
LM338K	Adj	5A	TO-3	3.95
78H05K	5V	5A	TO-3	7.95
78H12K	12V	5A	TO-3	8.95
78P05K	5V	10A	TO-3	14.95

IC SOCKETS

	1-99	100
8 PIN ST	.13	.11
14 PIN ST	.15	.12
16 PIN ST	.17	.13
18 PIN ST	.20	.18
20 PIN ST	.29	.27
22 PIN ST	.30	.27
24 PIN ST	.30	.27
28 PIN ST	.40	.32
40 PIN ST	.49	.39
64 PIN ST	4.25	CALL
ST=SOLDERTAIL		
8 PIN WW	.59	.49
14 PIN WW	.69	.52
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.28
24 PIN WW	1.49	1.35
28 PIN WW	1.69	1.49
40 PIN WW	1.99	1.80
WW=WIREWRAP		
16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	6.95	CALL
40 PIN ZIF	9.95	CALL

ZIF=TEXTOOL (ZERO INSERTION FORCE)

LINEAR

TL066	.99	LM733	.98
TL071	.69	LM741	.29
TL072	1.09	LM747	.69
TL074	1.95	LM748	.59
TL081	.59	MC1330	1.69
TL082	.99	MC1350	1.19
TL084	1.49	MC1372	6.95
LM301	.34	LM1414	1.59
LM309K	1.25	LM1458	.49
LM311	.59	LM1488	.49
LM311H	.89	LM1489	.49
LM317K	3.49	LM1496	.85
LM317T	.95	LM1812	8.25
LM318	1.49	LM1889	1.95
LM319	1.25	ULN2003	.79
LM320	see 7900	XR2206	3.75
LM322	1.65	XR2211	2.95
LM323K	4.79	XR2240	1.95
LM324	.49	MPQ2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.40	CA3081	.99
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	3.95	CA3089	1.95
LM339	.59	CA3130E	.99
LM340	see 7800	CA3146	1.29
LM350T	4.60	CA3160	1.19
LF353	.59	MC3470	1.95
LF356	.99	MC3480	8.95
LF357	.99	MC3487	2.95
LM358	.59	LM3900	.49
LM380	.89	LM3909	.98
LM383	1.95	LM3911	2.25
LM386	.89	LM3914	2.39
LM393	.45	MC4024	3.49
LM394H	4.60	MC4044	3.99
TL494	4.20	RC4136	1.25
TL497	3.25	RC4558	.69
NE555	.29	LM13600	1.49
NE556	.49	75107	1.49
NE558	1.29	75110	1.95
NE564	1.95	75150	1.95
LM565	.95	75154	1.95
LM566	1.49	75188	1.25
LM567	.79	75189	1.25
NE570	2.95	75451	.39
NE590	2.50	75452	.39
NE592	.98	75453	.39
LM710	.75	75477	1.29
LM723	.49	75492	.79

H=TO-5 CAN, K=TO-3, T=TO-220

EDGECARD CONNECTORS

100 PIN ST	S-100	.125	3.95
100 PIN WW	S-100	.125	4.95
62 PIN ST	IBM PC	.100	1.95
50 PIN ST	APPLE	.100	2.95
44 PIN ST	STD	.156	1.95
44 PIN WW	STD	.156	4.95

36 PIN CENTRONICS

MALE

IDCEN36	RIBBON CABLE	6.95
CEN36	SOLDER CUP	4.95
CEN36PC	RT ANGLE PC MOUNT	4.95

FEMALE

IDCEN36/F	RIBBON CABLE	7.95

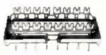
INTERSIL

ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	4.95
ICM7207A	5.95
ICM7208	15.95

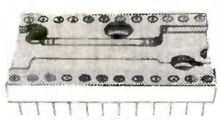
DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	---	.95	.95	---	---	---	1.75	---	2.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE BELOW


ICC16


IDP14


AUGAT 24ST

DIODES/OPTO/TRANSISTORS

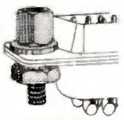
1N751	.25	4N26	.69
1N759	.25	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP04	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	.99
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

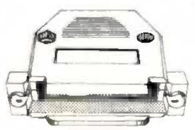
D-SUBMINIATURE

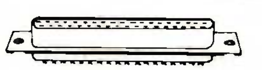
DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.25	1.80	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.50	2.35	4.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	---	1.95	2.65	---
	FEMALE	DBxxSR	1.25	1.55	---	2.00	2.79	---
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	---	3.89	5.60	---
	FEMALE	DBxxSWW	2.76	4.27	---	6.84	9.95	---
IDC RIBBON CABLE	MALE	IDBxxP	2.70	2.95	---	3.98	5.70	---
	FEMALE	IDBxxS	2.92	3.20	---	4.33	6.76	---
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30	---	---
	GREY	HOODxx	.65	.65	---	.65	.75	.95

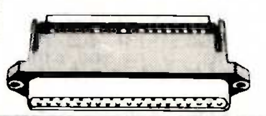
ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED.
EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR

MOUNTING HARDWARE $1.00


MTG HDWR


HOOD25


DB37S


IDB37S

LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM CATHODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
MAN-8940	COM CATHODE	.8"	1.99
TIL-313	COM CATHODE	.3"	.45
HP5082-7760	COM CATHODE	.43"	1.29
TIL-311	4x7 HEX W/LOGIC	.270"	9.95
HP5082-7340	4x7 HEX W/LOGIC	.290"	7.95

DIFFUSED LEDS

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

SWITCHES

SPST	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.39
SPST	MINI-PUSHBUTTON N.C.	.39
SPST	TOGGLE ON-OFF	.49
BCD OUTPUT	10 POSITION 6 PIN DIP	1.95

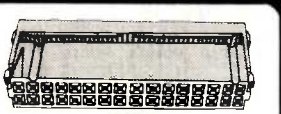
DIP SWITCHES

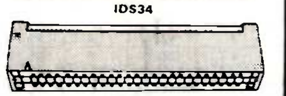
4 POSITION	.85	7 POSITION	.95
5 POSITION	.90	8 POSITION	.95
6 POSITION	.90	10 POSITION	1.29

IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.79	.99	1.39	1.59	1.99	2.25
RIBBON HEADER	IDMxx	---	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.65	2.75	3.80	3.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE ABOVE


IDS34


IDE50

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	SINGLE COLOR 10'	COLOR CODED 1'	COLOR CODED 10'
10	.18	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.50
25	.45	4.00	.75	6.85
26	.46	4.10	.78	7.15
34	.61	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

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LC-3	2 CONDUCTOR	.99
LC-HP	3 CONDUCTOR W/STD FEMALE SOCKET	1.49

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3.63" SQ	ETRI	14.95
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PS-IBM-150 $129.95
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- -12 @ .5A, -5 @ .5A
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PS-100 $89.95
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  -12V @ .1A
- +5V @ 5A IF +12V IS NOT USED
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PS-TDK $29.95
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24	IDWRAP 24	5	1.95
28	IDWRAP 28	5	1.95
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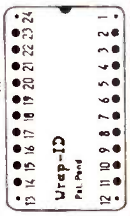

ID WRAP 24

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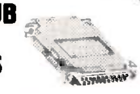

CAPACITORS

TANTALUM

1.0µf	15V	.35	.47µf	35V	.45
6.8	15V	.70	1.0	35V	.45
10	15V	.80	2.2	35V	.65
22	15V	1.35	4.7	35V	.85
.22	35V	.40	10	35V	1.00

DISC

10pf	50V	.05	680	50V	.05
22	50V	.05	.001µf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

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.01µf	50V	.14	.1µf	50V	.18
.047µf	50V	.15	.47µf	50V	.25

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1µf	25V	.14	1µf	50V	.14
2.2	35V	.15	10	50V	.16
4.7	50V	.15	22	16V	.14
10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
100	16V	.18	220	25V	.30
220	35V	.20	470	50V	.50
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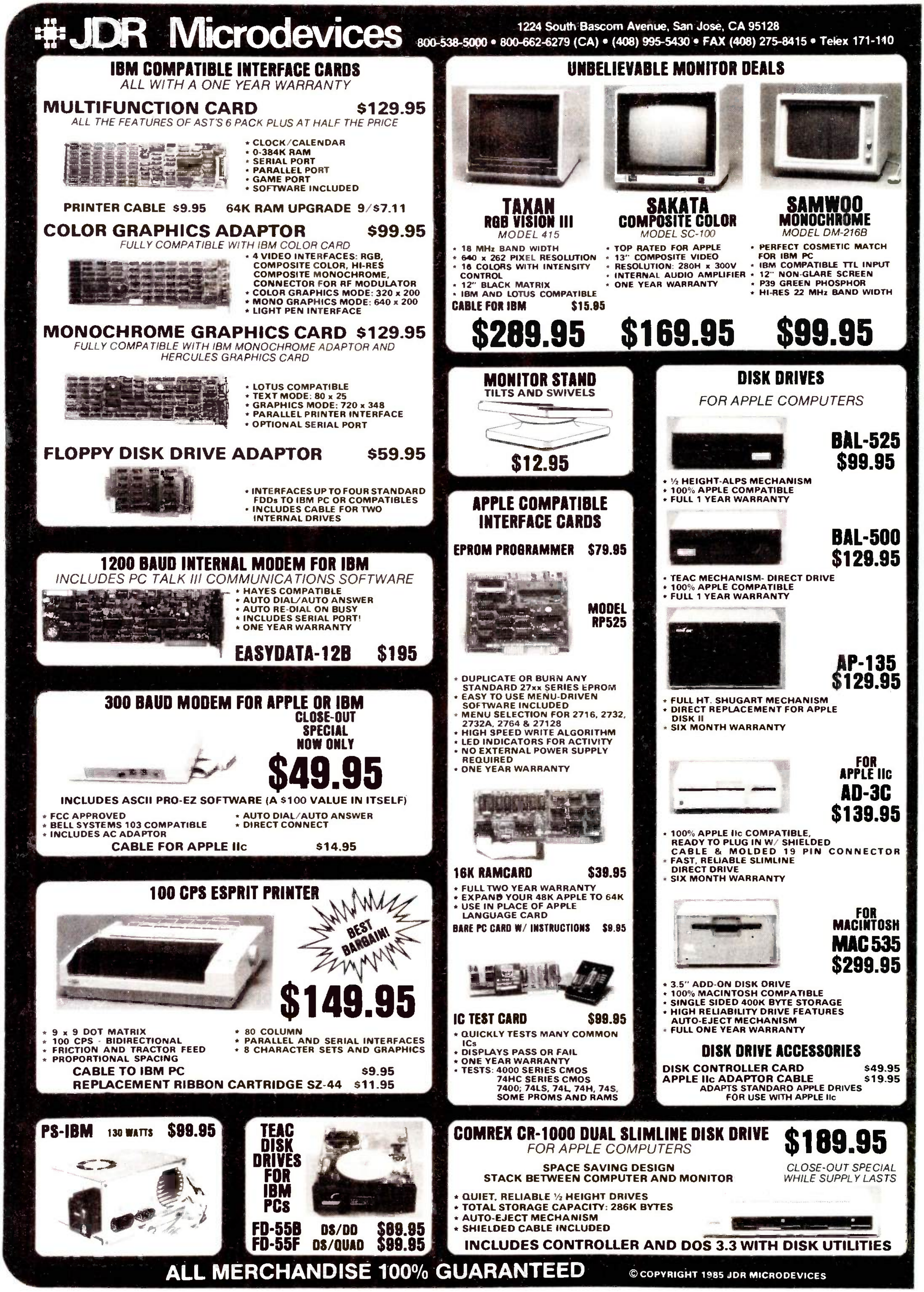
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• ½ HEIGHT-ALPS MECHANISM
• 100% APPLE COMPATIBLE
• FULL 1 YEAR WARRANTY
BAL-500 $129.95
• TEAC MECHANISM- DIRECT DRIVE
• 100% APPLE COMPATIBLE
• FULL 1 YEAR WARRANTY
AP-135 $129.95
• FULL HT. SHUGART MECHANISM
• DIRECT REPLACEMENT FOR APPLE DISK II
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AD-3C $139.95
• 100% APPLE IIc COMPATIBLE, READY TO PLUG IN W/ SHIELDED CABLE & MOLDED 19 PIN CONNECTOR
• FAST, RELIABLE SLIMLINE DIRECT DRIVE
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MAC 535 $299.95
• 3.5" ADD-ON DISK DRIVE
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FD-55B DS/DD $89.95
FD-55F DS/QUAD $99.95
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U·N·C·L·A·S·S·I·F·I·E·D A·D·S

WANTED: Anti-apartheid/human-rights/educational 501 (c) (3) organization seeks tax-deductible donations of computers and equipment to help free South Africa. Richard Knight, The Africa Fund, 198 Broadway, New York, NY 10038, (212) 962-1210.

WANTED: Nonprofit grass-roots community groups need tax-deductible donation of microcomputers and printers to implement and administer vitally needed inner-city development programs. National Training & Information Center, 954 West Washington, Chicago, IL 60607, (312) 243-3035.

WANTED: Nonprofit youth organization seeks tax-deductible contributions of computer equipment for young people placed in foster and group homes, and agency use. Dan Seidel, Youth Advocates, 2317 East John St., Seattle, WA 98112, (206) 322-7838.

WANTED: Nonprofit agency providing rent subsidies and home improvements for low-income families seeks tax-deductible computer hardware to expand service area. L. Von Kuhen, Suffolk Community Development Corp., 625 Middle Country Rd., Coram, NY 11727, (516) 698-8201.

WANTED: Volunteer fire department seeks tax-deductible donation of an IBM PC or compatible plus peripherals, hard disk, and public-domain software. Robert Moore, Western Reserve Joint Fire District, 111 South Main St., Poland, OH 44514.

NEEDED: Nonprofit agency for the economically underprivileged needs tax-deductible donation of IBM, Apple, or Radio Shack computer and/or printer and peripherals. Sr. M. Zita Green, Pittsburgh Catholic Education Programs, 205 Orchard Place, Pittsburgh, PA 15210, (412) 488-2752.

WANTED: Religious community seeks tax-deductible donation of Commodore or IBM PC-compatible computers and hardware for educational and administrative purposes. Fr. Joseph of Jesus, ODM, The Apostles of Infinite Love, CP 308, St. Jovite, Quebec J0T 2H0, Canada.

WANTED: Nonprofit agency needs information on procurement of Apple II+ public-domain software and hardware to help score the *California Psychological Inventory* answer sheets. David Jones, Psychological Tester, Department of Corrections, Powhatan Reception and Classification Center, State Farm, VA 23160.

WANTED: Undergraduate physics labs at nonprofit college need tax-deductible donations of computers, monitors, printers, etc., to incorporate computer data acquisition and control into curriculum. MS-DOS preferred. Will pay shipping. Dr. Donald Simanek, Lock Haven University, Lock Haven, PA 17745, (717) 893-2079 or 893-2048.

WANTED: Documentation for 8080 or Z80 Tiny C interpreter. G. A. Findlay, 87 Somerfield St., Christchurch, New Zealand.

WANTED: Correspondence with users of Atari 800XL computer or information on an Atari users group. Oscar Buratovich, L. Servera, 106, Cala Ratjada (Mallorca), Spain.

WANTED: Correspondence with other computerists in English or Italian. Francesco Lombardi, Via E. Zacconi 16, 47037 Rimini (FO), Italy.

NEEDED: Correspondence with anyone using Vista S-100 5¼-inch double-sided VBIOS. I have much public-domain software and write in C and assembly, including multispooling BIOS. Larry Dass, 4 Nancevallon, Brea, Camborne, Cornwall TR14 9DE, England; tel. (0209)714475.

WANTED: Inmate seeks public-domain listings of disk-based software for IBM PC XT and tape-based software for C-64. Educational, language, and assembly type software preferred. S. D. Betesh, KP-PEN, Box 22, Kingston, Ontario K7L 4V7, Canada.

WANTED: Contact with Tandy 2000 users group or individuals for mutual support. Stan Wright, 5 Jefferson Ct., RR 4, Princeton, NJ 08540, (201) 329-2411.

WANTED: Contact with DEC Rainbow 100 users group or individuals for mutual support. Marvin Gilbreath, 710 South Eagle, Weimar, TX 78962.

FOR SALE: Several industrial-control computers manufactured by Jarr Corp. and Micromint Inc. Systems include motherboard, power supply, processor board, parallel-interface board, and EPROM programmer. Priced reasonably. Court Johnson, New Ipswich, NH 03071, (603) 878-2966.

FOR TRADE: Antique computer of historical interest. Egli "The Millionaire" 4-function computer. Swiss-made in 1895, suitcase size, brass gears, full readouts with decimal, instructions. Mint operating condition. Trade for IBM PC, drives, printer, and public-domain software. Doug Johnson, 1941 South 250 E., Orem, UT 84058, (801) 224-9246.

WANTED: Tractor-feed assembly for Qume Sprint 8, 132 characters. Quote price. S. Gilbert, 154 Munson Ave., West Hempstead, NY 11552, (516) 486-0367.

FOR SALE: Morrow DJ/DMA floppy-disk controller: $275. Two California Computer Systems 16K static RAM boards: $80 each. Other equipment available. Lou Dottore, 20360 Blackfoot Ave., Euclid, OH 44117, (216) 486-0823.

FOR SALE: CompuPro 816 with 512K memory, M-Drive, MPX-1, and 8-channel 50-kHz 12-bit A/D/A converter. Excellent condition. $7000 or best offer. Also, IDS Prism 132 printer with color graphics and more. $1500 or best offer. Karim Chichakly, POB 21, Cornish Flat, NH 03746, (603) 469-3693.

WANTED: Technical information and schematics of the hardware of the Apple Macintosh and IBM PC, XT, and AT. Will pay postage. Willibert Fabritius, Stegbenden 31, 5166 Kreuzau, West Germany.

FOR SALE: S-100 Z80 CP/M system. TDL ZPU, system monitor board with one parallel and two serial ports, monitor, CCS 64K RAM, 12-slot mainframe, graphics board, two 315K 5¼-inch drives. ADDS Viewpoint terminal. Send SASE. Richard Ray, 347 South Havenside Ave., Newbury Park, CA 91320.

FOR SALE: BYTE, September 1975 through December 1984: $300. Missing November 1980. Will deliver within 50 miles. A. C. Costanzo, 201 Frost Pond Rd., Glen Cove, NY 11542, (516) 671-2207.

FOR SALE: Heathkit H-8 digital computer with 16K RAM and manuals. $225 or best offer. John Creamer, 131 Pennsylvania, Dyess AFB, TX 79607, (915) 695-4831.

WANTED: Individuals to form a users group for the Memotech MTX512 to develop software/hardware and exchange information. Steve Cooley, POB 2932, Kalamazoo, MI 49003, (616) 323-7822.

FOR SALE: Hewlett-Packard HP 86B, 128K RAM, dual 3½-inch microfloppies, 12-inch Graf monochrome display, and more. $2400. Wendell Anderson, POB 449, Bogota, NJ 07603, (201) 342-5497.

WANTED: Our Mac user group would like to trade public-domain software. John B. Hancock, 209 Johnson, Warrensburg, MO 64093.

FOR SALE: S-100 system with Cromemco ZPU, 16K RAM, 16K EPROM, four MITS RS-232 ports, and vectored interrupt/real-time clock board. Altair 8800b enclosure with motherboard and power supply. All operative when removed from service. $450 or best offer. J. Frenzel, 12406 Sceptre Cove, Austin, TX 78727.

WANTED: Recommendations and information about computer kits and sources, documentation, and software starter packages that can be upgraded to a high-performance, cost-effective, single-user word-processing system. A. Lloyd Freeman, 6116 Everest Way, Sacramento, CA 95842-2898, (916) 344-7375.

WANTED: Graduate student researching the application of distributed operating systems would appreciate correspondence with others working in this field. Zach Stern, Apt. T-1, 897 Clopper Rd., Gaithersburg, MD 20878.

UNCLASSIFIED ADS MUST *be noncommercial, from readers who have computer equipment to buy, sell, or trade on a onetime basis. All requests for donated computer equipment must be from nonprofit organizations. Programs to be exchanged must be written by the individual or be in the public domain. Ads must be typed double-spaced, contain 50 words or less, and include full name and address. This is a free service; ads are printed as space permits.* BYTE *reserves the right to reject any unclassified ad that does not meet these criteria. When you submit your ad* (BYTE, *Unclassified Ads,* POB 372, *Hancock,* NH 03449), *allow at least four months for it to appear.*

WANTED: Apple II-associated hardware. Send description and price. Erik Sea, 22 Edgar Dr., London, Ontario N6G 1K1, Canada.

FOR SALE: BYTE, all issues. 1975–1979: $200. 1980–1984: $30 per year, will sell by year. Issue number 1: $25. Perfect condition; buyer pays shipping. William L. King, 8222 Sprenger NE, Albuquerque, NM 87109, (505) 821-4692.

FOR SALE: Radio Shack Quick Printer II, excellent condition: $35. Gary, 903 Nora Dr., Colesville, MD 20904, (301) 622-2709.

FOR SALE: CompuPro Enclosure 2: $425; CompuPro Disk 1 DMA-FDC: $265; SSM VB3 memory-mapped 80 by 35 video: $255; 10-megabyte SA1004 Winchester with WD1001 controller, power, cables, and BIOS: $660. Other equipment available. David Israel, 136 Thorndike St., Brookline, MA 02146, (617) 566-3441.

FOR SALE: RCA CDP 18S020 COSMAC evaluation board and CDP18S021 Microterminal with manuals: $195. EXIOM 801 Microprinter with electrosensitive paper and manuals, new: $185. Stan Sims, 2435 Char Rt. 1, McFarland, WI 53558, (608) 838-8782.

WANTED: Electronics student seeks books and correspondence about digital electronics and microprocessors. Jose Luis Regueiro, Adolfo Berro 1097, Montevideo, Uruguay.

WANTED: Hewlett-Packard 96 programmable calculator. Jean Gauval, 14570 120th Ave. N, Largo, FL 33544.

AVAILABLE: CP/M and IBM public-domain library disks on a variety of topics and in many formats. Send SASE. Want IBM PCjr or IBM clone (BDS or AT&T units). Will consider trades. Need dates and condition. J. Cramer, POB 28606B4, Columbus, OH 43228-0606.

FOR SALE: Lomas Data Products Thunder-186 S-100 board with 8-MHz 80186, 256K memory with parity, floppy-disk controller, I/O ports (two serial, one parallel), manuals, and more. $750 or best offer. Dan Blumenfeld, 3900 Chestnut St. #803, Philadelphia, PA 19104, (215) 898-1956.

FOR SALE: Sanyo 555-2 with 256K RAM, video board, two DS/DD drives, and more. $925. Robert Warren, 81 Camille Dr. Apt. #2, El Paso, TX 79912, (915) 581-3519.

FOR SALE: SD Systems 700 Series multiuser computer system (supports 5 users), 96-megabyte cartridge-disk storage unit, and more. Perfect condition. Stephen F. Wheeler, 322 Chimney Rock #801, Tyler, TX 75701, (214) 581-1158.

FOR SALE: New multifunction card for the IBM PC with 64K, serial port, parallel port, clock/calendar warranty, and more. $205. Ed. Yentzen, POB 47142, Dallas, TX 75247, (214) 821-0224.

FOR SALE: Apple hardware. Will sell parts separately at bargain price. 16K RAM, 128K RAM, EPROM programmer Z80 card, disk controller, and others. All work perfectly. George Lopez-H., 677 Shaller Blvd., Ridgefield, NJ 07657, (201) 941-8129.

WANTED: Leftovers from your IBM PC upgrade. Also, need Exidy Sorcerer equipment for spare parts. Let me know what you have and how much you want. Jeff Becker, 1710 Valley Rd., Champaign, IL 61820.

FOR SALE: Hewlett-Packard 125 computer, dual drives (DS/DD), and more. $1300. Altos 8000-10, multiuser (4), 10-megabyte hard disk, 8-inch floppy, and more. $1700. Jonathan Chilvers, 90 Gazania Court, Novato, CA 94947, (415) 892-7056.

FOR SALE: NEC PC-8001A with 12-inch green-screen monitor, expansion unit, dual 5¼-inch disk drives, NEC dot-matrix printer, 64K RAM, manuals, and more. $1500. Ralph Freshour, POB 7000-309, Redondo Beach, CA 90277, (213) 375-6391.

FOR SALE: OSM ZEuS 4 multiuser computer system with Heath terminal, unused 8-inch SS/SD disk drive, cabling, manuals, 6.3-megabyte hard disk, and more. $4000. R. P. Perkins, M.D., 2211 Lomas Blvd. NE, Albuquerque, NM 87106, (505) 277-4158.

FOR SALE: Operation/service manual with schematics/illustrations for Zenith/Heath Model Z-89-48: $45; manual set (10) for Ithaca Intersystems Series II MPU-80 and MPU-8000 S-100 systems: $50; manuals for Intertec SuperBrain: $35. You pay postage. William Orr, U.S. Embassy, APO New York, NY 09777.

B·O·M·B

BYTE's Ongoing Monitor Box

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BOMB *Results*

THE STARS OF JULY

Computing at Chaos Manor lit up the sky in July with Jerry Pournelle's invitation to "Come to the Faire." In second, readers selected Steve Ciarcia's "Living in a Sensible Environment," which contains the finishing touches on his most recent Circuit Cellar project. BYTELINES by Sol Libes came in third, followed by What's New. Microbytes was fifth and the "Start-up" of Bruce Webster's According to Webster followed in sixth place. Glenn J. Adler wins $100 for "Liquid-Crystal Displays for Portables," which placed seventh. His was the first non-staff-written article to appear in the lineup. Eighth place went to Ask BYTE, conducted by Steve Ciarcia. BYTE Japan came in ninth; here William Raike presented "Peripherals, Chips, and New Computers" in the Japanese computing scene. In tenth place and winner of the $50 bonus is Richard Wilton, author of the theme covering "Microcomputers in NASA's SIR-B."

R·E·A·D·E·R S·E·R·V·I·C·E

TO GET FURTHER information on the products advertised in BYTE, either pick up your touch-tone telephone and use TIPS (if you are a subscriber), or fill out the reader service card. Either way full instructions are provided following this reader service index which is provided as an additional service by the publisher, who assumes no liability for errors or omissions. *Correspond directly with company.

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6) When TIPS says "Enter magazine code & issue code"
Enter [1] [#] [1] [0] [5] [#] [#]

ENTER YOUR INQUIRIES

7a) When TIPS says "Enter (next) Inquiry Number"
Enter one inquiry selection from below (ignore blank boxes)

b) Repeat 7a as needed (maximum 17 inquiry numbers)

1. □ □ □ [#] [#]   6. □ □ □ [#] [#]   10. □ □ □ [#] [#]   14. □ □ □ [#] [#]
2. □ □ □ [#] [#]   7. □ □ □ [#] [#]   11. □ □ □ [#] [#]   15. □ □ □ [#] [#]
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5. □ □ □ [#] [#]

END SESSION

8) End session by entering [*] [*] [9] [1] [#] [#]

9) Hang up after hearing final message
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Inquiry 245

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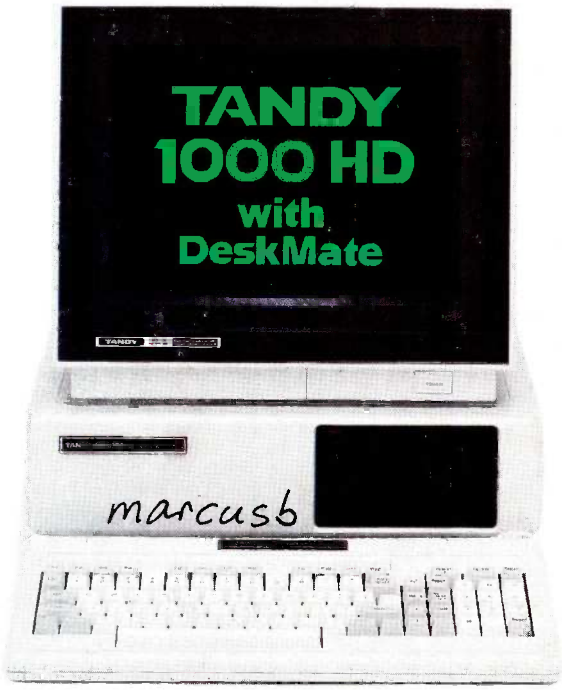

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