SIMULATION
A dot matrix printer that will improve your image.

Meet the Apple ImageWriter, the newest dot matrix printer for your Apple Personal Computer.

And with all that it has going for it, just maybe the best dot matrix printer on the market.

Take legibility, for instance.

The ImageWriter crams 140 x 160 dots into each square inch. So you get text that's highly readable and high resolution graphics, besides.

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The ImageWriter cruises at an unbelievable 120 characters per second. And that's just in the text mode. It's even faster printing graphics. 180 characters per second, to be exact.

What's more, the graphics dump is up to 60% faster than other comparably priced dot matrix printers. And that makes the ImageWriter fast enough to handle the Lisa™

Yet it's just as at home with an Apple III or Apple IIe. Thanks to Apple software experts who designed the control electronics to give the ImageWriter perfect compatibility. Not to mention some special capabilities like superscript and subscript, to name just two.

Now, with all this high-speed performance, you'd expect the ImageWriter to make the Devil's Own Noise. It doesn't. In fact, the ImageWriter is specially constructed — with overlaid seams and special sounddeadening materials — to achieve a remarkable 53 dB. How loud is a remarkable 53 dB? You'd make more noise if you read this aloud.

The ImageWriter even has quiet good looks, since we designed it to look like the rest of the Apple Family.

Yet even with all its improvements, the ImageWriter is a better deal than any other dot matrix printer with comparable performance. And you can print that.
Charge!

Go out there and get the Apple Personal Computer System you really want. Now. Without laying out your extra cash. Without tying up your other lines of credit. With the Apple Card. The only consumer credit card reserved exclusively for the purchase of Apple Computers, peripherals and software.

Like all our products, it works simply:

Fill out an application (short, to the point and annotated in English) at an authorized Apple dealer honoring the Card. Your salesperson will call in the application and in most cases get an approval for you right on the spot.

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So stop by a participating authorized Apple dealer and get an Apple Card. Just think of it as credit where credit is due.

Give your floppy disks the boot.

We call it the ‘floppy disk shuffle.” It happens when you have two or more software programs on floppies and you need to work with both. What do you do? You put one disk in, boot it, do your work, take it out, put the other disk in, boot it, do your work — you get the idea.

Well, you can stop shuffling any time now.

Thanks to a unique new software program called Catalyst™ from Quark, Inc. Specially designed for your Apple III and Profile™ hard disk.

Catalyst allows you to take a wide variety of software programs and store them on your Profile. Once they’re on your Profile, you just select the program you want from the Catalyst menu that appears on your monitor — then Catalyst does the rest. You’ll never have to boot those programs again.

What kinds of programs will work with Profile and Catalyst?

Almost anything written for the Apple III including copy-protected programs like VisiCalc®, Quick File™ and Apple Writer III. Or languages like Pascal, BASIC, or COBOL.

And once you’ve loaded these programs into your Profile, the only diskette you may ever need is the Catalyst.

So if you have an Apple III and a Profile and more floppies than you care to flip through, get yourself a Catalyst. And boot those disks for good.
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Cover painting by Robert Tinney
Where BYTE Is Going

We want to clear up some confusion about different kinds of articles in BYTE that have sometimes been mistaken for one another, to explain how we intend to avoid the same problem in the future, and to reaffirm BYTE's editorial direction as a magazine for personal computer users.

BYTE publishes reviews in order to help readers make purchasing decisions on personal computers, peripherals, and software. A review passes judgment on a product. Every review in BYTE appears in the Reviews section and carries a banner that includes the word “review.” Although staff members sometimes write reviews, we more often solicit them from personal computer users who are not on staff. We try to ensure that reviews are thorough, frank, and fair. Fairness requires that all reviews be performed on actual shipping products rather than prototypes or beta-test machines and software. To do otherwise is unfair to the reader, the reviewer, and the manufacturer. In a few cases, we have mistakenly published reviews of prerelease products. (We owe an apology to Supersoft for holding a prerelease version of its C compiler up to the standard of a shipping product in our August 1983 issue.)

BYTE publishes product descriptions to give readers an early look at forthcoming products that are innovative and important. BYTE staff members write almost all product descriptions because of the absolute confidentiality required in gaining access to prototypes and beta-test products months before product announcements. Because product descriptions are written at such an early stage of a product's development, they cannot pass judgment on the final product. Rather, the goal of a product description is to give the reader as much technical information as possible at the time and also a detailed impression of how it feels to use the product, how the product works, and how it breaks new ground.

When we see a prototype or test system at an even earlier stage of development, we call the resulting article a product preview rather than a product description. Again we try to give our readers an early look at something new and interesting, and an impression of the product-to-be, but we also recognize that the manufacturer may make significant changes before going into production. A product preview usually has less detail than a product description.

To review a prerelease product would be unfair, but product descriptions and previews do point out design limitations that cannot be changed by shipping date (for example, the HP 150’s lack of provision for an 8087 coprocessor, or Macintosh’s lack of an inboard second disk drive). At this writing, BYTE has done product previews of both the HP 150 and the Macintosh, but has not yet received review machines of these products. As soon as machines arrive, we will assign them to reviewers. We will publish the reviews as quickly as possible after their completion, but bear in mind that a good review requires the writer to use a product for four to eight weeks and then spend another two weeks or more in the writing. It takes another three to four months to turn a completed manuscript into a printed article in BYTE.

Those readers who have recently suggested that BYTE publishes too many favorable reviews have typically mistaken product previews and product reviews and product descriptions for reviews. The editors of BYTE are under no pressure to review any product favorably. We enjoy complete editorial
How Cromemco plugs you into the state of the art.

Cromemco offers you the most complete line of S-100 boards and peripherals in the business. These boards use the new IEEE-696 state-of-the-art standard. One-stop shopping can satisfy your design needs the easy way.

You can build one system, or a hundred, exactly the way you want, and upgrade existing systems with a simple board swap or addition. And since we design our own boards for our own systems, we always take advantage of the latest developments in IC technology.

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We have over 30 S-100 boards to fill your needs. And all are supported by a broad line of software. Our Board Products Catalog has the latest information. Call today for your copy, or to get the name of our nearest dealer or distributor. Or, write Cromemco, Inc., 280 Bernardo Avenue, P.O. Box 7400, Mountain View, CA 94039. Tel: (415) 964-7400. In Europe: Cromemco A/S, Vesterbrogade 1C, 1620 Copenhagen, Denmark.

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freedom, which remains unabridged even when advertisers have canceled ads because they disliked a review.

BYTE does sometimes accept articles from the designers or developers of some interesting new product or technology but never asks or permits them to review their own creations. We publish design and development articles because they can appear months earlier than reviews, can contain insights into technical creativity, and can provide a glimpse of the state of the art or the future direction of personal computing.

In some recent cases, BYTE has been guilty of insufficient editorial zeal in purging promotional material from certain articles. We deeply regret these errors, are correcting the circumstances that led to them, and will redouble our efforts to see that no expressions of self-interest appear in these pages. We definitely erred in moving the affiliations of authors from the beginning of the article to the end. The change was made for purely graphical reasons, not to mislead the reader, and is reversed in the April issue. In upcoming issues we will also provide distinctive graphics to make reviews, product descriptions, product previews, and design articles look markedly different from one another.

We try our best to present independent reviews of all products covered in design articles, product descriptions, and product previews. This has been the case with the June 1983 issue on "16-Bit Designs," which attempted to show the great variety of systems becoming available despite the tide of PC compatibles and to stimulate dialogue between designers and users. In a few instances, circumstances prevented our publishing in-depth reviews of products featured in that issue. Four of the systems described—Gavilan, Sunrise, Pronto, and TI 99/2—had hardly been announced and could not have been reviewed then. Unfortunately, we are still awaiting review machines of the Gavilan, the Sunrise (Xerox 1800), and the Pronto. The TI 99/2 died aborning but was of interest as an under-$100 16-bit computer. Despite these exceptions, most of the systems presented in the June issue have been reviewed or are scheduled for review in the near future. Berry Kercheval's independent review of the HP Series 200 Model 16 appeared in November. (Generally he liked the machine, but he found serious fault with the documentation, the keyboard, and the Pascal compiler. David Colver, in turn, found Kercheval's review wanting, and we publish Colver's letter on page 15 in this issue.) Reviews of the DEC Professional 350, the Altos 586, the Fujitsu Model 16s, and the Sritek 68000 board for the IBM PC are in progress. A review of the DEC Rainbow is scheduled to appear in April.

This issue contains product descriptions of the Tandy 2000 and the IBM PCjr. Reviews will follow as soon as possible; we would be delighted to receive reviews from any readers who get one of the first production machines from Tandy or IBM.

In some areas of advanced technology, such as perpendicular magnetics, there is not yet a product to describe, preview, or hand over to an independent reviewer. Furthermore, it is extremely difficult to find an expert author who is not working for one of the few companies active in that field.

BYTE is committed both to covering new technology in depth and to providing independent, well-informed, frank, and fair product reviews. Although we will seek technical expertise in academe, industry, and private life, BYTE is and will remain a magazine for personal computer users. The sophisticated user is both our most common reader and our best writer. We believe that users should shape the future of personal computing, and we invite you once again to do so through the pages of this magazine.

—Phil Lemmons, Managing Editor
The Chameleon by Seequa does everything an IBM PC does. For about $2000 less than an IBM.

The Chameleon lets you run popular IBM software like Lotus® 1-2-3™ and Wordstar.® It has a full 83 key keyboard just like an IBM. Disk drives like an IBM. And a bright 80 x 25 character screen just like an IBM.

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So if you've been interested in an IBM personal computer, now you know where you can get one for $1995. Wherever they sell Chameleons.

The Chameleon by

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Memory: 128K to 1MB depending on model. All models are expandable.
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Keyboard: Detachable with 105 total keys. Also an optional portable version straps onto the front screen area for easy transportability.
Disk Operating Software: "CP/M" for 8 bit.
**MS DOS for 16 bit, LAN DOS for multi-user 8 or 16 bit operation.
Networking: Up to 255 HeadStart VPU's may be connected via coaxial interface into one of 2 optional data storage systems.
Optional Data Storage Systems: 2 models available. A 10MB, 5½" system is expandable to 20MB. A 50MB, 8½" system (25MB fixed, 25MB removable) is expandable to 200MB.

Intertec's HeadStart is the smallest, smartest, fastest, most powerful business computer money can buy. And the most expandable (it's networkable up to 255 user stations.)

Great Ideas Come In Small Packages.

Instead of three bulky components, HeadStart needs only two—the keyboard and CRT. There's no need for a cumbersome disk and processor cabinet. With HeadStart, it's all in the CRT enclosure.

HeadStart's small but powerful 3½" disk drive offers as much storage as larger 5½" disks. Its 8 and 16 bit processors make software availability no problem.

And HeadStart's small size permits easy transportability with no sacrifice in performance. Each Video Processing Unit (VPU) comes with its own easy-carrying handle. A portable keyboard option is also available.

How Fast Is Fast?
HeadStart's RAM Disk, an electronic emulation of the typical second internal drive, responds up to fifty times faster than conventional microcomputers.

Depress a key and you get a response within a split second. Literally before your finger leaves the key.

And HeadStart is incredibly powerful, too. Up to one megabyte of internal memory can tackle even the most sophisticated applications.

Some Ideas Are Bigger Than Others.

Because HeadStart is designed to be both a single and multi-user computer, you buy only as much computer as you need today. But as your business grows, it grows with you.

Each HeadStart Video Processing Unit comes with its own memory, processors, disk and multi-user interfaces.

Just add a 10 or 50 megabyte Data Storage System and up to 255 users can share a common data base in an incredibly powerful, multi-user network.

HeadStart is available in three different models. All offer full performance, transportability, and are easily expandable.

Unlike conventional, single-user-only computers, HeadStart is here today with the designed-in technology to be here tomorrow.

So get a HeadStart on the other guys. For more information, call (803) 798-9100 or write: Intertec, 2300 Broad River Road, Columbia, SC 29210.
Staff-written highlights of late developments in the microcomputer industry.

**SINCLAIR ANNOUNCES 68008-BASED BUSINESS COMPUTER**
Sinclair Research Ltd. introduced in England a low-priced computer using a 68008 processor. The 68008 is an 8-bit data bus version of Motorola's 16-bit 68000. The QL (for "quantum leap") computer will include 128K bytes of RAM, two 100K-byte tape drives, two local-area network ports, two RS-232C serial ports, SuperBASIC, and a multitasking concurrent operating system. It will sell for £399 (about $570) through mail order in England.

Bundled with the machine will be QL Abacus, a spreadsheet package; Archive, a database manager; Easel, graphics software; and Quill, a word processor. While the company may add a hard-disk interface, it has no plans for a floppy-disk drive. Sinclair hopes to bring the QL to the U.S. late this year.

**LOTUS ANNOUNCES NEW INTEGRATED SOFTWARE PACKAGE**
Lotus Development Corp. has introduced an integrated software package including word processing, database management, telecommunications, spreadsheet, and graphics capabilities. Lotus says the spreadsheet portion is compatible with 1-2-3 and has enhanced graphics and macro capabilities. The program lets you display multiple windows simultaneously, even into a single document. Lotus says the new product will be available in the summer.

**SEIKO OFFERS WRISTWATCH-DISPLAY COMPUTER**
Seiko Electronics and Instruments Co. of Tokyo has developed a microcomputer that uses a 4-line by 10-character LCD display on a wristwatch. In addition to normal watch and alarm functions, the $85 watch includes 2K bytes of CMOS RAM and 6K bytes of ROM and has four cursor and function keys. A separate 62-key keyboard, which will cost about $26, uses wireless electromagnetic induction to transmit information to the watch.

A $127 Z80-based controller can be used with the keyboard and watch to program in BASIC, to interface with a printer, and to use ROM cartridges that Seiko plans to offer. The controller's Microsoft BASIC is not compatible with MSX or any other version of BASIC. With an optional interface adapter, not yet released, the computer can use an RS-232C interface for communications. Seiko began selling the UC-2000 series products in Japan last month and may offer them in the U.S. later this year.

**KOALA PAD MAKER ADDS LIGHT PEN TO LINE**
Koala Technologies Corp. announced at the Winter Consumer Electronics Show (CES) that it will manufacture and distribute the Gibson Light Pen for Apple, IBM, and Commodore microcomputers. The $300 pen can be used to draw high-resolution color animation, shapes, and graphs directly on a CRT screen using the Pentrack Language System and Penpainter software, which are included.

**RADIO SHACK MODEL 100 GETS DISK DRIVE, MONITOR**
Radio Shack has introduced a disk drive and video interface for its Model 100 notebook-size computer. The DiskNideo Interface includes one 184K-byte 5¼-inch floppy-disk drive, with room for an optional second drive, as well as an interface for a standard video monitor or television set. Model 100 disks will not be compatible with other disk formats. The video interface displays 25 lines by 80 characters on a monitor (25 by 40 on a television display) and supports the full Model 100 character set, but it cannot use Model 100 dot graphics. The DiskNideo Interface will sell for $799; an optional second disk drive is $239.95.

**COLECO'S ADAM TO GET DISK DRIVE, MODEM, AND OTHER ADD-ONS**
Coleco Industries Inc. announced a variety of add-on products for its Adam computer system at CES. The products, which should all be available by late summer, include a 300/1200-bps modem for less than $250, a second digital data-pack (cassette) drive for under $200, a 64K memory expander for under $200, and a tractor-feed option for the Adam's printer for about $125.

Coleco also announced a 5¼-inch double-sided, double-density disk drive with a 360K-byte capacity for less than $400. Included with the disk drive—or available separately on a digital data pack—will be Digital Research's Personal CP/M operating system, making Coleco the first U.S. manufacturer to use this home computer version of CP/M.
A TOUCHSCREEN AND NEW COMPUTERS FROM COMMODORE
Commodore Business Machines Inc. showed a touch-sensitive screen and supporting software at CES, similar to the Hewlett-Packard Model 150’s touchscreen. The screen should be available in late spring at a “not very high” price.

Commodore also showed its new 264 series of computers. Features include 64K bytes of RAM, windowing, 128 colors, two tone generators, and a machine-language monitor. The 264 will be available in several versions, each with different ROM-based applications software. Available software includes 264 Magic Desk, a combination calculation and filing program using icons for mode selection; 264 Word Processor; and 264 3-Plus-1, an integrated package including a spreadsheet, word processor, file manager, and graphics. Prices for the 264, which will be available in early summer, were not announced.

NEW ADD-ONS FOR APPLE II AND MACINTOSH
Apple Computer Corp. is shipping its new ProDOS operating system with all Apple II disk-drive packages; it is available separately for $40. Apple also unveiled a $700 protocol card to allow Apple II computers to emulate IBM 3270 and 2780 terminals. A $300 terminal-emulation package is also required.

Apple is selling modems that connect to the RS-232C serial port of any Apple product except the original Apple II: a 300-bps modem is $225; a 1200-bps version is $495.

A number of third-party vendors unveiled products for Apple’s new Macintosh computer. Most are translations of software available for the Apple II or IBM PC, including IBM terminal emulation, accounting, game, and business-productivity software. Included are Microsoft’s Multiplan, Word, Chart, and File programs, and Lotus Development Corporation’s popular 1-2-3 spreadsheet program. As for hardware products, Tecmar Inc. has announced a 5-megabyte removable cartridge hard-disk drive, and Devong Systems Inc. has introduced a line of 5- to 32-megabyte hard-disk systems for the Macintosh.

UNIX PRODUCTS ANNOUNCED AT UNIFORUM SHOW
The peak of February’s Uniforum show in Washington, D.C. was an agreement between AT&T and Digital Research Inc. to publish a library of applications software for UNIX System V in an effort to make that version of UNIX a standard. Software approved by DRI and AT&T will be sold by both companies. According to AT&T, over 90 companies have published over 300 programs for UNIX so far.

AT&T also announced enhancements to UNIX System V and demonstrated its Documentors Workbench and a version of BASIC for software developers to run under UNIX.

Whitesmiths Ltd. showed a $550 version of IDRIS, its UNIX-like operating system, for the IBM Personal Computer.

NANOBYTES
Despite strong efforts by a number of microcomputer-based chess programs, this year’s World Computer Chess Championship was led by mainframe-based programs. In winning the title, Cray Blitz, a program running on a Cray supercomputer, defeated AT&T Bell Labs’ Belle, which is classified as a “master” chess player, and Northwestern University’s Nuchess.

Harris Semiconductor is sampling the 80C88, a CMOS version of Intel’s 8088 microprocessor to be available late this year. Harris already is producing the 80C86. CMOS microprocessors use far less power than NMOS versions, allowing use in portable computers and industrial and military applications.

Sony Corp. is reportedly developing a version of its double-sided 3½-inch disk drive that can store 5 megabytes of information.

Hitachi has reportedly developed a one-megabit memory chip.

Select Software has introduced Select Bilingual, a $395 word processor able to give prompts and display text in both Spanish and English.

Microsoft and National Semiconductor announced that Microsoft’s XENIX, an implementation of UNIX, will be available for National Semiconductor’s 16032 processor.

Commodore, Coleco, and Epson have signed agreements with CompuServe, which will provide special information services for owners of those computers.

Epson America Inc. will sell a $795 MS-DOS expansion card for its Z80-based QX-10 computer, with 256K bytes of RAM and an 8088 processor.

Creative Software has announced three integrated software packages for the Commodore 64 and the IBM PC and PCjr. Priced at $49.95 each are: Joe’s Writer, a word processor; Fred’s Filer, an index card file; and Jack’s Calc, a spreadsheet package.

IBM is now selling PC/IX, a $900 version of UNIX System III, through its National Accounts and National Marketing divisions.
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PerComNet IBM® interface cards are available now to provide true networking capabilities for IBM and most IBM compatible personal computers. This includes the sharing of peripheral devices such as printers, modems, floppy disk drives, and all PERCOM DATA High Performance PHD™ Hard Disk Drives.

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You’re buying a computer to solve problems. Why not have more problem-solving programs to choose from?

Specially designed shock isolation system protects the fixed disk from jolts.

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Life can be tough on the road. A true portable has got to be tougher. The COMPAQ PLUS is.
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Tallgrass Technologies Corporation
Letters

Common Concern

I share the doubts and concerns of your correspondents (Letters, page 12, November 1983) about your use of articles describing new products contributed by employees of the manufacturer involved. I was particularly disappointed by the June 1983 issue on 16-bit designs, which seemed largely composed of such material. However, there are deeper and more disturbing aspects involved than your correspondents have noted.

In this country, Hewlett-Packard has been promoting its 68000-based model 9816 computer with mail shots and advertisements in trade publications using the slogan "a lion packaged as a housecat," attributing the phrase to BYTE. These words begin and conclude the description of the 9816 authored by an HP employee ("Tight Squeeze: The HP Series 200 Model 16," June 1983, page 110).

I telephoned the HP representative in charge of the sales campaign and told him of my misgivings about the use of wording that gave the impression that an independent BYTE review had drawn this favorable conclusion. His answers were surprising.

He told me that the article was too professionally written to have been the work of an HP engineer, so that a staff writer must have ghost-written it, and it was thereby a BYTE article regardless of the attribution to HP; that BYTE would not have published it if they had disbelieved it; and that BYTE had been contacted by HP and had given consent for the promotion in question. Nevertheless, he apologized if HP had unintentionally appeared to mislead.

I would like to see your version of this story in print. If HP, one of the most reputable firms in the business, can manipulate BYTE in this way, then you owe it to your readers to prevent less scrupulous operators from doing the same.

You might argue that the independent review of the 9816 ("A Look at the HP Series 200 Model 16" by Berry Kercheval, November 1983, page 328) should tend to verify or counterbalance the manufacturer-submitted descriptions. I use the HP machines professionally, and I can only remark how disappointing this review is.

HP BASIC is one of the best BASICS around and is unusual in having separate subroutines and functions. How can a serious review illustrate this language with a three-page listing of a game program, written as one large routine? Should not potential purchasers be warned of a significant shortcoming in the system, that the file-handling software can be very slow unless used with care and understanding? Why are independently compiled modules that borrow much syntax, power, and elegance from Modula-2 and are the core concept of the Pascal implementation, mentioned in just a few lines, whereas several paragraphs are devoted to explaining that you can't play a tune on the bleeper?

Perhaps publishing the maker's description is not such a bad idea after all.

David Colver
29 Chepstow Place
London, England W2 4TT

Mr. Colver's letter is representative of several BYTE has received in the past few months. This month's editorial (see page 4) addresses in detail the issues raised by these letters.

As to the specifics of Mr. Colver's letter, no BYTE editor had any role in the authorship of the June article on the HP 200-16. John Monahan of Hewlett-Packard wrote the article, as indicated when the article was published. The purpose of the theme articles in the "16-Bit Designs" issue was to show the views and intentions of people who are designing today's personal computers, in the hope of starting more direct communication between computer designers and computer users. None of the articles on 16-bit designs was a review or was labeled as a review. (This is not to disclaim BYTE's responsibility; see the editorial for more on this.)

Permission for HP's use of the quotation from Mr. Monahan's article was granted by telephone. BYTE is now developing new procedures to prevent the misleading use of quotations.

Praise for Objectivity

I bought my first computer in November 1982 and am still pleased with it. I am a writer, not a computer expert. I read everything I can find on computers. My friends, with whom I compare notes frequently, own IBM PC, PC-compatible, Kaypro, Apple, and Zenith computers. We do not put each other down, and we are not fooled by magazine authors who haughtily demean products they consider to be inferior.

Almost every article we read in computer publications is biased. The author has a prejudice from his or her long experience in computers and selects facts to prove the prejudice. I don't believe that the proponents of Apple, IBM, Kaypro, etc., intentionally misuse their vast knowledge to confuse us. I think, however, that they are lazy about objectivity almost all of them.

BYTE is far and away the best of the computer magazines I have read, and I now subscribe to 10. After today, I will subscribe to only three, BYTE included.

On such subjects as what computer companies are going to do, magazines should stick with excellent interviews with corporate executives who know what they're talking about, such as your interview with Philip D. Estridge of IBM (November 1983, page 88).

Magazines enjoy predicting that many of the hundreds of computer companies are going to go out of business. How many magazines are going to fold as a result of sloppy editing, shallow reporting, and childish biases?

Maintain your dignity. Continue to avoid the prejudicial comparisons that make other magazines look foolish. We all know that all of our computers have good points and weak points. We didn't buy mainframes.

Robert R. Jann
3320 Selwyn Ave.
Charlotte, NC 28209

Software Design Resources

Martin Dean laments the dearth of articles on "how to design software" ("Simplify, Simplify, Simplify," December 1983, page 161). I'd like to point out some papers that may be helpful:

- A case study of how a design evolved iteratively in response to user feedback is described in "A Communications Package for the IBM PC" by R. Moore and M. Geary (November
1983 BYTE, page 199).

- The design principles for an office-
system user interface are described in
“Designing the Star User Interface”
by D. Smith et al. (April 1982 BYTE,
page 242).

- A pattern-directed approach to data-
base query language similar to Dean's
is described in the paper “Query by
Example” by M. Zloof (Proceedings of
the National Computer Conference, 1975,
page 431).

- A general scheme of “filtering
templates,” with the specific example
of an information retrieval program
called Findit, is described in the
paper “A Metaphor for User Interface
Design” by A. Goldberg and D. Rob-
sen (Proceedings of the 12th Hawaii
International Conference on Systems
Sciences, 1979, page 148).

I agree with Dean that finding useful
descriptions of the design process is hard
(even harder than finding papers on good
designs themselves), but I don't think this
is due to a “plot.” Many commercial soft-
ware developers carefully guard their
designs, but there is still a tremendous
amount of published literature from
academia, research labs, and “enlight-
ened” commercial developers. Thorough
research of this literature pays off: one
ends up either with a body of existing
ideas on which to build, or with knowl-
dge of the existence of an area in which
few have thought (or written).

Paul McJones
Tandem Computers Inc.
2116 Kramer Ln.
Austin, TX 78758

A Scalpel Icon?

I must commend Tom Houston for his
article entitled “The Allegory of Software”
(December 1983, page 210). He brought
up a point that is all too frequently
glossed over by “user-friendly” software
enthusiasts. I believe the main point of his
article was that it is better to train people
to use software than to write sophisti-
cated software that condescends to the
level of a 10-year-old.

I will agree that much of the software
that has been written is not very good
from the user’s point of view. This is
usually because the input and output sec-
tions of the program were written by

people whose major skill was program-
ming and not what is now called human-

factors engineering. As a result, the pro-
gram could be cumbersome to use. The
answer to this problem, however, is pro-
grams that are efficient to use, not pro-
grams that are easy to use.

Systems based on the idea of meta-
phors run more slowly and use more
memory than systems designed by a stan-
dard approach such as menus or com-
mands. Moreover, they are only useful for
inexperienced users. A person who has
had enough experience with any partic-
ular program will be able to use it as effi-
ciently as a novice with a user-friendly
system.

No computer system can do the real
work that a professional is paid to do.
Anyone who spends a good proportion
of his life learning what to do with a com-
puter should be willing to spend about
one-thousandth of that time learning how
to use the computer itself. If a program
is well designed, learning how to use it
will pay off more in the long run than
using “metaphorical” software that is
almost a type of crutch.

One might say that the development of
user-friendly software was predicted as
early as 1950 in a science-fiction story by
Cyril Kornbluth, entitled The Little Black
Bag, in which the author described a
futuristic surgical kit with which a com-
plete idiot can practice medicine (trick:
the scalpels do all the work). I would
recommend this story to those involved
in developing easy-to-use systems be-
cause it gives a frightening glimpse at
what can happen if the development of
technology takes precedence over the
development of intelligence in people,
a.k.a. “education.”

Paul B. Callahan
701 Stuart Hall
University Park, PA 16802

IBM Drive Door Fixes

Had I authored “Buddy, Can You Spare
a Door Latch?” (by Jerry Pournelle,
December 1983, page 59) about the
eusive door latch for the Tandon drive,
the article would have been subtitled,
“Whence Cometh the Door Latch.”

My experience with the doors on the
drives in my IBM PC has been that the
plastic guide pins shift, causing malposi-
tioning and jamming of the doors.
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What we're really talking about here is useability. When you get right down to it, it's not any one big thing, but a combination of little things. Like the number of keystrokes it takes to get a job done. Or the effort it takes to switch from one function to another. Maybe a few keystrokes here and there doesn't seem like much of a difference. Or having to change disks to plot a graph. But when you multiply those little things by the thousands of times you do them, they make all the difference in the world.

Even the size of the spreadsheet is important. Some programs promise you a huge area to work with. Unfortunately, they can use so much of the computer's available memory just keeping track of all the blank cells that you're left with only a handful. But we've designed SuperCalc to give you the largest useable spreadsheet.

If you look at the printout below, you'll see a lot more examples of what we mean. And we think you'll realize why this is the most useable spreadsheet in the world.
Now we're introducing our newest version, SuperCalc3, which comes complete with the kind of graphics you'd expect to find in a program that does everything else so well. We give you full color and presentation quality. Plus eight different type styles to choose from. And new financial features like internal rate of return. We've even integrated all these functions onto one single disk. Which means you don't have to change disks all the time. Or settle for a weak spreadsheet and low-resolution graphics just for the sake of getting both in the same package.

As you might expect, we've made SuperCalc3 100% compatible with SuperCalc and SuperCalc2. So you can move up to it whenever you're ready. You can even convert your VisiCalc files. The SuperCalc family is available for CP/M, CP/M-86, Concurrent CP/M-86, MP/M, MS-DOS and PC-DOS operating systems. Right now, SuperCalc3 is available for the IBM PC, PC XT and IBM PC compatibles. It's only $395. And soon it'll be available for a lot more personal computers.

SuperCalc3. When you're really serious about spreadsheets, this is the one you'll wind up using. But don't take our word for it. Go try SuperCalc3 at your computer store today. And draw your own conclusions.

---

SuperCalc3
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My first “fix” was to reposition the pins and doors and everything worked fine until the next slippage/jam. My second fix mimicked the first with the addition of a carefully applied drop of superglue penetrating adhesive where the plastic pins are held in two slots on either side of the door.

Eventually one door itself broke, not the pins. My first try at a replacement part was successful. A visit to my local Computerland store, a short discussion with their “Mr. Fixit,” a brief rummaging through a box marked “Parts for Tandon Drives” and, voilà, a small box marked “IBM Office Products Division, 8529260, 1PCLC 283” had just the right part in it.

My total investment of time and effort was about 1.5 hours: 10 minutes for the initial phone call to determine the likelihood of success if I visited Computerland, a 1-hour round-trip drive to pick up the part, 20 minutes or so to get into the PC, remove one or two screws, and change the pesky door.

I hope that this note will help those with similar problems to (a) try doing it yourself, it’s an easy replacement job, and (b) have an easy time getting the part through (I presume) any IBM dealer or Product Center. In a call to the IBM Product Center in Stamford, Connecticut (just before mailing this note), I learned that the part is indeed available, although not in stock at the center. Delivery would be less than two weeks and the company representative with whom I spoke implied that IBM could expedite and foreshorten that delivery if the part is critical to the customer.

Donald P. Relyea
Hoffrel Instruments Inc.
POB 825
South Norwalk, CT 06854

Looking Over the Rainbow

A note on Rich Malloy’s “Reviewer’s Notebook” (December 1983, page 282). I was for a brief time a distressed owner of a DEC Rainbow 100. My impression of this machine, after about 50 hours of intensive use, was quite the opposite of Mr. Malloy’s. It struck me as the handsomest, most expensive smart terminal ever made. I ended up returning the unit for a refund after a DEC support person agreed with my criticisms:

1) The documentation is wretched, though slickly produced. In some instances, two documents contradict each other on the same point. No useful information is provided on screen formatting or using the function keys. An additional set of documents is available for about $250 extra. DEC informed me that there was no way I could get a look at these documents without purchasing them.

2) There is no high-level language support of screen formatting or function keys. By trial and error I figured out how to simulate PRINT AT and so forth. But why should I have to? Why is there no LOCATE statement in the Microsoft BASIC? I could not figure how to use the function keys at all. DEC’s advice was to buy the $250 documents and program the softkeys in machine code. Again, after spending nearly $4000 on a “system,” why should I have to code...
AGENT 2.0
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my own routines for such a rudimentary function? Obviously, DEC expects the end user only to buy packaged software.

3) DEC advertises that its dual processors can run "thousands" of extant CP/M and CP/M-86 disks. Not so. Because DEC has chosen a perverse disk format (single-sided quad-density, 98 tpi) and has shut out third-party vendors by an "authorization" program, the only software available for the Rainbow is what DEC approves and sells. This amounts to dozens, not thousands, of programs.

When BYTE does a full-bore review of the Rainbow, I hope you will address these points. I am convinced that my criticisms are valid, by my experience, by the concurrence of the DEC support person, and by the sudden plummet of DEC's stock after the Rainbow was introduced—attributed by a DEC spokesperson (in The New York Times) almost wholly to the personal computer division.

I think DEC rushed into the market with a handsome but immature product. In a year or two the Rainbow may be a good, solid, general-purpose microcomputer. At the moment it's a collage of impressive features with limited utility.

Carter Scholz
2110 Acton, #2
Berkeley, CA 94702

A review of the Rainbow is scheduled for April.

IBM Screen Displays

Many thanks to Tim Field for supplying the screen listing (the program for switching of monitors on the IBM PC). Other than some minor comment errors, the listing was bug-free and worked great the first time around ("Enhancing Screen Displays for the IBM PC," November 1983, page 99). This was my first try at assembly-language programming and I found this program useful in developing a feel for the power and flexibility this method of programming offers for functional control.

As pointed out by Mr. Field, the default values for initial conditions can be modified to suit the individual user. I find that starting with the monochrome screen rather than the color monitor, and white characters on a black background are more natural initial states. This start-up condition can be achieved by modifying three lines in the listing as follows:

<table>
<thead>
<tr>
<th>LINE</th>
<th>Original</th>
<th>Modified</th>
</tr>
</thead>
<tbody>
<tr>
<td>0112</td>
<td>CUR_MODE DW MONO_AREA</td>
<td></td>
</tr>
<tr>
<td>011A</td>
<td>COLBO_AREA S &lt;5019H,000FH,20H,3&gt;</td>
<td>&lt;5019H,000FH,10H,1&gt;</td>
</tr>
<tr>
<td>0122</td>
<td>COL40_AREA S &lt;2819H,000FH,10H,1&gt;</td>
<td></td>
</tr>
</tbody>
</table>

Line 012A remains unchanged; although the comment indicates the attribute to be reverse video, this is not the case. For reverse video the 0007h value should be 0070h.

Again, due to its ability to remain active under all operating modes, and its ease of implementation, this program is far superior to any of the other monitor-switching programs I have seen.

Sig Hansen Jr.
6530 Happy Canyon Rd.
POB 125
Santa Ynez, CA 93460

Thanks to Tim Field for his article "Enhancing Screen Displays for the IBM PC" (November 1983, page 99). One small detail should be pointed out to readers: the file, after assembling, should be converted to .COM by using the Exe2bin program. I spent a whole day trying to get it to work, and because the last paragraph of the article states that you can buy an installation program, I thought I was ripped off. Many thanks again for an "It's just what we needed" program.

Marvin Konopik
American Embassy
APO San Francisco, CA 96356

Address Correction

The International Association of Computer Crime Investigators was mentioned several times in "Computer Crime: A
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Address ____________________________ ____________________________
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Dear BYTE Readers,

I would like to comment on Mark Haas's review of the TI Professional in the December 1983 issue. On page 320, while comparing the TI and the IBM PC, he claims that the TI "also has a PSET STEP variation" which, in the context, implies that the IBM PC does not. In fact, IBM PC graphics coordinates can be used in the STEP format. There is a description of this in Chapter 3 of the IBM PC BASIC manual, beginning on page 38.

Daniel Bernstein
5 Brewster Ln.
Bellport, NY 11713

**Letters**

Growing Threat" by Collen Gillard and Jim Smith (October 1983, page 398). We are a newly formed nonprofit public-benefit corporation created to professionalize and educate the data-processing, legal, and criminal-justice communities in computer-crime investigation. Our address was incorrectly listed as Burlingame, California. Our correct address for anyone who may be interested in more information is:

International Association of Computer Crime Investigators
1100 Gough St., Ste. 8F
San Francisco, CA 94109

As we indicated in the article, we also collect data on computer crime cases. This type of information is made available to our members on a periodic basis. We are an international organization with members covering several continents.

Bruce Goldstein
1100 Gough St., Suite 8F
San Francisco, CA 94109

**Computer Crime Giving Hackers a Bad Name**

As a hacker, I feel that the term "hacker" has received a new, derogatory connotation implying illegal computer use. I have been using computers for about 10 years, and the term has always meant "one who is a computer hobbyist." I feel that those who access a computer without permission using false passwords should be accused of forgery!

Granted, it's sometimes easy to hit (access) a system, but saying "There's no security; it's so easy" does not erase the fact that access was granted under false pretense. It's also easy to write someone else's signature on checks or documents, but that doesn't make it right. Because computers cannot read a person's signature, the password became the computer equivalent of a signature. Those who use a false or forged password should be treated as forgers.

The recent article "Computer Crime: A Growing Threat" (October 1983, page 398) that referenced this problem was far from complete and a little misleading. The Los Alamos computer that was accessed was specially designed for easy public access.

(See *Electronics*, September 8, 1983, page 52.) And the last half of the article reads like an ad for the Secure Access Unit (SAU) hardware. The author failed to acknowledge that the same protection can be obtained with a simple software addition. In fact, all the SAU is is a computer and autodial modem. Why use two computers when you already have one that will easily handle the job?

As a hacker, I feel that the articles about computer theft are giving us a bad name. How about some positive articles on remote bulletin boards, remote systems, and public-domain software?

Mike Woodward
606 Kinglet St.
Suisun, CA 94585

**Kudos to Steve**

Again, Steve Ciarcia has another excellent construction article, "Build the H-COM Handicapped Communicator," (November 1983, page 36). Although I have no use for the communicator described, the article provided a wealth of information on single-chip microcomputer solutions to seemingly complex problems. I look forward to more projects like this, especially the well-documented, fun-to-read assembly-language listing. Keep up the good work.

Chris Brown
FEI/AMSFEUR
APO New York, NY 09086

**A Clarification**

I would like to comment on Mark Haas's review of the TI Professional in the December 1983 issue. On page 320, while comparing the TI and the IBM PC, he claims that the TI "also has a PSET STEP variation" which, in the context, implies that the IBM PC does not. In fact, IBM PC graphics coordinates can be used in the STEP format. There is a description of this in Chapter 3 of the IBM PC BASIC manual, beginning on page 38.

Daniel Bernstein
5 Brewster Ln.
Bellport, NY 11713
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It begins with the sense of touch.
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*DMX80 correspondence quality printer suggested retail price $395.
**Suggested retail price.
Build a Third-Generation Phonetic Speech Synthesizer

by Steve Ciarcia

The idea for this month's project may seem familiar to many of you, and with good reason: I've done projects on building speech synthesizers five times before. Why? The integrated-circuit technology for doing it keeps getting better and better, and I like nothing more than experimenting with new chips.

The Shadow of the Past

The most successful of the past speech-synthesis projects were the Sweet Talker, presented in September 1981 (see reference 3), and the Microvox, presented in August and September 1982 (see reference 4). Many of you have built and used these as peripheral devices on your personal computers.

The original Sweet Talker was a simple, parallel-port-driven phoneme-based synthesizer. To make it talk, you just sent 6-bit phoneme codes to it. It's still useful; I've used it for broadcasting weather reports, among other things (see reference 1).

The Microvox was an enhancement of the same basic design. Both these devices were built around the Votrax SC-01A chip, a member of the second generation of commercial speech-synthesis products. (The first generation consisted of hybrid modules containing many discrete components.)

Latest Technology

I suppose I would continue to tinker with improving the sound quality from this foundation if I had not been beaten to the punch by the appearance of an enhanced speech-synthesis chip. This month we'll look at the latest development in phonetic speech synthesis: the SSI263 integrated circuit from Silicon Systems Inc.

Speech-synthesis chips of the new third generation, such as the SSI263, produce much more intelligible
The latest development in phonetic speech synthesis is the Silicon Systems SSI263 chip

speech than did older devices, such as the SC-01A. The new chips achieve this through more flexible intonation, inflection, and filtration. With the SSI263, it is possible to vary these three effects on the fly as well as load new speech phonemes dynamically. When synthesizing in this way from sufficiently detailed data (at about 400 bits per second), the SSI263 generates the most human-sounding synthesized voice I've heard to date. (Systems that reproduce a digitized human voice can still sound better, however.) In its minimal operating mode, which requires data at about 50 to 70 bits per second, the quality of sound is comparable to that produced by the Votrax SC-01A.

Sweet Talker II

Seeing that the SSI263 could be easily interfaced to many different microprocessor-based systems, I decided to use an Apple II Plus as its host because the Apple's allocation of a separate address space for each expansion slot would eliminate address decoding on the speech card. The board, which contains only two chips, can be adapted for use with many other computers if you don't mind a little extra wiring. Out of sentiment for my earlier project, I decided to call the new package the "Sweet Talker II." It's shown in photo 1.

Programming the Sweet Talker II can be simple, if you'll settle for a monotonic, uninflected voice, or complicated, if you need the highest quality speech. Unlike its predecessor, the SC-01A, which used only a 6-bit phoneme input, the SSI263 contains five registers (totaling 40 bits) that influence the emitted sound. With the constant updating of all the registers (at a higher data rate and controlled by a more complex program), the SSI263 can even sing with vibrato.

Because the SSI263 is just out on the market, very little has been published on it. After a review of the basic techniques of computer speech, we'll go through some specific information about the device. Following that, we'll look at the simplicity of interfacing the SSI263 to a personal computer and discuss the software needed to support it.

Review of Computer Speech

There are three major techniques presently employed to allow computers to speak: formant synthesis, linear-predictive coding (LPC), and waveform digitization. The most noticeable difference between these three methods is the amount of data required to construct a word.

In formant synthesis, an electronic model of the human vocal tract is constructed. Driven with signals from frequency and noise generators, the model mimics the natural resonances of the vocal tract. The output spectrum contains bands of resonant frequencies called formants.

The most common variant of the formant technique is called phoneme synthesis, in which the spectral parameters are derived from basic word sounds—the phonemes. In such a circuit, each phoneme is assigned a digital code; the synthesizer circuit utters phoneme sounds corresponding to the codes it receives. Therefore, speech is produced simply by stringing the phoneme codes together.

The original electronic voices of this type were intelligible but had a slightly mechanical quality. The latest phoneme synthesizers, on the other hand, combine control of pitch, rate, amplitude, and filtration to achieve quite lifelike speech. Continuous speech using phoneme synthesis can generally be obtained with data at a rate of less than 100 bps (bits per second), using no extra control attributes. Even with all the embellishments, it never requires a data rate of more than 400 bps.

Linear-predictive coding (LPC) is similar to formant synthesis in that both techniques are based on the frequencies found in speech and use similar hardware to model the vocal tract. Instead of encoding phonemes, however, LPC uses stored filter coefficients, amplifier-gain settings, and excitation frequencies; the name of the method is derived from the programmed activities of the multistage lattice filters that produce the desired formants. Continuous speech can generally be achieved with data rates of 1200 to 2400 bps. LPC has been used in products from Texas Instruments (the Speak & Spell and the now-discontinued TI 99/4 Text-to-Speech Translator) and General Instrument (the VSM2032 Voice Synthesis Module).

The third technique of computerized speech is waveform digitization, which reproduces a voice waveform from its stored amplitude characteristics. The simplest form is uncompressed digital recording by pulse-code modulation (PCM). A more complex method involving data compression is called adaptive differential pulse-code modulation (ADPCM).

In digital recording by PCM, the analog waveform from a real human voice is sampled at a frequency twice that of the highest frequency to be preserved from the voice; the samples are sent through an analog-to-digital (A/D) converter and stored. The digital signal is played back through a digital-to-analog (D/A) converter and a low-pass filter. Since it's essentially a recorded voice, the reproduced speech retains the original inflections and accents. Unfortunately, waveform digitization requires very high data rates, so the vocabulary is usually limited by the amount of data that can be stored.

For more detail on speech digitization, you can refer to some of my previous articles in BYTE. In June 1978 I published a simple project for digitizing and reproducing speech from uncompressed data; you might call it "brute-force digitization" (see reference 5). The second project,
Support for the SS1263

As with many Circuit Cellar projects, the Sweet Talker II is available with the text-to-speech software from a source listed at the end of the article. In true Circuit Cellar tradition, however, many of you will hard-wire the unit as I've detailed. Unfortunately, since the program is owned by Silicon Systems Inc., royalties are involved and it cannot be published. In an effort to reward rather than diminish your hardwork, I will pay the royalty and provide the Apple II software to anyone sending me a photograph of his or her custom-assembled Sweet Talker II. This offer extends to noncommercial applications and individual experimenters until June 1, 1984.

In the long term, the SS1263 will be supported by Sweet Micro Systems, the company that makes the Mockingboard music-synthesis system for the Apple II. Sweet Micro Systems' latest version of the Mockingboard can use two optional SS1263s to provide synthesized voices that can sing along in stereo with the synthesized two-channel music; the chips are plugged right into sockets on the circuit board. Photo 3 on page 30 shows the new Mockingboard, containing one SS1263, plugged into an Apple II Plus.

I've made sure that the Sweet Talker II will be software-compatible with the voice software intended for the Mockingboard, and it should be compatible with other SS1263-based products for the Apple II as well.

published in June 1981, was for reproducing digitized speech from compressed data (reference 2), and the third article, appearing in June 1983, was a project that used ADPCM (see reference 6.)

SS1263 Integrated Circuit

The Silicon Systems SS1263 is a self-contained phoneme-based speech synthesizer. It consists of a single 24-pin CMOS (complementary metal-oxide semiconductor) integrated circuit that runs from a 5-V (volt) power source. It provides an analog output for music, sound effects, and continuous speech of unlimited vocabulary at low data rates. The SS1263 is easy to interface with any microprocessor; its principal characteristics are listed in table 1. Figure 1 contains a pinout diagram; a description of each pins function is shown in table 2. The SS1263 can use a 3.59-MHz color-burst crystal divided by 2 or 4 as a timebase, or it can run off an external 1- or 2-MHz clock signal.

The SS1263 contains five 8-bit internal registers, which allow 256 phoneme-equivalents; 4096 pitch variations; and control of amplitude, rate of articulation, and vocal-tract filter frequency response (useful for sound effects). The individual registers are described in the text box on page 38.

A Simple Circuit

Connecting the SS1263 to any microcomputer system is not hard, but with the Apple II family of computers (II, II Plus, and Ile) the connection is simplicity itself (due largely to the address decoding provided on the Apple's motherboard). As you can see in figure 2 on page 32, the entire Sweet Talker II circuitry consists of only two integrated circuits and a few passive components.

In figure 2, IC1 is the SS1263, which can be directly connected to the Apple's data and address buses, operating on interrupts generated on the IRQ (normal interrupt request) line. The chip is selected when the A6 address line and the R/W and I/O-select status lines are active. Address lines A0, A1, and A2 select the proper register for data to be entered through the eight data-bus lines D0 through D7. The three low-order address lines are individually asserted to trigger one of three mutually exclusive register-select inputs on the voice-synthesis chip: R50, R51, or R52.

When plugged into expansion slot 4 of any Apple II-series computer, the registers are addressed at hexadecimal C400 through C404 (decimal addresses 50240 through 50244).

The remaining components on the speech-synthesizer board constitute the amplifier and filter sections.
Capacitors C4 and C5 and resistors R2 and R3 form a simple low-pass filter. The audio signal is then amplified by an LM386 1-watt operational amplifier (IC2) to directly drive an 8-ohm speaker. Potentiometer R4 controls the volume on the external speaker (connected to the header provided). In addition to the +5 V supply needed by the SSI263, the board requires a +12 V supply to power the op amp.

Speaking in Phonemes

All the words in the English language can be written using only 26 alphabetic characters, but the language contains far more than 26 sounds—most letters of the alphabet (or combinations) can represent more than one sound. As a practical matter, English can be considered to contain 50 or so distinct sounds, called phonemes. These are listed in table 3 on page 33.

It's not as hard to use the phoneme list as it first appears. For example, the phonemes in the word “disk” are written as follows:

```
DISK
```

Simple enough. From the table, the corresponding digital codes (in hexadecimal) are

```
25 07 30 29
```

These are the values fed into the speech synthesizer.

Few words are quite that easy, though. For instance, the five distinct phonemes in “hello” are

```
HF EH L O W
```

These are translated into the hexadecimal codes

```
2C OA 20 11 23
```

It isn’t necessary for you to become a linguist to use a phonetic speech synthesizer because many lists of words and their phoneme equivalents are available (see reference 3).

Programming for Phoneme Synthesis

The speech-synthesizer board speaks a word when it receives, in sequence, the codes for the constituent phonemes. The programming for this can be simple: POKE statements in BASIC suffice. If the synthesizer were plugged into slot 4 of an Apple II, the program of listing 1 would cause it to say “hello” in a monotonic voice. Observe that the program loads the stop phoneme (hexadecimal 0) after the end of the word; this makes the synthesizer stop sounding the last phoneme.

You’ll also note that the first six executable statements in listing 1 load constant values into the registers in the speech-synthesis chip; the five attribute registers in the SSI263 must be properly initialized; once they have been, a program using this method can cause the chip to emit the sounds of essentially any word or series of words. But an interpreted BASIC program is not fast enough to operate in an interrupt mode or dynamically change the attribute registers with each phoneme.

So a program in BASIC can only scratch the surface of the SSI263’s features.
Figure 2: Schematic diagram of the Sweet Talker II circuitry.

Listing 1: This BASIC program causes the Sweet Talker II to pronounce the word “hello” by sending it the minimal set of phoneme codes.

```
10 REM SET UP SSI263 FOR TRANSITIONED INFLECTION
20 POKE 50243,255 :REM CONTROL BIT EQUALS 1
30 POKE 50240,192 :REM SET PHONEME DURATION
40 POKE 50243,116 :REM CONTROL BIT EQUALS 0 AND SET AMPLITUDE
50 POKE 50244,231 :REM SET FILTER FREQUENCY TO NORMAL
60 POKE 50242,168 :REM SET SPEECH RATE TO NORMAL
70 POKE 50241,127 :REM SET INFLECTION LEVEL
100 HOME
110 PRINT "HELLO"
120 DATA 44,18,32,17,35,0 :REM PHONEMES FOR WORD HELLO
130 FOR X=1 TO 6
140 READ A
150 POKE 50240,A :REM LOAD PHONEME INTO INPUT REGISTER
160 FOR T=0 TO 50 :NEXT T :REM DELAY TIL NEXT PHONEME TIME
170 NEXT X
180 END
```

capabilities. To really appreciate what it can do, you have to exercise the chip with an assembly-language program that adds inflection and intonation. The program in listing 2 on pages 34 and 35 also causes the system to say “hello” but with superior results. For speech applications requiring the most reliable intelligibility, an assembly-language word-list-to-phoneme output program is required.

But many applications require an essentially unlimited vocabulary, for instance, if you wanted your computer to read aloud the stories on the Associated Press newswire. (By the way, that’s an acid test for intelligibility of synthesized speech.) In such cases, you’ll need a program that can perform its own translation from normal spelling to phoneme codes using a text-to-speech algorithm.

Text-to-Speech Algorithm

A text-to-speech algorithm is a program that takes words spelled out in letters encoded in ASCII (American National Standard Code for Information Interchange) and analyzes them. It determines which characters are silent and which should produce sounds, and what kind of sounds, by following a set of general pronunciation rules. Most research in such synthesis by rule has been on English, but text-to-speech algorithms have been written for other languages as well.

The amount of program code
needed to implement a text-to-speech algorithm varies, with longer programs usually performing better. Typical microprocessor routines are in the 4K- to 8K-byte range, but some of the more sophisticated programs take up to 80K bytes. The main difference between the most common algorithms is the number of pronunciation exceptions and the length of word tables. An 80K-byte routine, for example, is often 90 percent look-up tables of words that are pronounced in unpredictable ways.

The Sweet Talker II speech synthesizer outlined in this article can be made to speak by direct input of individually selected phonemes, as demonstrated above, or through use of a text-to-speech algorithm. While two of my previous Circuit Cellar speech-synthesis projects, the Sweet Talker I and the Microvox, had some form of text-to-speech capability, they were built around the Votrax SC-01A; the software is not compatible with the SSI263 in the Sweet Talker II.

At first, I thought I would have to

---

**Table 3: Elementary speech sounds, or phonemes, that occur in English and a few other languages. Consonants are shown in a; vowels are listed in b. The four code columns for each phoneme represent spoken sounds of different length. You can choose the length that provides the best intelligibility or most pleasing sound. From left to right, the lengths decrease by about 25 percent in each column from the previous one. The code in column 1 can usually be used as the default value.**

<table>
<thead>
<tr>
<th>Phoneme</th>
<th>Code 1</th>
<th>Code 2</th>
<th>Code 3</th>
<th>Code 4</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>24</td>
<td>64</td>
<td>A4</td>
<td>E4</td>
<td>bat, tab</td>
</tr>
<tr>
<td>D</td>
<td>25</td>
<td>65</td>
<td>A5</td>
<td>E5</td>
<td>dub, bud</td>
</tr>
<tr>
<td>F</td>
<td>34</td>
<td>74</td>
<td>B4</td>
<td>F4</td>
<td>fat, ruff, photo, laugh</td>
</tr>
<tr>
<td>HV</td>
<td>2A</td>
<td>6A</td>
<td>A6</td>
<td>E6</td>
<td>eh</td>
</tr>
<tr>
<td>HVC</td>
<td>2B</td>
<td>6B</td>
<td>A6</td>
<td>E6</td>
<td>(post-B aspiration as in &quot;tab&quot;)</td>
</tr>
<tr>
<td>HF</td>
<td>2C</td>
<td>6C</td>
<td>AC</td>
<td>EC</td>
<td>hat, home</td>
</tr>
<tr>
<td>HFC</td>
<td>2D</td>
<td>6D</td>
<td>AD</td>
<td>ED</td>
<td>(post-P aspiration as in &quot;pad&quot;)</td>
</tr>
<tr>
<td>HN</td>
<td>2E</td>
<td>6E</td>
<td>AE</td>
<td>EE</td>
<td>ba-ba black sheep (voiceless glottal stop)</td>
</tr>
<tr>
<td>J</td>
<td>31</td>
<td>71</td>
<td>B1</td>
<td>F1</td>
<td>job, rage</td>
</tr>
<tr>
<td>K</td>
<td>26</td>
<td>66</td>
<td>A6</td>
<td>E6</td>
<td>big, gag</td>
</tr>
<tr>
<td>KV</td>
<td>26</td>
<td>66</td>
<td>A6</td>
<td>E6</td>
<td>lab, ball</td>
</tr>
<tr>
<td>L</td>
<td>20</td>
<td>60</td>
<td>A6</td>
<td>E6</td>
<td>hat, home</td>
</tr>
<tr>
<td>L1</td>
<td>21</td>
<td>61</td>
<td>A1</td>
<td>E1</td>
<td>plan, club, slam</td>
</tr>
<tr>
<td>LB</td>
<td>3F</td>
<td>7F</td>
<td>BF</td>
<td>FF</td>
<td>il (French)</td>
</tr>
<tr>
<td>LF</td>
<td>22</td>
<td>62</td>
<td>A2</td>
<td>E2</td>
<td>bottle</td>
</tr>
<tr>
<td>M</td>
<td>37</td>
<td>77</td>
<td>B7</td>
<td>F7</td>
<td>mad, dam</td>
</tr>
<tr>
<td>N</td>
<td>38</td>
<td>78</td>
<td>B8</td>
<td>F8</td>
<td>not, ton</td>
</tr>
<tr>
<td>NG</td>
<td>39</td>
<td>79</td>
<td>B9</td>
<td>F9</td>
<td>ring, rang, drink, drank</td>
</tr>
<tr>
<td>P</td>
<td>27</td>
<td>67</td>
<td>A7</td>
<td>E7</td>
<td>pat, tap</td>
</tr>
<tr>
<td>R</td>
<td>1D</td>
<td>5D</td>
<td>9D</td>
<td>DD</td>
<td>rat</td>
</tr>
<tr>
<td>R1</td>
<td>1E</td>
<td>5E</td>
<td>9E</td>
<td>DE</td>
<td>(French)</td>
</tr>
<tr>
<td>R2</td>
<td>1F</td>
<td>5F</td>
<td>9F</td>
<td>DF</td>
<td>(German)</td>
</tr>
<tr>
<td>S</td>
<td>30</td>
<td>70</td>
<td>B0</td>
<td>F0</td>
<td>sat, lass</td>
</tr>
<tr>
<td>SCH</td>
<td>32</td>
<td>72</td>
<td>B2</td>
<td>F2</td>
<td>shop, push</td>
</tr>
<tr>
<td>T</td>
<td>28</td>
<td>68</td>
<td>A6</td>
<td>E6</td>
<td>tap, pat, baked</td>
</tr>
<tr>
<td>THV</td>
<td>35</td>
<td>75</td>
<td>B5</td>
<td>F5</td>
<td>bathe, the</td>
</tr>
<tr>
<td>TH</td>
<td>36</td>
<td>76</td>
<td>B6</td>
<td>F6</td>
<td>bath, theory</td>
</tr>
<tr>
<td>L</td>
<td>33</td>
<td>73</td>
<td>B3</td>
<td>F3</td>
<td>vow, pave</td>
</tr>
<tr>
<td>W</td>
<td>23</td>
<td>63</td>
<td>A3</td>
<td>E3</td>
<td>why, quake</td>
</tr>
<tr>
<td>Y</td>
<td>03</td>
<td>43</td>
<td>83</td>
<td>C3</td>
<td>(French)</td>
</tr>
<tr>
<td>Y</td>
<td>04</td>
<td>44</td>
<td>84</td>
<td>C4</td>
<td>you</td>
</tr>
<tr>
<td>Z</td>
<td>2F</td>
<td>64</td>
<td>A4</td>
<td>E4</td>
<td>Zap, maze</td>
</tr>
<tr>
<td>(space)</td>
<td>00</td>
<td>40</td>
<td>60</td>
<td>C0</td>
<td>(pause)</td>
</tr>
</tbody>
</table>

---

**Table 3 (b): Foreign Sounds.**

<table>
<thead>
<tr>
<th>Phoneme</th>
<th>Codes</th>
<th>Examples</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>06</td>
<td>4B</td>
<td>C6</td>
</tr>
<tr>
<td>A1</td>
<td>09</td>
<td>49</td>
<td>B9</td>
</tr>
<tr>
<td>AE</td>
<td>0C</td>
<td>4C</td>
<td>6C</td>
</tr>
<tr>
<td>AE1</td>
<td>0D</td>
<td>4D</td>
<td>6D</td>
</tr>
<tr>
<td>AH</td>
<td>0E</td>
<td>4E</td>
<td>8E</td>
</tr>
<tr>
<td>AH1</td>
<td>0F</td>
<td>4F</td>
<td>8F</td>
</tr>
<tr>
<td>AW</td>
<td>10</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>E</td>
<td>01</td>
<td>41</td>
<td>81</td>
</tr>
<tr>
<td>E1</td>
<td>02</td>
<td>42</td>
<td>82</td>
</tr>
<tr>
<td>EH</td>
<td>0A</td>
<td>4A</td>
<td>8A</td>
</tr>
<tr>
<td>EH1</td>
<td>0B</td>
<td>4B</td>
<td>8B</td>
</tr>
<tr>
<td>ER</td>
<td>1C</td>
<td>5C</td>
<td>9C</td>
</tr>
<tr>
<td>I</td>
<td>07</td>
<td>47</td>
<td>87</td>
</tr>
<tr>
<td>O</td>
<td>11</td>
<td>51</td>
<td>91</td>
</tr>
<tr>
<td>CO</td>
<td>13</td>
<td>53</td>
<td>93</td>
</tr>
<tr>
<td>OU</td>
<td>12</td>
<td>52</td>
<td>92</td>
</tr>
<tr>
<td>U</td>
<td>16</td>
<td>56</td>
<td>96</td>
</tr>
<tr>
<td>U1</td>
<td>17</td>
<td>57</td>
<td>97</td>
</tr>
<tr>
<td>UH</td>
<td>18</td>
<td>58</td>
<td>98</td>
</tr>
<tr>
<td>UH1</td>
<td>19</td>
<td>59</td>
<td>99</td>
</tr>
<tr>
<td>UH2</td>
<td>1A</td>
<td>5A</td>
<td>9A</td>
</tr>
<tr>
<td>UH3</td>
<td>1B</td>
<td>5B</td>
<td>9B</td>
</tr>
</tbody>
</table>

**Foreign Sounds**

<table>
<thead>
<tr>
<th>Phoneme</th>
<th>Codes</th>
<th>Examples</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>AY</td>
<td>05</td>
<td>45</td>
<td>95</td>
</tr>
<tr>
<td>A</td>
<td>3A</td>
<td>7A</td>
<td>BA</td>
</tr>
<tr>
<td>E2</td>
<td>3E</td>
<td>7E</td>
<td>BE</td>
</tr>
<tr>
<td>IE</td>
<td>06</td>
<td>46</td>
<td>86</td>
</tr>
<tr>
<td>IU</td>
<td>14</td>
<td>54</td>
<td>94</td>
</tr>
<tr>
<td>IU1</td>
<td>15</td>
<td>55</td>
<td>95</td>
</tr>
<tr>
<td>OH</td>
<td>3B</td>
<td>7B</td>
<td>BB</td>
</tr>
<tr>
<td>U</td>
<td>3C</td>
<td>7C</td>
<td>BC</td>
</tr>
<tr>
<td>UH</td>
<td>3D</td>
<td>7D</td>
<td>BD</td>
</tr>
</tbody>
</table>

---

*(French)*

*French, or umlauted a (ö) in German*

*German*
Listing 2: An assembly-language program for the 6502 microprocessor that causes the synthesizer to say "hello" with better inflection and intonation by sending more data than the BASIC program.

```
1  * SSI-263 COMPOSITE DATA DRIVER
2  *
3  *
4  ORG $8000
5  *
6  *
7  OUTPTR EQU $FB ; POINTER TO START OF DATA
8  ENDPTR EQU $FD ; POINTER TO END OF DATA
9  BUSY EQU $FF ; BUSY FLAG
10  IRQL EQU $03FE ; IRQ VECTOR, LOW BYTE
11  IRQH EQU $03FF ; IRQ VECTOR, HIGH BYTE
12  BASE EQU $C440 ; REGISTER 0 OF SSI-263
13  DURPHON EQU BASE
14  INFLECT EQU BASE+$01 ; REGISTER 1 OF SSI-263
15  RATEINF EQU BASE+$02 ; REGISTER 2 OF SSI-263
16  CTTRAMP EQU BASE+$03 ; REGISTER 3 OF SSI-263
17  FILFREQ EQU BASE+$04 ; REGISTER 4 OF SSI-263
18  *
19  *
20  SET-UP ROUTINE *
21  *
22  *
23  B000: 7B SEI ; DISABLE INTERRUPTS
24  B001: A9 2E LDA <$INTERR ; INT SERVICE ROUTINE, LOW ADDRESS
25  B003: BD FE 03 STA IRQL
26  B006: A9 80 LDA <$INTERR+1
27  B008: BD FF 03 STA IRQH
28  *
29  B00B: A9 80 LDA <$TABLE ; DATA TABLE, HIGH ADDRESS
30  B00D: BD FF 80 STA OUTPTR+1
31  B00F: BD FF FE STA ENDPTR+1
32  B011: A9 69 LDA <$TABLE
33  B013: BD FF 80 STA OUTPTR
34  B015: A9 9B LDA <$TABLE+$32
35  B017: BD FF 80 STA ENDPTR
36  *
37  B019: A9 FF LDA <$FF ; SET BUSY FLAG
38  B01B: BD FF 80 STA BUSY
39  B01D: A9 80 LDA <$80 ; SET SSI-263 TO
40  B01F: BD 43 C4 STA CTTRAMP ; TRANSITIONED INFLECTION MODE
41  B022: A9 C0 LDA <$C0
42  B024: BD 40 C4 STA DURPHON
43  B027: A9 70 LDA <$70
44  B029: BD 43 C4 STA CTTRAMP
45  B02C: 58 CLI ; CLEAR INTERRUPT MASK
46  B02D: 60 RTS ; RETURN TO CALLER
47  *
48  *
49  *
50  INTERRUPT SERVICE ROUTINE *
51  *
52  *
53  B02E: 8A INTERX TXA ; SAVE X REGISTER
54  B02F: 4B PHA
55  B030: 9B TYA ; SAVE Y REGISTER
56  B031: 4B PHA
57  B032: A0 00 LDY <$00 ; INIT Y REGISTER
58  B034: A2 04 LDX <$04 ; INIT X REGISTER
59  B036: A5 FB LDA OUTPTR ; CHECK FOR END OF DATA
60  B038: C5 FD CMP ENDPTR
61  B03A: D0 1B BNE CONT ; NO, SO CONTINUE
62  B03C: A5 FC LDA OUTPTR+1
```

Listing 2 continued on page 35
<table>
<thead>
<tr>
<th>Address</th>
<th>Code</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>803E:</td>
<td>C5</td>
<td>CMF-ENDPTR+1</td>
</tr>
<tr>
<td>8040:</td>
<td>D0</td>
<td>BNE CONT</td>
</tr>
<tr>
<td>8042:</td>
<td>A9</td>
<td>LDA $$00</td>
</tr>
<tr>
<td>8044:</td>
<td>BD</td>
<td>STA DURPHON</td>
</tr>
<tr>
<td>8047:</td>
<td>A9</td>
<td>LDA $$70</td>
</tr>
<tr>
<td>8049:</td>
<td>BD</td>
<td>STA CTTRAMP</td>
</tr>
<tr>
<td>804C:</td>
<td>A9</td>
<td>LDA $$00</td>
</tr>
<tr>
<td>804E:</td>
<td>85</td>
<td>STA BUSY</td>
</tr>
<tr>
<td>8050:</td>
<td>6B</td>
<td>RET PLA</td>
</tr>
<tr>
<td>8051:</td>
<td>A8</td>
<td>TAY</td>
</tr>
<tr>
<td>8052:</td>
<td>6B</td>
<td>PLA</td>
</tr>
<tr>
<td>8053:</td>
<td>AA</td>
<td>TAX</td>
</tr>
<tr>
<td>8054:</td>
<td>A5</td>
<td>LDA #$45</td>
</tr>
<tr>
<td>8056:</td>
<td>40</td>
<td>RTI</td>
</tr>
<tr>
<td>805B:</td>
<td>83</td>
<td>DO 02 BNE C0</td>
</tr>
<tr>
<td>805C:</td>
<td>E6</td>
<td>INC OUTPTR+1</td>
</tr>
<tr>
<td>805D:</td>
<td>7A</td>
<td>DEX</td>
</tr>
<tr>
<td>805E:</td>
<td>85</td>
<td>CONT1</td>
</tr>
<tr>
<td>805F:</td>
<td>64</td>
<td>INC OUTPTR</td>
</tr>
<tr>
<td>8062:</td>
<td>CA</td>
<td>DEX</td>
</tr>
<tr>
<td>8063:</td>
<td>E0</td>
<td>CFX $$FF</td>
</tr>
<tr>
<td>8065:</td>
<td>00</td>
<td>BNE CONT</td>
</tr>
<tr>
<td>8067:</td>
<td>F0</td>
<td>BEQ RET</td>
</tr>
<tr>
<td>8069:</td>
<td>E7</td>
<td>LDA (OUTPTR), Y</td>
</tr>
<tr>
<td>806C:</td>
<td>7A</td>
<td>STA BASE,X</td>
</tr>
<tr>
<td>806E:</td>
<td>80</td>
<td>INC OUTPTR+1</td>
</tr>
<tr>
<td>8071:</td>
<td>7B</td>
<td>DEX</td>
</tr>
<tr>
<td>8073:</td>
<td>74</td>
<td>CFX $$FF</td>
</tr>
<tr>
<td>8076:</td>
<td>7A</td>
<td>BNE CONT</td>
</tr>
<tr>
<td>807B:</td>
<td>E9</td>
<td>BEQ RET</td>
</tr>
<tr>
<td>807D:</td>
<td>81</td>
<td>LDA (OUTPTR), Y</td>
</tr>
<tr>
<td>807F:</td>
<td>87</td>
<td>INC OUTPTR+1</td>
</tr>
<tr>
<td>8082:</td>
<td>7A</td>
<td>DEX</td>
</tr>
<tr>
<td>8085:</td>
<td>5A</td>
<td>CFX $$FF</td>
</tr>
<tr>
<td>8087:</td>
<td>79</td>
<td>BNE CONT</td>
</tr>
<tr>
<td>808A:</td>
<td>61</td>
<td>BEQ RET</td>
</tr>
<tr>
<td>808C:</td>
<td>6D</td>
<td>LDA (OUTPTR), Y</td>
</tr>
<tr>
<td>808F:</td>
<td>80</td>
<td>INC OUTPTR+1</td>
</tr>
<tr>
<td>8091:</td>
<td>E7</td>
<td>DEX</td>
</tr>
<tr>
<td>8094:</td>
<td>58</td>
<td>CFX $$FF</td>
</tr>
<tr>
<td>8096:</td>
<td>E7</td>
<td>BNE CONT</td>
</tr>
<tr>
<td>8099:</td>
<td>50</td>
<td>BEQ RET</td>
</tr>
</tbody>
</table>

find a new text-to-speech program. Fortunately, Silicon Systems had foreseen the demand for a text-to-speech routine for the SSI263 and arranged for the necessary software to be available under license.

**Customizing Software**

The Sweet Talker II's text-to-speech routine was produced by Sweet Micro Systems of Cranston, Rhode Island. It was derived from an algorithm originally developed at the Naval Research Laboratory and uses a similar rule-definition format. But it's much more versatile, and it nicely uses the talents of the SSI263. (At this writing, the software has been implemented only for the Apple II computer family.)

One problem of text-to-speech translation is of personal interest to me. There isn't an algorithm written that can digest and properly pronounce "Ciarcia" (it should sound like "see-AH-see-uh") unless there is a specific rule for that character string that outputs a predetermined set of phonemes when the string is detected.

---

BYTE March 1984
Figure 3: Format of the rules in the text-to-speech algorithm.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>!</td>
<td>represents any nonalphanumeric character in the input string</td>
</tr>
<tr>
<td>#</td>
<td>represents one or more vowels</td>
</tr>
<tr>
<td>:</td>
<td>represents zero or more consonants</td>
</tr>
<tr>
<td>+</td>
<td>represents a front vowel (E, I, Y)</td>
</tr>
<tr>
<td>$</td>
<td>represents one consonant</td>
</tr>
<tr>
<td>(A)</td>
<td>represents a voiced consonant</td>
</tr>
<tr>
<td>(B, D, G, J, L, M, N, R, V, W, Z)</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Context symbols used in the rules of the text-to-speech algorithm.

Most text-to-speech routines don't let you modify the rule tables or expand the number of exceptions. The Sweet Micro Systems program employs a rule-based method that encompasses whole-word, morpheme, and letter rules in character-specific subtables. Furthermore, this new program also comes with a utility routine for changing, editing, or redefining those rules. The utility can even adjust the size of the main routine depending on whether rules or characters in the rules have been inserted or deleted. This flexibility in design allows you to totally redefine the rule table for foreign languages and dialects, to prepare for certain proper names, or simply to improve pronunciation of a specific frequent word.

The original Naval Research Laboratory algorithm did not include any facility for varying intonation and stress, but the software for the SSI263 uses a simple yet effective system of stress markers to allow intonation and stress to be specified. (In addition, a more extensive utility program is available that provides total control over parametric changes on an individual phoneme basis. This utility routine allows you to create high-quality words or phrases that can be easily used in any application, without the need for the text-to-speech algorithm and rule table to be resident in memory at the time of execution.)

How the Algorithm Works

Before I describe the rule-based text-to-speech algorithm, an explanation of the rule format is in order. Figure 3 shows that each rule consists of several different components. The letter or letters contained within the parenthetic delimiters are the characters to be matched in the input string. The symbols to the left of the delimiters define the left context (what comes before the characters to be matched), and the symbols to the right define the right context. The context symbols’ meanings are listed in table 4. The equals symbol ("=") denotes the end of the rule definition, and the numbers to the right are the phoneme codes in hexadecimal. Most rules have a left or right context for the matched characters, but some situations do not require either.

The routine begins by converting the entire input string to uppercase characters to maintain uniformity in conversion. During this period, all characters in the input string are categorized and marked according to the symbol groupings described in table 4, and corresponding rule symbols are stored for later use. Also, stress markers are found and marked for use in the determination of intonation and stress characteristics.

The first input character is then compared to the first applicable rule in the subtable for that character. Since all rules in a single subtable begin with the same character, the algorithm attempts to match the left context first, then if the match succeeds, it attempts to match the second and following characters, if any, remaining in the parenthetic string. If that match succeeds, the algorithm attempts to match the right context. Should any match attempt fail, the algorithm proceeds to the next rule in the subtable and attempts to match that rule.

The last rule in every rule subtable for a given letter contains a parenthetic string of just that letter with no left or right context, thus guaranteeing a match for any letter in the input string. Once a match has been achieved, the algorithm then places the phoneme codes designated in the rule (to the right of the equals sign) into a phoneme buffer.

The rule table also allows the definition of punctuation marks and numbers. This allows a description of those characters to be pronounced. Some rules, for silent letters, are defined with no phoneme codes. The algorithm simply places nothing in the phoneme buffer and proceeds to the next character in the input string.

When the routine attempts a match on either the left or right context, it may encounter special symbols in the rule, those shown in table 4. These symbols cause the algorithm to compare each context symbol in the rule to the categorical symbols assigned earlier to the characters in the input string. Again, should the algorithm encounter a failure in a match attempt, it will proceed to the next rule.

When the phoneme conversion is complete, the routine collects values for intonation and stress characteristics in other buffers. The parameters involved are those for pitch inflection, output amplitude, speech rate, filter frequency, rate of inflection transition (slope), and rate of articulation transition (slope). These last two parameters are not stored in separate buffers but as one nybble of parameters in the speech-rate and amplitude parameter buffers, respectively. A detailed explanation of these parameters appears in table 5.
Interpreting the Rules

Let's look at a few sample cases of the phoneme rules. For instance:

\[(A)! = 0804\]

This rule states that a letter A preceded and followed by a nonalphanumeric character (the "!" context) is to be pronounced by the phonemes A and Y1.

The above points indicate that on both sides of the A are one or more nonalphabetic characters, which can be a space, punctuation mark, number, or any symbol other than an alphabetic letter. For example, the A in the string "1A" would be pronounced according to the above rule since it meets the conditions indicated. The strings " A", "A%", and "$A?" would all match the above pattern.

When putting another rule into a subtable, you must carefully consider the exact position of that rule because the algorithm takes the rules in sequence. If the conditional parameters of two rules were similar, it would be possible for sequential preference to cause the wrong rule to be selected for a given input string.

For example, it is possible that "YOUR" would be pronounced like "you-are" if the rule for "YOU" preceded a specific rule for "YOUR", because the rule for "YOU" would be accepted before the rule for "YOUR" was even considered, so the rule for "YOUR" never would be evaluated. (After accepting "YOU", the algorithm would next search the "R" subtable for a rule to satisfy "R" in the last position.)

To avoid such errors, clearly the rule for "YOUR" must precede the rule for "YOU"; "YOU" would not be mispronounced by the first rule since the trailing "R" would cause a no-match situation. The algorithm would continue to search the subtable until it reached the rule for "YOU".

The example given above for the letter A is tightly defined, and the pronunciation appears to be an exception to a rule that is more generally applicable, which comes next in the table:

\[(A)! = 0804\]

\[2(A)! = 1A\]

The second rule states that "A" in the input string followed by a nonalphabetic character is to be pronounced as the phoneme UH (hexadecimal 1A represents UH). The second rule does not specify anything in particular to the left of "A". Therefore, as long as "A" is merely followed by a nonalphabetic character, this pronunciation will be used. Note that if the rules were reversed, the rule \[(A)!\] would never be reached because the \[(A)!\] rule would match its patterns. Although rule 1 above is rather narrow in scope, the class of nonalphabetic characters comprises a number of different symbols, and even more specific rules might sometimes be needed. For example, if you found that the pronunciation for the input string "A?" was too short, a rule could be created to deal with this, as follows:

\[(A)! = 080404\]

The algorithm would proceed to the next rule.

In addition to adding new rules, you may delete any rule within the range of the subtable, with the exception of the last rule. (Each subtable must have at least one rule, even if its input character is to produce no sound.) All rules following the deleted rule will move up one position, reducing the rule count and number of bytes accordingly.

The text-to-speech software provides a convenient test mode as part of the rule editor to let you evaluate any changes made to the rule tables.

The Rule Editor

The rule-table editor provided with the text-to-speech algorithm allows complete control over the rules that govern the conversion of input text into phonemes.

The rule table contains all alphabetic characters, all numbers, all punctuation marks, and all printable special-purpose symbols. (Control characters are not included.) Although the number of rules in a table is unlimited (insofar as the disk storage and memory capacity will allow), extremely large tables will cause the conversion process and the output of speech to slow down.

When the rule editor is in use, the
The test mode allows you to enter any word or phrase up to 239 characters long, including punctuation marks. The algorithm then converts the input phrase into phoneme codes, based on the rules currently in the rule table, and instructs the Sweet Talker II to speak the codes. Commands available in the test mode.

The rule editor provides a set of editing functions (6a) and a test mode with several commands (6b) consisting of control characters.

### Table 6

<table>
<thead>
<tr>
<th>Key</th>
<th>Function</th>
<th>Key</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>delete an entry</td>
<td>S</td>
<td>select new subtable</td>
</tr>
<tr>
<td>E</td>
<td>edit an entry</td>
<td>T</td>
<td>test mode</td>
</tr>
<tr>
<td>H</td>
<td>help menu</td>
<td>U</td>
<td>update main rule table</td>
</tr>
<tr>
<td>I</td>
<td>insert a new rule</td>
<td>Control-P</td>
<td>print current subtable</td>
</tr>
<tr>
<td>Q</td>
<td>quit or exit program</td>
<td>Control-S</td>
<td>save rule table to disk</td>
</tr>
</tbody>
</table>

The algorithm then converts the input phrase into phoneme codes, based on the rules currently in the rule table, and instructs the Sweet Talker II to speak the codes.

### SSI263 Registers

The rules discussed below are listed with their bits in order of decreasing significance.

#### Duration/Phoneme Register 0

<table>
<thead>
<tr>
<th>DR1</th>
<th>DR0</th>
<th>P5</th>
<th>P4</th>
<th>P3</th>
<th>P2</th>
<th>P1</th>
<th>P0</th>
</tr>
</thead>
<tbody>
<tr>
<td>D5</td>
<td>D4</td>
<td>D3</td>
<td>D2</td>
<td>D1</td>
<td>D0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The duration/phoneme register, D/P, is an 8-bit register where the 8 low-order bits (D5 through D0) designate one of 64 phonemes (P5 through P0). Table 3 on page 33 lists the 64 phonemes produced by the SSI263. The 8 high-order bits of the D/P register (DR1 and DR0) control the duration (timing) of the phoneme called out by the 6 low-order bits (P5 through P0).

#### Inflection Pitch Register 1

<table>
<thead>
<tr>
<th>I0</th>
<th>I9</th>
<th>I8</th>
<th>I7</th>
<th>I6</th>
<th>I5</th>
<th>I4</th>
<th>I3</th>
</tr>
</thead>
<tbody>
<tr>
<td>D7</td>
<td>D6</td>
<td>D5</td>
<td>D4</td>
<td>D3</td>
<td>D2</td>
<td>D1</td>
<td>D0</td>
</tr>
</tbody>
</table>

The inflection register is an 8-bit register (D7 through D0) where all 8 bits (I0 through I3) set or determine the rate of movement of inflection pitch. There are two modes of implementing inflection: transitioned inflection and immediate or instantaneous inflection. Immediate inflection causes the current output to instantly take on the value corresponding to the 8-bit code in the inflection register and the 4-bit code in the R/I register. The total of 12 bits in these two inflection registers gives a range of seven octaves on an even-tempered scale. The immediate mode is useful for singing, musical sound effects, and for fine-tuning a duplication of human inflection.

#### Rate/Inflection Register 2

<table>
<thead>
<tr>
<th>R3</th>
<th>R2</th>
<th>R1</th>
<th>R0</th>
<th>I1</th>
<th>I2</th>
<th>I1</th>
</tr>
</thead>
<tbody>
<tr>
<td>D7</td>
<td>D6</td>
<td>D5</td>
<td>D4</td>
<td>D3</td>
<td>D2</td>
<td>D1</td>
</tr>
</tbody>
</table>

The rate/inflection register, R/I, is an 8-bit register where the 4 high-order bits (D7 through D4) designate one of 16 (R3 through R0) overall settings of speech sound-effects rates and A/R timing response. The 4 low-order bits (D3 through D0) of the R/I register (I11, I2, I1, and I0) are 4 bits of inflection that are always in the immediate mode. In combination with the 8 bits of inflection from the I inflection register, I2, I1, and I0 are the 3 low-order bits of the 12-bit counter-inflection chain, and I11 is the MSB (most significant bit).

#### Control/Articulation/Amplitude Register 3

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<tr>
<th>CTL</th>
<th>TR2</th>
<th>TR1</th>
<th>TR0</th>
<th>A3</th>
<th>A2</th>
<th>A1</th>
<th>A0</th>
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<tbody>
<tr>
<td>D7</td>
<td>D6</td>
<td>D5</td>
<td>D4</td>
<td>D3</td>
<td>D2</td>
<td>D1</td>
<td>D0</td>
</tr>
</tbody>
</table>

This 8-bit register, C/A/A, has three control characters as shown in Table 6. To make the rule-table changes permanent, the rule table must be saved to disk after an editing session.

#### Intonation

Perhaps the best way to see how the text-to-speech routine deals with indications of varying intonation and stress is to provide examples of usage. When entering text to be spoken, you can indicate what words or syllables are to differ in stress by setting them off with slash marks ("/").

For example, the string of characters

HELLO

would be pronounced with monotone inflection. But the string

/HE/LL/O

would produce stress on the first syllable, while the string

HELLO

functions. The 4 low-order bits (D3 through D0) designate one of 16 (A3 through A0) amplitude levels of the analog audio output (AO, pin 1). The MSB (D7) of this register (C/A/A) is the control (CTL) bit. When this bit is found to be high, the SSI263 is powered down. The remaining 3 bits (D6, D5, and D4) of the C/A/A register (TR2, TR1, and TR0) determine the rate of movement of the formant position for articulation.

#### Filter-Frequency Register 4

<table>
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<tr>
<th>FF7</th>
<th>FF6</th>
<th>FF5</th>
<th>FF4</th>
<th>FF3</th>
<th>FF2</th>
<th>FF1</th>
<th>FF0</th>
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<tbody>
<tr>
<td>D7</td>
<td>D6</td>
<td>D5</td>
<td>D4</td>
<td>D3</td>
<td>D2</td>
<td>D1</td>
<td>D0</td>
</tr>
</tbody>
</table>

The filter-frequency register is an 8-bit register (D7 through D0) in which all 8 bits (FF7 through FF0) instantaneously set or shift the frequency of all the vocal-tract filters (formants), which can produce an effect similar to slowing down or speeding up a record player, but with a greater range and without affecting inflection (pitch) or other SSI263 timing. With a setting other than the normal one for speech, the filter-frequency register can raise or lower the vocal-tract filter frequencies to create sound effects.
would put stress on the final "O". The program is smart enough to consider punctuation in setting inflection. The text string

HELLO?

would be pronounced with a rise in pitch at the end, and the string

HELLO.

would be sounded with a drop in pitch at the end.

The algorithm looks for pairs of stress markers; it can ordinarily be overridden only by proper terminating punctuation, such as a period or question mark. The type of terminator determines the slope of pitch inflection at the end of a phrase or sentence. Multiple pairs of stress markers can be used to set the starting level of inflection and to specially emphasize any subsequent stressed portions of the remaining phrase or sentence.

Figure 4 depicts the inflection pattern for a single pair of stress markers. The inflection level begins at the default of level 2; it continues at this level until the program encounters the first stress marker, where it raises the pitch to level 3. The inflection level remains at level 3 until the program finds the second marker. After the second marker is found, the program looks for the terminator at the end of the clause. The inflection level will be raised or lowered at the end depending on the type of terminator. If no terminator exists, then the algorithm assumes that it should glide the pitch down (as in a declarative statement), but the glide will begin at a later point than otherwise. The maximum value of the up or down glide is predetermined; if the limit is reached prior to the end of the phrase or sentence, it will continue at that level.

Let's take a look at some real examples:

/HOW/ ARE YOU?

"HOW" is stressed; its pitch glides up to the fourth level until the limit is reached or the terminator is encountered.

HOW ARE /YOU?

A simple system of stress markers allows specification of intonation and stress.

The word "YOU" is stressed in this case; the pitch then continues to glide up until the end of the sentence. Since the algorithm finds the interrogative terminator before anything else happens, the glide also stops at that point. In this case, the sound produced for the word "YOU" is very short. It is so short that the algorithm may not have time to react to the stress marker and initiate a glide before it encounters the terminator. The result may be an abrupt rise in pitch. Greater and more significant differences may be seen in the following example:

DID YOU /SEE/ THAT?

The effect of the stress markers and question mark works extremely well in this particular case.

The question-mark terminator has two possible effects on a sentence. In general, the question mark causes the pitch inflection to glide up at the end of a sentence, with one exception. The algorithm looks for questions whose first word begins with
"WH". In such cases, the glide at the end of the sentence should be down. For example:

WHAT /WAS/ THAT?

When the algorithm encounters multiple pairs of stress markers, the inflection follows the pattern in figure 5. In figure 5, we can see the inflection pattern beginning at level 3 and continuing until the text-to-speech routine finds the first stress marker. The level then goes to level 4 until the routine finds the second marker. At that point, the inflection level drops to 2, where it stays until the third marker is reached. The inflection level then goes up to level 3 again and remains until another marker or the terminator comes along.

As a general rule, the first syllable in a clause is stressed to a greater degree than subsequent syllables. This inflection pattern does not take effect if a compound sentence contains multiple pairs of stress markers or clauses separated by commas. Commas are also considered terminators, so the clause preceding the comma will be treated separately.

The other speech parameters besides pitch are also altered, in a rather consistent and straightforward manner, when a syllable is being stressed. Their changes are shown in figure 6.

In Conclusion

I haven't mentioned many uses for speech synthesis, but I'm sure you have a few ideas for what you could do with a speech synthesizer. I hope you now appreciate the amount of vocal power currently available at a relatively low price. The SSI263's highly intelligible speech promises new applications for computers, and the Sweet Talker II will likely enjoy a lot of indirect software support because of its compatibility with other SSI263-based speech synthesizers.

The invention of SSI263 does not mean the demise of other approaches to computer speech. But it introduces low-cost speech output into fields that could never previously have justified the expense.
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New Machines, Networks, and Sundry Software

Chaos Manor is inundated with new computers

by Jerry Pournelle

We've got three new machines—four if you count the IBM PC, which arrived only a month ago. Alas, the work load at Chaos Manor has come in a flood that threatens to drown us, and we haven't yet been able to get a new editorial assistant on board, so there's not been as much hacking about with the machines as I'd like.

Meanwhile, things are happening in micro land. The winds of change are blowing again, and it's a bit hard to look far ahead. Even so, we can spot some trends.

First, though, the Corvus.

Corvus

The Corvus Concept is a fairly revolutionary piece of equipment. Corvus calls it a "workstation," which is to say that not only is it a full computer based on the Motorola 68000 chip, but the company has also paid a lot of attention to making it communicate with other equipment.

The Concept is an 8-MHz machine with 512K bytes of memory, a 720 by 560 bit-mapped display, a well laid out Keytronics keyboard that looks an awful lot like an IBM Selectric, a hard disk, and a bunch of communications ports. The screen is unusual: it's taller than it is wide, or it can be laid on its side so that it's wider than tall. The monitor is a big Ball Brothers that feels like it weighs a ton; you want hefty furniture, and don't expect to carry a Concept around very much.

I'm very fond of the detached keyboard, and I like the character set used on the screen. Being bit-mapped, it can show boldface and italics. The machine comes with a text editor called "Edword." The name is a horrid pun, but the editor itself is quite nice, sort of a well-tamed EMACS with lots of dedicated keys. The editor continuously updates the disk file every 30 seconds or so. That takes less than a second to write to the hard disk; it's not particularly distracting. This means that power failures, or playful kittens, can't lose you more than a few seconds' worth of work. Edword (ye gods I hate that name!) keeps a complete disk file of everything you've done, so that there's a full Undo function; enough presses of Undo will get you right back to a blank screen.

The operating system and disk formats are Corvus's own, of course, and are going to require more study. So far, I've used UCSD p-System and CP/M-68K on the Sage and CP/M-68K on the Compupro 68000. I think I prefer Corvus's own operating system to the other two, but that view is based on far too little experience to put any confidence in.

One feature I like in the Corvus is a Suspend key; pressing it will let you do other tasks, such as communications through the modem, after which you can resume editing or whatever.

We're always concerned about hard-disk systems. Some, like the Kaypro 10, must be shut down in a particular sequence that retracts the disk head to what's called a "landing position." There wasn't any obvious shutdown procedure for the Corvus, so Alex called David Ramsey of Corvus to ask how to turn the machine off.

"Set all switches to the 'off' position," was the reply.

While we were on the phone the wind came up, and we had two short power failures, with power restoration too quick to allow us to turn off the machine, so that the Corvus disk powered down and back up unattended. The Corvus never lost a single byte of data and is unharmed. By contrast, there seems to be a newly developed bad area on the Kaypro 10's hard disk; we don't know if this is related to the spate of storms and power failures we've had this month, but it might be.

There's a lot to like about the Corvus, and you'll certainly be hearing more about it in future columns.
I confess that until I began playing with its new machinery, I wasn't much impressed with the company; but the Concept has completely changed my view.

Alex has done more with the Corvus than I have. His notes open with, "I think the Concept is great!" He's also anxious to see Corvus’s Unix for the 68000 Concept, which it claims will be available Real Soon Now. At COMDEX, Corvus showed off its new "gateway" to the IBM SNA (System Network Architecture); that plugs into the Corvus Unix engine, which is a 68000 box something like the Concept but not quite. The company will also be adding an interface to Ethernet.

Networking

Computer networks are the coming thing. Individual micros are powerful enough to do most of the work needed by small businesses, but not all of it. In particular, micros can’t store and easily retrieve huge gobs of data, and of course they’re limited in the number of data sources that can be active.

The obvious solution is to connect a bunch of micros together. Networking has long been done with big mainframe machines and minicomputers; it’s harder to accomplish for micros than it sounds. Of course, one might use the same kind of network interface for micros that is used on minicomputers. One of the most popular is Ethernet, developed by Xerox. The problem is that an interface board to couple any machine to Ethernet will cost about $1000, which is trivial compared to the cost of a big mini but is no small sum for micro users.

One of the Concept’s strongest features is communications. The machine comes with an Omninet interface; we also have Omninet interface boards for the IBM PC, the Apple, and our S-100 system. Omninet uses a twisted pair of wires and will run up to 2000 feet between workstations. Alex is even now stringing wires through the house. With luck, we’ll soon have all the major machines in Chaos Manor connected to the Corvus hard disk.

Corvus believes in Omninet. Its new headquarters in Silicon Gulch is wired for communications: coaxial cable between buildings, Omninet inside each. Corvus will use its “SNA gateway” box as an interface between other kinds of computer networks. The “gateway” looks a lot like the bottom part of a Concept. It has big slots for an Ethernet board and small slots for Apple boards. For that matter, the Concept has four Apple-type slots in back. We’re told that most Apple boards, including 5¼- and 8-inch disk controllers, will run in those.

If you listened in the right places at COMDEX, you could hear rumors of an IBM multiuser machine that would be the big brother of the IBM PC. If that’s truly in the works—and it makes sense—then a network officially supported by IBM wouldn’t be far behind.

With luck, we’ll soon have all the major machines in Chaos Manor connected to the Corvus hard disk.

An IBM “big micro” would surely be built around a larger chip than the 8088 used in the PC and PCjr. Since IBM owns some 15% percent of Intel, it’s likely to be one of the new Intel family, possibly the iAPX286, or even the 486, unless the production problems Intel has had lately persist longer than I think they will. Whatever IBM uses, I suspect the “Super PC” will connect downhill to the PC and uphill to IBM mainframes.

What net might IBM use? It has several choices.

(1) It can go with the fast but relatively expensive Ethernet. If Big Blue does that, Ethernet will be “legitimized,” with some drop in prices as a result of increased volume of sales. The most popular IBM PC Ethernet interface is based on one very complicated chip, so hardware prices have the potential to drop.

On the other hand, the low-cost net designers won’t give up. Omninet will get a fair amount of business, because Omninet can hook into Apple and other machines incompatible with Ethernet. Besides, if Ethernet can be put on one (expensive) chip, the less expensive nets can be put on a single (cheaper) chip as well. There’ll also be a scramble to build gateways to the IBM network.

(2) It can go with an existing low-cost net system like Omninet, Arcnet, or some other RS-232C-type network. This doesn’t seem likely: IBM would be just another competitor in an already crowded market.

(3) It can go with its own expensive network. This is certainly consistent with IBM’s past actions. It wouldn’t be a popular choice among users, but that hasn’t concerned IBM in the past.

(4) It can devise its own cheap networking system. This is a nontrivial R&D task even for IBM; but it would certainly have a major effect on the market, causing a big shakeout and cleanup. Alex doesn’t think this alternative is likely, and I’m inclined to agree.

Networking Really Is Important

Why worry about networks? Businesses and hackers alike will want them. There’s so much appeal for business in a network that links incompatible machinery—such as Apple, IBM, Kaypro, Eagle, Corvus, etc.—that “independent” networks will flourish no matter what IBM does. For example: once we have Omninet set up, I’ll be able to transfer files among the Apple, Corvus, Compu­pro, Z-100, and IBM PC machines, neatly solving a number of the disk-format problems that have plagued us for months.

Networks will be forced upon the bigger companies just to increase productivity. Some businesses may resist, but that will stop the day the managers of Company A find that all of Company B’s employees know of A’s newest developments before all of A’s people know.

In fact, there’s going to be a thriving business in building gateways between various popular networks, and outfits like Corvus are getting a head start. A black box that interconverts all networking protocols will be mandatory when a business wants to con-
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nect several “unfriendly” networks.

Some years ago, Digital Research sold something called “CP/Net” that allowed CP/M machines to talk to each other. We had a copy here at Chaos Manor, but we never had it running. CP/Net languished within Digital Research, getting little support or sales, and in early 1983 Digital Research quietly removed it from the market, neatly stranding several outfits who'd signed up for the 16-bit version. In theory, Digital Research will support CP/Net, although the company no longer sells it. In practice, that support is minimal.

At this fall's COMDEX, DR announced "Soft/Net," its new network. Unlike hardware manufacturers who sponsor networks built around one particular kind of network hardware, DR plans to support all the major networks, including Omninet, Arcnet, and Ethernet. (In fact, DR had TI Professionals, IBM PCs, and Computrons talking to each other in its booth at COMDEX.) This is a clever move, since there's no clear-cut network leader. If IBM announces a micro network, DR can quickly add it to its stable—always assuming that Digital Research doesn't already know what Big Blue plans. There's some evidence that it does, as we'll see later.

Soft/Net is supposed to connect to both 8-bit and 16-bit micros running CP/M, CP/M+, CP/M-86, and Concurrent CP/M. The network is supposed to look just like any other disk or printer to the computer; current software should run without changes. In theory, that will end disk-format incompatibilities: put your files on the central disk drive and use PIP to move them to another machine. Soft/Net should also be a big boon to bulletin-board operators.

DR promises all the usual trimmings to go with Soft/Net: file sharing, password protection, record locking, and file locking. (File locking means that no one else can write to a particular file while you're using it; record locking protects only specified records within a file.) If DR can make this work, it will be tremendously popular and successful. I believe that Concurrent CP/M will replace PC-DOS in the IBM PC world; add Soft/Net, and DR will have given the micro world a new de facto standard. The computer world desperately needs a software network that works with all the other popular networks; we wish Digital Research well in this effort.

Operating Systems, Past and Future

When microcomputers first came out, there were oodles of different operating systems, and the only way our computers could talk to each other was by (ugh!l paper tape. Then came the CP/M revolution, and suddenly hackers with machines made by different companies could communicate simply by swapping disks. CP/M quickly became the de facto standard.

For a while, few doubted that CP/M with upgrades to 16-bit systems would continue to be the standard; then came IBM. For some reason, Digital Research didn't sign up IBM, and Microsoft's PC-DOS became the standard for IBM PCs. CP/M-86 was available, but few bought it.

The original PC-DOS had remarkable similarities to CP/M 1.4. However, the commands for PC-DOS were quite different from CP/M's, in some cases being precisely backward. PC-DOS also suffered from CP/M 1.4's major limitations, and many programmers muttered that it wasn't a truly an operating system: it was merely a job-control language. It was obvious to most that vanilla PC-DOS wasn't long for this world. Changes would be made.

The inevitable was delayed a bit by embellishments to PC-DOS: incidentally, that made PC-DOS less and less like MS-DOS, increasing the babel in 16-bit land. Even so, PC-DOS has too many limits. Something's going to give.

There are several possibilities.

Unix

Unix, for the tiny few who don't know, is a multiuser, multitasking operating system developed at Bell Laboratories. Multitasking means that one user can do several jobs at the same time, with some interconnection between the jobs; multiuser allows more than one person to use the computer, not all that useful for a micro: better, I'd think, to have "one user, one computer." Multitasking, though, is very useful.

It seems that Unix System 5 is going to be very different from Xenix. As a result, Microsoft will not be writing a version of System 5 for Intel for the iAPX286. Instead, Intel has contracted for a version of System 5 from Digital Research. Xenix's position in the marketplace may now be somewhat less secure than it once seemed.

Unix probably would have become commercially popular, but Bell had some legal problems involving anticongestion, so the price tag was kept very high—except for nonprofit users. These latter could buy Unix for trivial bucks, and did, so that a number of computer science students learned to use Unix, and many came to love it.

We've heard rumors of Unix for micros since the late 70s. The rumormongers are usually very positive. "I can't wait;" and "Wow, will you love Unix!" are typical. A few detractors mutter that users had better be prepared to know more than they want to about their computers; Unix lets you do a lot more than CP/M does, but before you can do anything you must learn more about Unix than you'll ever need to know about CP/M.

I won't get into that debate here. For one or another reason, a series of "almost Unix" systems were developed, the best known of which was Xenix.

Meanwhile, a few outfits, such as Charles River Data, have a real live Unix clone (called Unos) on their MC68000 systems. After the first of the year, when, for reasons never clear to me, we're going to dismantle the world's best-run telephone company (have you ever tried to make a phone call in Paris?), Unix will, we are told, be a lot cheaper for ordinary businesses; some predict a rush to Unix. Others are more skeptical.

At the moment, there's no clear "standard" operating system for MC68000 microcomputers. Unix may take over that spot.
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One prediction I can make with confidence: you won’t see “vanilla Unix” anywhere a business user can get at it. Straight from the box, Unix is user-threatening. Unix is very adaptable, though, and can be surrounded with a very friendly command structure “shell.”

**Concurrent CP/M 3.1**

A major contender for supremacy in the PC-compatible world is Digital Research’s Concurrent CP/M-86, which I’ll call CCPM.

CCPM has a lot going for it. For one thing, it’s file compatible with CP/M 2.2, meaning that it’s possible, if nontrivial, to transfer files written on 8-bit machines up to your PC-compatible 16-bit equipment. This is important for companies planning an upgrade from 8-bit equipment.

Second, CCPM is multitasking. That is, you can be working with your text editor, go do some calculations, drop that to start printing a file, let that be printing and start a long compilation, and leave the compiler going while you return to your text editor as if you’d never left it. This is such a nifty feature that anyone who uses it will never understand how he got along without it.

Even so, CCPM hasn’t quite caught on, largely because so much PC-DOS software is out there, and there were a few difficulties with early versions of CCPM.

Have no fear. Concurrent CP/M-86 3.1 is here.

The new CCPM is not only multitasking, it is also multiuser, which means it looks an awful lot like Unix. Indeed, you can recompile most CCPM programs and they’ll run under the Unix operating systems that are being developed in various skunk works in Silicon Valley.

More important, CCPM 3.1 emulates PC-DOS: that is, along with CCPM you can get an enhancement that will let you, as one (or more) of the multiple tasks CCPM is capable of, run PC-DOS programs right out of the box. Now there are limits, of course: programs that are hardware specific to the IBM PC aren’t going to run on anything but a PC. However, all the PC-compatible software will
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run with any machine with CCPM. In particular, we’re getting it going on our Compupro Dual Processor, as well as on the Compupro 8086/8087 and the Eagle 1600. Also, Compupro is developing a PC-compatible video board for the S-100 bus; this will let us use even more PC-DOS software without modification. (That board should be available sometime in the spring of 1984.)

CCPM 3.1 will also support the Digital Research GSX graphics package, Soft/Net network communications, the 8087 math chip, and a print spooler. Test versions are being delivered to beta test sites as I write this. CCPM 3.1 is not yet released, and is an OEM product, but it should be released not long after you read this. I expect to like it a lot.

Windows, Too

One of the big themes of this fall’s COMDEX was “windows.” Window is a generic term for displaying more than one job (task) on a computer screen at once. Until recently, windows were available only on very expensive computers like the Xerox Star; then the Apple Lisa showed up. Since then, many companies have raced to put windows on the IBM PC.

There’s a difference between windows and concurrency. The original Concurrent CP/M will run more than one task at a time, but you can watch only one at a time. This is like a television: you have a number of channels, but you can watch only one at a time. You have to constantly switch channels to see when the commercial is over.

With computers, windows let you watch more than one program, or channel if you will. Each window sits on its own portion of the screen; you can move freely between them (usually with a mouse). If, say, you are processing words and get a sudden urge to draw a graph, you can see both with windows.

You can also have windows without concurrency: that is, windows can be a screen feature to let you watch different displays, but they’re all generated by the same program. Some of the most widely advertised “window” systems are that kind.

The newest version of Concurrent CP/M has both: you can start a long assembly, and while that’s running, open a new window to start an entirely different program, while leaving a window open on the assembly. You could then open another window and use it to watch a program running under PC-DOS. CCPM 3.1 supports up to four concurrent tasks, and you can watch them all in operation on the same screen.

Deep Silence

Many of us have known for almost a year about Concurrent CP/M’s ability to run PC-DOS programs. Why, then, has it taken Digital Research so long to announce it? I don’t know, but I have a guess. Digital made a serious mistake when IBM brought out the PC. There are a number of rumors about why the PC didn’t come out with CP/M-86. No matter which is true, it was a very serious situation for Digital Research. It had been the de facto standard, and suddenly it was only a far-

Text continued on page 58
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Concurrent CP/M is a genuine advance over both CP/M+ and PC-DOS. When users try it, they don't want to go back to the older systems. Digital got its concurrent system in operation well before anyone else, and I've seen nothing that can touch it.

One suspects that IBM recognizes just how valuable Concurrent is; certainly, there are many signs of impending IBM support for Concurrent. However, Concurrent 3.1 isn't out of testing yet. It takes a lot of memory, pushing the limits that the PCjr can support. There's still time for IBM to make some sales. It's a pure guess on my part, but I think IBM will announce support of Concurrent, but not for a while, and that DR isn't talking about Concurrent CP/M's PC compatibility because IBM doesn't want DR to do that yet. DR isn't about to give IBM any more trouble. If it cooperates with Big Blue, it will be the standard again. If it doesn't, it will have problems.
### Rogue

Rogue is an Adventure-like computer game for the IBM PC. Unlike the original Adventure, the Rogue dungeons are randomly generated each time you play, so that no two games are ever alike.

It isn't played entirely like Adventure, either. For one thing, you move your character around on the screen with the cursor arrows (or with a mouse; the Logimouse works fine). Commands are menu driven; there are an awful lot of them, things like “q” for quaff a magic potion you may have found, “w” for wield a particular weapon, and such. You can read scrolls, put on rings of power, change weapons, change armor, and like that.

I hate to confess it, but the game is a real time trap. I found myself thinking “just one more try” far too often. The object of the game is to retrieve the Amulet of Yendor, but I haven't the faintest clue how one does that; I was killed every time, although once I got down to the fifteenth level and accumulated nearly 4000 gold pieces before a combination of trolls and quaggas got me.

Rogue is advertised as the most popular game running on Unix, and Alex says that's probably true. The

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**IBM**

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Artificial Intelligence Design Systems company has put it onto the IBM PC (requires 128K bytes of memory and a disk drive). It’s also added a command called “S,” for “Supervisor”; when you press that, the dungeon map vanishes, and a dummy of the PC-DOS operating system appears on the screen. This is intended to fool your boss into thinking you’re working.

At one time, there were simultaneous Rogue games going on every PC-compatible machine in this house. It certainly was the game of the month. Recommended, but I won’t be responsible if you get fired for wasting too much time with it.

Copy Protection

Longtime readers of this column will know that I don’t much approve of copy-protection schemes. They’re all right for games, but businesses must have backups of important software. The argument for copy protection usually goes: “We have a $700 product here that can be copied in half a minute for five bucks. Of course we protect it!” Which is all very well—until you ask the justification for charging $700 for something that can be produced for less than five bucks. The answer to that one often goes, “We put all that effort into software development, and when we sell it, people make illegal copies. We have to get a lot from each sale.”

Fortunately, competition plus the expanding market base will drive the price of software down to something reasonable, say a small multiple of the price of a good book. Meanwhile, copy protection continues. It’s an evil practice. It’s also futile. Let me give an example.

A number of programs designed to defeat copy protection are available. About the best I know of for the IBM PC is System Backup from Norell Data Systems. System Backup was written by a good friend who thoroughly understands the IBM PC; the program is revised as new and more clever protection schemes are devised.

I had a new version of System Backup at hand when Rogue arrived. I don’t usually run master disks, so we routinely tried to make a copy. Wouldn’t work. Rogue is copy protected. It’s a game, so that’s not so important; but I wanted to test the new System Backup, and Rogue was right there, so why not?

System Backup made a copy, but it reported a CRC error. We tested the copy on the IBM PC, and it seemed to work properly. Then we tried it on the Eagle Spirit. It worked there, but it wouldn’t save the game. That was interesting enough that we tried the original disk on the Spirit; it worked fine, and indeed the copy can read a saved game; it just won’t save one. On the IBM, though, the copy saves and reads and runs fine.

I gathered all the data and called System Backup’s author. We agreed this was an interesting case. What, for instance, was the CRC error?

The problem, you see, is that copy protection involves putting carefully engineered errors into the system. A copy-protected disk has garbled sectors, improperly formatted sectors, and such like; it also has a means for reprogramming the disk controller to allow it to find all, and only, the good sectors on the disk.

It’s therefore impossible to tell whether an error on a copy-protected disk is a real error, caused by stray magnetic fields or spilled coffee, or a contrived error that’s part of the copy-protection scheme.

Another problem: have the copy protectors thought everything through? They’ve reprogrammed your disk controller; do they undo that when you exit the program? If not, you’ll have to reset the machine, or perhaps even turn it off and back on again.

Every time a publisher devises a new copy-protection scheme, a systems engineer will find a way to defeat it. That’s inevitable: if the software can be made to load into the machine, then it can be copied. There is a class of systems engineer who enjoys defeating copy-protection schemes, much as Yardley enjoyed breaking codes. Any copy-protection scheme, no matter how elaborate, will be defeated—unless, in the effort...
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<tr>
<td>Graphplan</td>
<td>WordStar</td>
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<tr>
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The satisfying silence of the slim, Epson-designed disk-drives is one way for you to judge or, for an inside-out perspective, here is an excerpt from a review by Jim Hanson in the April, 1983 issue of Microcomputing.

"The Epson QX-10 is soundly designed and executed. I looked hard and found no evidence of kludging or shorting out anything in the name of economy. All the connectors have gold on them and are of quality manufacture. The printed circuit boards are heavy, with soldermarks on both sides of double-sided boards. The circuit boards are completely silk-screened with component labels, and the layout is as professional and clean as you will find anywhere."

Isn't this what you expect? After all, it's an Epson.

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BYTE March 1984 65
to make the software uncopyable, it’s made so fragile that it’s no longer reliable. That, alas, is all too common.

Programs like System Backup are revised each time a new copy-protection scheme comes out. They’re one remedy for the copy-protection disease. Another is simply to stay away from publishers who are more concerned with their own protection than their customers’ requirements.

Does That Suit You?

As I’m writing this, the radio tells me that the space shuttle Columbia will miss her morning landing, due to a glitch in one of the IBM general-purpose computers aboard the spacecraft.

I wonder what that will do to IBM’s stock?

In any event, it reminded me of another computer aboard the ship.

I was, many and many a year ago, involved in full pressure suit design and testing, and indeed my Experimental Stress Laboratory at the Boeing Company did some of the crucial simulations that led to choosing the Goodyear suit for the Apollo mission.

Suit design is tricky. One doesn’t want too much pressure in them, lest they blow up like balloons and become so stiff that the astronaut can’t move. On the other hand, there has to be enough pressure to keep the astronaut alive. Finally, you can’t have your astronaut go too quickly from 14.7 psi (pounds per square inch), which is standard atmospheric pressure, down to, say, 3.8 psi, which is about the minimum needed to keep the occupant healthy in a pure oxygen environment. Sudden pressure drops can cause lots of problems, including what divers know as “the bends,” which is caused by nitrogen bubbles forming in the bloodstream.

That’s another story. In any event, NASA sponsored several suit design efforts, but eventually the shuttle suits were produced by the Hamilton Standard Company. Before it was over, it had put a couple of hundred million dollars into building fewer than 50 suits. The cost overrun for pressure suits was a significant fraction of the total overrun for the shuttle program.

One of the features of the shuttle suit is a computer, which is supposed to monitor how well the suit is working. NASA is quite proud of it. In fact, though, it’s very primitive compared to anything you’re likely to be using; it has about 1K bytes of program ROM. Even a Timex has more memory and processing ability. Moreover, it isn’t as if the environment is particularly harsh: after all, the astronaut has to endure it as well as the computer. Alas, as far as I can tell, NASA didn’t bother with modular design, so that upgrading that computer is going to be hideously expensive.

NASA doesn’t have the money, so the upgrade probably won’t happen.

The micro revolution was originally driven by the need for on-board computers in missile and space-booster guidance systems; it’s a darned shame that the suits are designed in a way that makes it tough to retrofit newer technology. With
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proper design, the astronaut could have an in-suit computer that would not only monitor suit performance but also be a general-purpose computer and alarm clock. Instead, kids have better machines stored unused in their bedroom closet. Sigh.

Thanks for the Memory ...

One feature of the IBM PC is memory checking. For each block of eight memory chips in the PC, there's a ninth chip whose purpose is to store the parity bits for the other eight. A parity bit is the logical sum of the Is and Os in a memory cell; if there are an odd number of Is in a “word” of memory, parity is odd; if an even number, it's even.

The IBM, along with many other PC-compatible machines like the Zenith Z-100, looks at the parity bit when it accesses a memory cell; if the parity isn't what it should be, the PC reports a memory error.

It also dumps the program. Moreover, if there's any memory error on power-up, the IBM PC renders itself useless. This may not be optimum if you're checking as I found out when I stuffed my Eagle full of memory sockets for 512K bytes of memory. This is eight blocks of 64K bytes, and thus I'd expected it to take eight additional memory chips for parity checking; but it didn't. The Eagle's chips are arranged in blocks of eight, not nine.

I was curious enough about this to ask the Eagle people, who referred me to Gary Kappenman, Eagle's vice-president for R & D.

Eagle had considered doing parity checking, he said; but it decided against it. First, parity checking introduces new chances for error. There are 12 percent more chips in the system, and each of those is as likely to fail as any other memory chip; if it does, it will have the same effect as a real memory error.

Second, there's no software to take advantage of parity checking. The parity check doesn't restore your data; it merely notes that there's been some kind of error and dumps your program. Now if the error was in a program instruction, that's probably what you wanted; but if it were merely in a data area, so that the effect would be to spell the word “data” as “daqt,” I think I'd rather not be told if being informed dumps my text and renders my computer useless.

If there were software to tell you about memory errors and ask you what to do, Eagle might consider designing parity checks into its machine; until then, Eagle thinks it causes more problems than it's worth.

Incidentally, the Eagle 1600 has yet another undocumented feature, a memory test on power-up; one merely holds down the “t” key while the system comes up. Thus you can, if you like, test memory each time as the IBM does; but it's your choice. This will hopefully be documented in Eagle's revised systems manuals for the 1600. I wish the IBM PC offered a way of doing without the memory checks. It takes Lucy (for Lucy Van Pelt because she's a fussbudget) one
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whack of a long time to warm up and be useful now that we have big memory boards in her.

**Don't Use Function 37**

Time out for some technical advice to hackers and programmers. Others can listen in, but no apologies if you don't understand.

If you're writing software for CP/M 2.2x systems and you use BDOS (basic disk operating system) calls, do not use Function 37, "Reset Drive." Tony has tried to use that "feature" in several programs, and each time he's got into terrible trouble. There's an unrecoverable and undocumented bug in CP/M 2.2; the result is that attempts to use Function 37 to tell the program you have changed disks can cause ungodly horrible results.

As an example, you can write garbage into the directory of a hard disk, losing all the programs on it. (This is one reason that we do not and will not have a hard disk on our experimental system: we test a lot of software from many sources, and some of that software tries to use Function 37. This would be a disaster for us.)

You can also with Function 37 dump the user's program and scramble up his disk directories. There is no foolproof way to get around the bugs in Function 37. Don't use it. Instead, use Function 13, "Reset System." That's more work, and takes longer, because 13 recomputes the bit maps for all the logical disk devices, then sets logical disk "A" as the logged-on disk; if you started with something else logged on, you'll have to write code to take care of that.

Tony says this may not be fixed in CP/M-86, so be very careful about using it there, too.

Incidentally, there's no mention of this bug in Andy Johnson-Laird's otherwise excellent *The Programmer's CP/M Handbook* (Osborne/McGraw-Hill), which I recommend to anyone trying to write programs involving the CP/M operating system.

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The fascinating tale behind the world’s first* laser video disc player with a semiconductor laser by Hitachi.

Changes in the heat sink temperature resulted in considerable noise [see fig. 2(a)]. Mirror feedback increased the noise (mode hopping noise) and is represented by the clearly visible peaks.

**Fig. 2 RIN (Relative Intensity Noise) at various temperatures**

(a) Without HF superimposition

(b) With HF superimposition

The line in fig. 2(b), however, is remarkably straight. It represents measurements under the same conditions as for fig. 2(a) but with a superimposed HF (high frequency) sinusoidal current. These experiments clearly show that noise can be virtually totally suppressed by HF current superimposition.

This important breakthrough made a laser video disc player with a semiconductor laser a practical possibility. And Hitachi’s technological expertise has made such a high-quality, ultra-compact and light player a reality. Other special features include an exceptionally durable motor, unusual design for rapid servicing, ultra-high speed random access and accurate tracking with a Hitachi-developed 3-directional actuator.

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*Specifically, the world’s first mass-produced laser video disc player with a semiconductor laser. Production began September, 1982.*

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**Fig. 1 Measuring Laser Noise**

A special configuration to measure laser noise was used. [see fig. 1] An automatic power control circuit maintained a constant power output. A beam splitter deflected part of the output which was focused on a detector. Another part was focused on a mirror and an attenuator controlled the feedback light intensity.

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Smartcom II. We spent a lot of time developing it, so you can spend less time using it. Smartcom II prompts you in the simple steps required to create, send, receive, display, list, name and re-name files. It even receives data completely unattended—especially helpful when you're sending work from home to the office, or vice versa.

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Calling or answering a system listed in the directory requires just a few quick keystrokes. You can store lengthy log-on sequences the same way. Press one key, and Smartcom II automatically connects you to a utility or information service.
Smartmodem 1200 and 1200B are FCC approved in the U.S. and DOC approved in Canada. All require an IBM PC with minimum 56K bytes of memory: IBM DOS 1.10 or 100: disk drive, and 80-column display.

Smartmodem 1200B. (Includes telephone cable. No serial card or separate power source is needed.)

NOTE: Smartmodem 1200 may be installed in the IBM Personal Computer XT or the Expansion Unit. In those units, another board installed in the slot to the immediate right of the Smartmodem 1200 may not clear the modem; also, the brackets may not fit properly. If this occurs, the slot to the right of the modem should be left empty.

And, in addition to the IBM PC, Smartcom II is also available for the DEC Rainbow™ 100. Xerox 820-II™ and Kaypro II™ personal computers.

Backed by the experience and reputation of Hayes. A solid leader in the microcomputer industry, Hayes provides excellent documentation for all products. A limited two-year warranty on all hardware. And full support from us to your dealer.

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holder to remind you where to put the manual away when you’re finished using it.

However, there’s a problem. Much of Digital Research’s software comes with a README file of errata and additions. It’s formatted so that any simpleminded line printer can make a hard copy, and the line sizes are right for inserting the corrections into your document.

Alas, how do you do that? You need tractor-feed fanfold paper, and I’ve not found anyone who’ll sell it in the proper size. The result is a long bunch with scissors or paper cutter if you use formfeed, or standing there pretending to be a sheet-feeding machine if you use prepunched notebook paper (assuming you can find the proper size and hole arrangement of that).

Worry no more. William Simmonds of Anthropomorphic Systems has sent me a box of paper of proper size. He says, “I couldn’t find anyone who made or carried this paper, so I simply had a large supply made up.”

He’ll sell you a carton of 1000 for $20 or a case of 2500 for $40. May be stiff price, but he’s not getting rich on it—and Lord knows it’s a needed service.

Thanks, Mr. Simmonds.

One Way Out

Another public benefactor is Microsolutions and its Uniform program. Regular readers will know that we’ve had our problems with disk formats. A few have written to ask why we don’t use some kind of transfer program. The answer to that is simple: it’s blooming slow. As a last resort we can always use serial transfer, but consider the situation where the machines are in locations separated by several miles, and both are in constant use. Much better to transfer disks. As my late mad friend MacLean used to say, "Parallel is faster than serial."

Microsolutions has a program called Uniform that reads many and many a 5¼-inch format; about 40 so far. There’s also a MS-DOS/PC-DOS <--> CP/M bidirectional file-copy program. The company’s added the Epson QX-10 and is coming up with a version to run on the Otrona Attache.

If there’s ever the slightest chance that you’ll have to deal with several different kinds of micros, get Uniform; the savings in nervous energy and frustration are more than worth the price of the program. Microsolutions keeps revising it, too. Strongly recommended.

Graphics and the Z-29

My son Alex is very interested in graphics, and I ought to have him work on this, but he’s delivering the new WRITE manual to Compupro in Hayward. There’s a story that goes with that, but this isn’t the place to tell it.

One graphics product that impressed him mightily was the Imaginator 2 from Cleveland Codonics. This is an add-on board for the Heath/Zenith Z-29 terminals; with that add-on, the Z-29 becomes one heck of a bargain graphics terminal. The monochrome add-on board is about $900, with 672 by 500 pixels (dots) shown on the screen.

The upgraded Z-29 keeps all its old features, and the graphics mode can be commanded either from the terminal keyboard or from the computer. The graphics mode emulates the popular Tektronix 4010/4014 terminal, with a number of additional commands that can be called in from BASIC or Pascal, etc. The Imaginator 2 uses the NEC 7220 graphics chip for some of its functions, but for speed reasons it doesn’t rely on it alone.

There’s also a color Imaginator that requires more modification to the Z-29.

The Imaginator 2 plus a Z-29 terminal costs less than many dedicated graphics terminals, and still it acts as a superb text terminal. Alex thinks Zenith ought to offer the terminal with this board in it and won’t be surprised if it decides to do this.

Alex asked a lot of questions at COMDEX and is satisfied. (That’s an understatement; he was impressed.) Still, fair warning: I haven’t actually installed one of these boards in our Z-29, so I don’t know how easy that is to do, or how good the documents are. Maybe in the future.
How good a manager are you? Thoughtware Module 1.1 “Assessing Personal Management Skills” will tell you. This program is a three-part, comprehensive self-assessment of your personal attitudes, behavior and understanding as they relate to your effectiveness as a manager.

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Zorro's Hidden Capabilities

Computer companies have a long tradition of hiding features of their new products. Zenith, for example; has yet to send me updates to its software to tell me how to format single-sided disks on Zorro the Z-100. It claims it will do that Real Soon Now. We'll see.

Zenith has also brought out CP/M-86 for the Z-100. It has been through beta testing and is out in the marketplace. We don't have our own copy yet, but Jim Ransom has had problems getting Logitech's Modula-2 compiler for CP/M-86 running with his Z-100. I don't know the details; perhaps when I get a copy of CP/M-86 here I can find out.

I find among my notes another: CP/M-85 cannot find a directory on the CP/M-86 disks that came from Logitech, but the IBM PC reads them fine under Concurrent CP/M-86. I suspect some format problems. More when I know more.

Meanwhile, there's a hidden feature to Zenith's CP/M-86: it can run CP/M-80 software without modification. Bringing up the Z-100 under CP/M-80 and then running normal CP/M-80 software with it gives you a much larger temporary program area (TPA: the "usable" memory for a program). At COMDEX Alex was unable to find any Zenith employees or dealers who knew about this feature.

It ought to trump it, though, because it's an important selling point. Currently, DEC's Rainbow, the Compupro CP/M-8/16 systems, and the Fujitsu Micro 16 are the only machines I can think of that can do this.

With WRITE, for example, our text memory area is about 35K bytes under CP/M-85; but under CP/M-86 it's well over 40K bytes. WRITE works fine, and since Tony used some very complex BIOS (basic input/output system) calls in that program, it's a pretty good test.

Upgrading Zorro

Don't buy Zenith 8-inch drives. They're overpriced, and they don't work any better than anyone else's. Zenith's current software supports only two 5¼-inch and two 8-inch drives anyway, and it has no plans to upgrade to more. For that matter, there isn't enough power in the Z-100 case to run four full-power 5¼-inch drives anyway.

We've been using our Compupro 8-inch drives disconnected from the experimental box as a way to transfer files from the Zenith to our Compupro systems. Alas, for reasons I haven't had time to analyze, the only completely reliable way to do that is to use old-fashioned single-sided single-density IBM 3740/1-format disks. Sometimes the Z-100 will read double-density and sometimes it won't, and sometimes the Compupro doesn't seem to understand the Zenith's double-density disks. One day I'll do a systematic investigation; until then, we use Old Reliable slow 241K SSSD.

HELP!

I love to get mail. As I've said before, it's as if I have my own intelligence network out there; it makes writing this column no end easier, and obviously I can't do the User to User column at all without reader letters.

However.

Please help simplify my life. For example: there's no point in sending me long press releases about promotions within your company. Most of those are accompanied by photographs of nervous people with strange smiles. Sometimes we use the photos: we tack them to the walls with captions like "Hi! I'm not wearing any underwear!" or "I know a secret! I'm nude from the waist down!" which is what those grins suggest they're thinking.

We also use them as targets for our Beeman Hurricane air pistol. (I can recommend air pistol shooting at pictures of computer company presidents as a means for computer columnists to relax.)

Second, before you write asking me how to make contact with some company whose products I have reviewed, please look at the big box that always accompanies the column. If you read the October BYTE and want to make contact with Larry Weed's Problem-Knowledge Coupler company, look in the box in the Oc-
October issue rather than writing me to ask for the address.

Third, please do not send me form letters. If you're a dealer for products I've reviewed favorably, God bless you; but I don't need flyers describing stuff I've already written about, and I particularly don't need solicitations to buy a Sage computer. I already have one, for Heaven's sake!

Finally, there's a letter from Jonathan Sachs of Sand River Software to the managing editor of BYTE. Sachs says, "Several weeks ago I wrote to Jerry Pournelle asking how I could get a copy of a program he mentioned. To date he has not replied."

Mr. Sachs says he is upset because "I pay money to read Jerry's column because I think I can profit from the information in it. Now it appears that he's got a program that would make my business more efficient—but I can't get it, or even find out for sure what it is, because he doesn't answer mail.

"From my point of view, this is no different from the behavior of a software producer that refuses to support the product it sells. Jerry regularly (and justifiably) rails against such practices. Does he realize he's guilty of them himself?"

Both the original letter inquiring about some of Tony Pietsch's experimental work and this letter to BYTE's managing editor were unaccompanied by a self-addressed stamped envelope.

I try to answer mail. I really do, and I apologize to all those whose letters I just can't get to; but darn it all, I don't like addressing envelopes and while I'm willing to pay postage if someone forgets, I don't like having it demanded of me.

No, Mr. Sachs; I do not believe a columnist has the same obligations to provide individual support as does a software company, nor do I believe BYTE's managing editor has the obligation to drop what he's doing and answer your letter. I'm sorry you're going to cancel your subscription, but I guess I'm just going to have to live with the situation.

In other words: I'll try to answer letters. I can't guarantee an individual reply even if you send a self-addressed stamped envelope, although I'll do my best. I certainly am not accepting heavy guilt trips because one or another letter didn't get answered. I do feel pretty bad when someone sends me a really neat program and I don't get to it quickly.

I'm Really Trying ... As I write this, Dr. Allan Trimpi, who's way overqualified for the job, is off in the next room cataloging about seven cubic feet of software. We'll then assign the most promising stuff to assistants. Maybe we'll get caught up. It isn't likely, but we can try.
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<th>Features/Functions</th>
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<td>Diagnostic Testing</td>
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<tr>
<td>Advanced Spooler</td>
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<td>No</td>
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<tr>
<td>Simple Menu Setup</td>
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<td>Disk Cache</td>
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A First Look at Dayflo

A free-form database gets you closer to your ideas

by Ezra Shapiro

Dayflo, a program announced at COMDEX in November and released during the first quarter of 1984, is representative of the new wave of “idea processing” software. Dubbed “a personal information-management system” by its creators, the program is a free-form, text-oriented database-management package, designed—at least initially—to run on the IBM PC XT.

The central principle behind the structure of Dayflo stems from the realization that note scrabbling and the constant organization and reorganization of small scraps of paper into larger documents are a major part of what goes on in the world. A program that answers the demands of a typical office environment would have to be able to move quickly from one kind of note to another and allow for the impulsive entry or retrieval of information at the time of thought, without the traditional delays of program start-up and data entry.

Dayflo Software of Irvine, California, states that the average office personal computer is used only half an hour a day. Dayflo represents an attempt to create a flexible tool that can be used throughout the day. It allows variable-length text records to be tagged and recalled in much the same way that a standard database manager handles fixed-length records. However, Dayflo’s form design is only as structured as the user wants it to be. The program seeks to accommodate itself to the ebb and flow of the workplace, hence its name and guiding philosophy. For a look at Dayflo in use, see the sequence of operations in photos 1 through 15.

The Metaphor

Dayflo is structured around the metaphor of the executive desktop—a fairly standard theme these days—but this version adds a number of perceptive twists. The program begins by assuming that you have an open file folder on your desk, one containing a collection of information that relates to your current project. Up to 19 other folders are piled off to one side, as if they had been gathered from a nearby filing cabinet. These folders may or may not pertain to the task at hand.

You’re also equipped with a trash basket, a pair of scissors, a tray in which to drop pieces of paper, and a scratch pad, all of which are constantly available. During the course of the day, you pull the scraps in your folder into presentable form, sometimes using items from the other folders on the desk, sometimes digging new material out of the filing cabinet. If you’re interrupted, simply jot a note on your pad—even if you happen to be in the middle of a paragraph. When the opportunity presents itself, you can make a copy of the note and file it in the appropriate location. When a task is completed, you close the folder and move on to the next, or you refile it in the filing cabinet and begin gathering material for the next job. At the end of the day, you can leave your folders as they are or stuff them back into the cabinet.

Dayflo adjusts to the ebb and flow of the workplace.

With a few additional permutations, this is Dayflo.

An Evolutionary Step

Text management has always been a primary concern of software developers. From the earliest line editors to the sophisticated screen-oriented word-processing systems of today, programmers have struggled to accomplish two goals: to apply the power of the computer to the relatively straightforward tasks involved in word-by-word data entry; and to aid the writer by easing the creative process of transferring ideas to paper. While the first goal has largely been met, the second has proved more elusive.

For obvious reasons, the focus in the computer industry has been on tailoring features to the needs of the business world. The first true word processors were aimed at the secretarial arena—a major selling point was (and still is, in many cases) not how much easier a program could make the process of creating a rough draft, but how much easier it could make the final presentation of an error-free business letter.

Recent efforts have concentrated on a more advanced problem, the business report. Spreadsheet-based text processors are good examples of the current approach, as are many of the integrated business packages now appearing on the market—programs that incorporate ledger computation, graphics, and data retrieval with text handling. But until the past year or so, very little has been done to expedite the storage, retrieval, and manipulation of ideas as opposed to data.
Most word-processing programs provide relatively simple block moves; they transfer chunks of text within an individual document or among a small group of documents stored in on-line buffers. When data transfers must occur outside the limits of a work in progress, things become unpleasant. The mechanisms provided by the typical text processor for, first, labeling and storing, and second, locating and recalling blocks of information, are cumbersome at best. In most cases, the writer must both name the block and remember the name in order to have a prayer of finding and reusing the information.

On the other hand, most database-management software, while adept at storage and retrieval of punch card-style chunks of data, is miserable at text processing, and the restrictions of fixed entry forms and precisely limited entry length would drive a creative writer up the walls. And it's almost impossible to combine a mixture of data types and formats into a cohesive whole without retreating to the use of a word processor.

Dayflo is a philosophical combination of text manager and database manager intended to provide the user with a quick method of linking labels to idea units, thus adding a degree of control and organization to a normally haphazard process.

**How It Works**

When you first enter the Dayflo environment, you are presented with an almost blank screen, representing the Dayflo "wait state." You can begin...
typing immediately, as the blank screen is essentially a word processor. You are working on the equivalent of a sheet of paper on a scratch pad resting in an open folder on your desk. (In Dayflo terminology, this "folder" is called a "stack," and that term will be used from here on.)

Pressing the *(PrtSc) key displays a line of menu options close to the bottom of the screen; these provide such standard functions as format changes, search and replace, block moves, and toggling between inserting and overwriting. A second list of menu choices, accessed by punching the down cursor key, shows the possibilities for accomplishing functions that deal with overall Dayflo operations.

The document you're creating is a single record in a text database. It and other records like it have been organized into 20 stacks. The current stack can contain a large number of records, which can be flipped through one by one. When you begin work in a new stack, the "bottom" of the stack is always the scratch-pad area, but as you flip through your records, you tuck them under the scratch pad; thus, while each stack contains a scratch pad, it won't always be the bottom record. A status line indicates your position in the stack as you move around.

Block moves of text can be performed by marking the beginning and the end of the section and pressing one of the PC's function keys. Selecting the "Cut" option moves the block into a buffer called the "cutout
Photo 9: Page layout options are limited but sufficiently complete to generate professional reports. More sophisticated layouts can be produced using Reportflo, an optional companion program.

Photo 10: The Item Dictionary lists all field names that Dayflo "knows" and their attributes. If you enter data that does not conform to the dictionary specifications, the program will request verification before accepting the information. Nonindexed items can be retrieved only as part of entire records; indexed items can be retrieved independently.

Photo 13: Blocks are stored in the Dayflo "cutout holder" and pasted in where needed. Once a block has been placed in the holder, it remains available for reuse until an active decision is made to throw it away.

Photo 14: The holder itself is much like a stack; blocks can be stored as if they were scraps of paper. The only real difference is that the cutout holder cannot be used to update the main database.

holder." Positioning the cursor at the new location and choosing "Paste" completes the transfer. The holder itself is much like a stack, although the fragments it contains can neither be edited nor stored until reunited with actual stack records. It will accumulate snippets of text until it is told to clear itself, which is ideal for gathering a series of segments and then relocating them. Moves can be accomplished within a record or from one record to another, regardless of stack boundaries.

However, Dayflo is more than a text editor with advanced buffering capabilities: it is a full-fledged database manager. Once a record has been completed, it can be stored in a central database for future use. Although stacks can be created entirely from scratch, a more typical event would be to extract the contents of a stack from the database by searching for single or multiple relationships.

In a finished record, all entries must be tagged with a field name, or "item name," as defined in a user-generated name dictionary. A one- or two-keystroke toggle command activates the switch from text entry to name entry. "Indexed" names can be used for eventual retrieval of the item or its record; "nonindexed" names merely identify items and cannot be used as keys for searching.

Free-form blocks of text can be entered on the scratch pad or in the middle of a preexisting document, as with any simple word processor. However, Dayflo will not allow you to end an editing session until you have included at least one indexed field name (the default is "&RECORD NAME"). Such a precaution is designed to save the unwitting from themselves; if it were possible to store raw text in the main database
without a field name from which to begin a search (and theoretically it is possible), retrieval would necessitate searching every record under every field name in order to match a character string. With a large database, this could take a disturbingly long time.

**Maneuvering on the Desktop**

The Dayflo "Status" command provides access to a number of screens of configuration information that can be altered to suit the needs of the moment, including database in use, printer assignment, page layout, video attributes, warning messages, and text format. The most frequently consulted status screen is probably that for Work Area Status.

The Work Area is your desktop. The status screen shows the titles of all the stacks in use, the number of records in each stack, the number of records in the trash, the number of blocks in the cutout holder, the current stack, and your position within the current stack as measured in distance from the scratch pad.

Work Area commands let you build new stacks, move between stacks, print records, sort records within the stack, extract new records from the database, duplicate records, and initiate cleanup procedures. You can access command mode either by moving to the Work Area command menu and making your choice or by typing one function key followed by a mnemonic initial. In either case, maneuvers rarely require more than two or three keystrokes.

**Weak Points**

As is the case with all new programs, Dayflo is not without its weaknesses. To Dayflo Software's credit, however, it does not view the initial release as an end to the development process. Dayflo will be enhanced as the product evolves.

At the time this report was written, Dayflo had some drawbacks, particularly in the user-interface portions of the program. Shortly before its release to the buying public, Dayflo staff members were still debating whether the program should come up showing the Work Area Status screen (to provide an overview of work in progress) or return to the point at which the user had been working. The general opinion was that the latter solution would be best for users who had learned the system, and that opening with the status screen was an interim step in the training process that would prove annoying within several days of use.
However, as the prerelease versions lacked both provisions for field configurability and any sort of macro-key command capacity, either option would be irritating to a certain percentage of users. The problem was solved at Dayflo offices by the widespread use of Pro-Key, a keyboard reconfiguration program for the IBM PC—the solution is an admitted patch, well below the overall high standards of the operation.

A conscious effort has been made to imitate the Wordstar approach to menus and help screens (the experienced user can circumvent these screens with quick function-key commands), but a number of the screens could easily entrap and confuse a novice, and the language used, while concise, is intimidating. For example, the initial Dayflo work screen is labeled “wait state”—terse and to the point, but useless to the uninitiated.

Dayflo does not interact well with other software packages on the market. Although it can accommodate text output from other packages, Dayflo can’t handle raw data files. The user must wait until the other packages spit out information in a form that Dayflo can digest. Although designers are working on a solution, it’s not a simple problem; building in all the translation algorithms for the varied universe of available data structures is no small task.

Finally, Dayflo may suffer as a result of its massive size. The basic program is more than 75,000 lines of program code written in C, which compiles down to 1 megabyte. And that’s without the object database or databases, Reportflo (a companion program for fancier output), or spreadsheeting capabilities (one of the first of a projected series of enhancement packages). To say that Dayflo is designed for a hard-disk environment is something of an understatement; it absolutely requires a hard disk.

Conclusions
The more you work with Dayflo and become accustomed to its idiosyncrasies, the more you become conscious of its power. It is possible to design simulated fixed-length
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databases (e.g., phone directories) that coexist quite peacefully with pure text records within the context of the overall structure of the program. Diverse records can be combined within the same stack or the same record, and data can be transferred between them at will. Command logs can be constructed to perform extremely complex search and retrieval operations; records can be copied, split, combined, and mutilated, as freely as you please, as long as you remember to include at least one indexed field name within a given record. True, the package demands a bit of learning, but its flexibility more than compensates for the effort.

Dayflo demonstrates the advantages of applying lateral thinking to an old problem. Its architects claim that the theory behind Dayflo is nothing revolutionary, but the program allows text entry with an uncommon ease and spontaneity. With a little practice, users find Dayflo procedures quite natural, and a return to older programs can be frustrating.

Dayflo's open logic can encourage you to develop a terrible mess, certainly as bad as any on a real desktop, and unless you perform regular cleanup, order in the stacks can fall apart. But, all things considered, it's pleasant to have that much control. Freedom is not without its price.

Whether or not Dayflo will dramatically increase the use of personal computers in the office is another question entirely. It's certainly a wonderful program for writers of all types, and executives who are used to working with software will be pleased by the speed with which they can pirouette through all that data. For them, the program is a major step in the right direction. But new users will have to be induced to learn the program before they can appreciate it. It may well be that Dayflo's shot at revolutionizing the workplace will depend more on marketing and training than on its outstanding potential as a tool.

Ezra Shapiro is a technical editor at BYTE's West Coast bureau. He can be reached at McGraw-Hill, 425 Battery St., San Francisco, CA 94111.
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The term simulation is suspect at best. In the minds of many, this word connotes a counterfeit or sham: a rhinestone masquerading as a diamond. In the context of computers, however, simulation has no negative meanings and we hope that our March theme issue helps this beleaguered word to regain its standing in the lexical community.

Simulation is the process of representing or modeling the behaviors of a system on a computer. This software model attempts to mimic the processes of the original system as nearly as possible. Data enters the model, is acted upon, and then the "system's" responses are recorded. Until quite recently, the field of computer simulation was exclusively the province of mainframe systems, but as microcomputers have become more powerful and capable, they have become increasingly important to the would-be simulationist.

Our lead article by Richard Bronson is an overview of microcomputer simulation; it covers the two basic types of computer simulation and surveys some of the simulation languages available for microcomputers. Articles by E. Hart Rasmussen and Pat Macaluso investigate the mathematical underpinnings of simulations. These articles contain source-code listings so that interested readers can try their hand at modeling.

In terms of applications, we explore computer-generated graphics with Peter Sørensen—simulations of things that never were. Philip Schrodt takes a look at using microcomputer simulations in the social sciences. Ronald Miller gives us a view of simulation and graphics on microcomputers. To round out the issue, Charles Pratt of the Society for Computer Simulation offers us a "going further" article for those who want to get more information about the field.

Even three of our software reviews are related to the theme of simulation and modeling. Stan Miastkowski checks out the Microsoft Flight Simulator for airworthiness on page 224, Dennis Barker reviews a mystery adventure game (page 301), and on page 274 Richard Grehan explores a software package that makes a computer simulate the internal workings of a computer—a novel twist indeed.

To discover some of the whys and hows of microcomputer simulation, please join us ... in the queue.

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Computer Simulation
What It Is and How It's Done

An introduction to modeling and computer simulation as they apply to microcomputers

by Richard Bronson

According to Robert Shannon in *Systems Simulation: The Art and Science*, "Simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies for the operation of the system." This description emphasizes both facets of an exciting and expanding field. The art is the creative process of constructing a simple model that adequately replicates the dynamic behavior of a system; the science involves transferring a model into computer code and then analyzing its behavior to predict the responses of a real system.

Computer simulation is a child of the computer age. Without computers there could be no computer simulation, and without computer simulation we would be without one of our most powerful and versatile methods for problem solving. Simulation techniques are currently used in over 70 fields spanning ambulance dispatching, consumer-behavior patternning, financial forecasting, harbor design, manpower planning, water-resource management, educational funding, aircraft design, and urban development. In each, simulation is a tool for solving problems.

Simulation is a unique discipline in that there are relatively few people engaged in the “pure science” aspects of the field; those who are develop simulation languages and statistical tests. The bulk of practitioners apply simulation to problem analysis and solution in other fields. They use simulation techniques to provide structure and definition to imprecisely worded verbal descriptions, to identify key components, to quantify interactions, and then to code, experiment, and recommend.

Two Types of Simulation

Simulation, as practiced today, falls into one of two types: discrete or continuous. Each has its own set of procedures for model conceptualization, each is based on a different area of mathematics, each uses its own set of computer languages, and each solves different sets of problems.

Discrete simulation deals primarily with queuing systems in which customers arrive at a service facility, then wait in a line (queue) if all servers are busy, eventually receive service, and finally depart from the facility when service is completed. Air traffic control problems are often embedded in such systems. Here, the aircraft seeking permission to land becomes the customers and the runway assumes the role of servers. With scheduling problems involving court cases in the judicial system, judges are modeled as servers, and the cases become customers.

Of prime interest in all queuing systems is the expeditious processing of customers. Since customer arrival times and the times required to service individual customers are generally random events, mathematical models for queuing systems are anchored in probability and statistics. Questions regarding the average time a customer spends in the system and the length of a queue can be answered only when the probability distributions governing arrival and service patterns are known (or can be assumed). For almost all probability distributions, the only technique available for answering these questions is computer simulation.

Large blocks of time in which the state of the underlying system does not change are a defining characteristic of discrete simulation. Another characteristic is that units moving through the system are measured as integers. Queuing systems have these properties, which is why their problems are so amenable to solution by discrete simulation. Customer arrivals and customer departures occur in unit amounts; the number of customers in a service facility at all times can be represented as an integer. Arrivals and departures occur at discrete instances and, in between, nothing of importance to the state of the system transpires—the same customers receive service and the same customers wait.

Continuous simulation, in contrast, deals with systems that change continuously with respect to time and with measurements that are not re-
stricted to integers. A simple example is the trajectory of a rocket in flight; there is no instant of time when the system as measured by the rocket's position in space does not change. Less obvious examples are provided by Levin and Roberts in their book *The Dynamics of Human Service Delivery* (see bibliography). For example, one case study assesses the effects on student performance from student-teacher interaction at the elementary school level.

Of prime interest in all continuous systems is the time-varying behavior of all quantities in the system. Since behavior patterns are governed generally by rates of change, mathematical models for continuous systems are based on differential equations. And the only technique available for solving most sets of differential equations is numerical integration, which is the core of all continuous-simulation languages.

It's not always clear whether it is better to use discrete or continuous simulation in solving a particular problem. Population growth problems seem ideal candidates for discrete simulation. They can be modeled easily as self-service queuing systems with people as customers (and their own servers), births as customer arrivals, and deaths as customer departures. Yet population problems often are analyzed with continuous simulation primarily because the time between successive births and deaths is small (seconds) compared to the time span of interest (years). It is more economical in both computational time and memory requirements to approximate the system as a continuous one rather than having the computer update its queue files every few seconds. The problem of using nonintegral values is obviated by the magnitude of the items being measured; a population of 60.38 is perfectly acceptable when the unit of measure is millions of people.

The choice between simulation branches is further obscured by systems that possess both types of behavior. Pritsker and Pegden offer a good example in their book *Introduction to Simulation and SLAM* (see bibliography) of such a hybrid system, part continuous and part discrete, based on a simulation study by Ashour and Bindingnavle. Ingots of warm steel arrive at a soaking pit of hot liquid where they are immersed and heated to high temperatures for further processing. If the soaking pit is full, ingots must wait for space in a holding tank. The random arrival pattern and subsequent queueing are vintage discrete simulation. The service pattern, raising the temperature of the ingots as they soak in the hot bath, is continuous based on the temperature of the pit, the temperature of the arriving ingots, and Newton's law of heating. To simulate such a system, elements of both types of simulation are needed.

**Models**

Models are often classified as either *iconic, analog,* or *abstract.* An iconic model looks identical to the system it represents; one example is a wood and paint mock-up of an automobile shell. From a distance the mock-up appears to be an automobile, but since it contains no engine or interior, it is an incomplete one. Nonetheless, if the purpose of the model is to determine the aerodynamic characteristics of the car it represents, then it may be all that is needed to achieve the objective. An analog model acts like the system it represents even though it may appear quite different. Engineers often build electrical systems to model mechanical spring systems and then predict the motion of the mass at the end of the spring by measuring the current in the electrical model. Abstract models are sets of mathematical equations for quantities in the systems being modeled. The solutions of the equations are used to predict the behavior of the systems.

Discrete simulations employ analog models with computer files representing most components in a system. Each customer is a file, every queue is a file, and there is even a calendar file for storing service completion times and arrival times. These files are then manipulated according to patterns established by the modeler to mimic the behavior of the underlying system. Only servers are spared the indignity of being reduced to files; instead they become variables assigned either the value 1 when they are busy, or the value 0 when they are free.

Abstract models of differential equations are the bases of all continuous simulations. For technological systems, such equations are consequences of physical principles, such as Newton's laws of motion, governing changes in the states of the systems. Unfortunately, no such principles currently exist in the social sciences, but in the late 1950s and early 1960s Jay Forrester and his associates at MIT developed system dynamics as an approach for generating differential equations in these areas. Prior to 1960, continuous simulation was practiced almost exclusively by electrical and aerospace engineers. As a result of Forrester's work, abstract models now exist in economics, sociology, management science, and ecology.

Once constructed, nearly all simulation models must be coded for a computer and then run before any inferences are possible. Mathematical solutions are preferred but almost never obtained, given the complexity of interactions between components in models, even reasonably simple models. Mental inferences are dangerous. Forrester, in a 1971 article for *Technology Review* (see bibliography), cited the following experience:

> Time after time we have gone into a corporation that is having severe and well-known difficulties. The difficulties can be major and obvious, such as a falling market share, low profitability, or instability of employment. Such difficulties are known throughout the company and by anyone outside who reads the management press. One can enter such a company and discuss with people in key decision points what they are doing to solve the problem. . . . In a troubled company, people are usually trying in good conscience and to the best of their abilities to solve the major difficulties. Policies are being followed at various points in the organization on the presumption that they will alleviate the difficulties. One can combine these
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policies into a computer model to show the consequences of how the policies interact with one another. In many instances it then emerges that the known policies describe a system that actually causes the troubles. In other words, the known and intended practices of the organization are fully sufficient to create the difficulty, regardless of what happens outside the company or in the marketplace.

In Forrester's experience, individuals perceive a problem, develop a conceptual model of the system in which the problem exists, mentally run the problem based on these mental inferences were faulty. The net result is often the opposite of that intended because the mental inferences were faulty.

Lave and March, in their book An Introduction to Models in the Social Sciences (see bibliography), present a more striking example of the pitfalls awaiting those who would bypass the computer in favor of mental deductions. The example is credited to Bertraud de Jouvenal and features the thoughts of the philosopher Jean Jacques Rousseau. Rousseau built a population model for eighteenth-century England based on three assumptions: (1) the birth rate in London is lower than the birth rate in rural England; (2) the death rate in London is higher than the death rate in rural England; (3) as England industrializes, people leave the countryside in increasing numbers and move to London. Rousseau concluded that, since London's birth rate was lower and its death rate higher than rural England and since people moved from rural England to London, the population of England must decline eventually to zero. Had Rousseau coded his model for a computer he would have reached just the opposite conclusion. In quantifying the rates for computer input, he would have seen that as long as London's birth rate was greater than its death rate, regardless of how they compared to similar rates elsewhere, the population of London must grow.

If a scholar of Rousseau's stature can err on such a simple model, then Forrester's experiences with twentieth-century man and complex models are not surprising.

When a computer is used to run a model, a computer language is a necessity. Although some experienced practitioners prefer a general-purpose language such as FORTRAN, most opt for specially designed computer-simulation languages that also fall into two classes: discrete and continuous. Both types are easy to program and possess special features of value to simulationists. Both permit the modeler to focus attention on the system rather than the details of programming.

Discrete Simulation Languages

There are hosts of discrete simulation languages available: SIMPAS, CAPS, SIMULA, and DEMOS to name but a few, with new ones introduced yearly, but the overwhelming majority of simulation studies that utilize such languages are written in GPSS, SIMSCRIPT, GAS, or SLAM. GPSS was introduced first by IBM and its latest version, GPSS V, is still supported by them. A faster

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version, GPSS/H, which runs on a wider variety of mainframes and minicomputers, is supported by Wolverine Software of Annandale, Virginia. SIMSCRIPT is a product of CACI of Los Angeles, California, and requires its own compiler. Both GASP and SLAM are supported by Pritsker & Associates of West Lafayette, Indiana, and are compatible with many FORTRAN compilers.

SIMSCRIPT and GASP are event-oriented simulation languages, which means that they are a set of subroutines for file creation, file manipulation, scheduling, and statistical analysis that the modeler combines in the way that best replicates the system under study. A completely coded model consists essentially of calls to subroutines and assignment statements for updating files associated with individual customers.

GPSS is a process-oriented simulation language in which the modeler stipulates the processes involved in the system, such as creating customers, seizing servers, queuing in lines, and collecting statistics. Once this delineation is complete, the simulation language automatically creates, manipulates, and updates the necessary files. Process-oriented languages are conceptually easier to understand and easier to code than event-oriented languages, but the latter are more flexible and give modelers a wider range of options for representing systems.

SLAM is a relatively new language and potentially the most versatile of all. It allows for both event-oriented and process-oriented simulations as well as continuous simulation for those segments of a model requiring it. Figure 1 is the main portion of a SLAM program in its process-oriented mode for a one-person barber shop. The first and last lines simply frame the process being modeled. Line 2 creates customers with times between arrivals governed by an exponential distribution having mean 25. Line 3 directs each arriving customer into queue #1 to await the barber. Line 4 of the code states there is only one barber whose service times are normally distributed with a mean of 20 and a standard deviation of 5. This activity is designated as activity #1. Line 5 instructs SLAM to terminate a customer upon completion of service and to terminate the simulation after 100 customers have been processed. SLAM does the rest including taking the first customer in the queue and placing that person in service when the barber is free, reporting statistics on each queue and each activity designated by a number, and sampling from stipulated probability distributions. SLAM automatically creates and updates a calendar of service completion times for all customers in service coupled with the time of the next customer arrival, and at each time in chronological order, SLAM creates, manipulates, and terminates all necessary files for replicating the queuing system as stipulated in the code.

### Continuous-Simulation Languages

All continuous-simulation languages are based on numerical-integration routines for solving sets of first-order differential equations, both linear and nonlinear. Many adhere to standards established by the Society for Computer Simulation (SCS) of La Jolla, California. Such languages provide modelers with a choice of integration algorithms including variable-step Runge-Kutta routines and routines for solving stiff differential equations, they allow inclusion of user-written subroutines in the host language of the source code, and they provide options for graphic output with internal scaling of axes. A continuous-simulation language can be mastered in under five hours.

The forerunner of most continuous-simulation languages is the IBM product CSMP, but there are now many others that run on a greater variety of computers. Some of these languages include CSSL-IV from Simulation Services of Chatsworth, California, ACSL from Mitchell and Gauthier Associates of Concord, Massachusetts, EASY5 from Boeing Computer Services of Tukwila, Washington, and DARE from the Department of Electrical Engineering at the University of Arizona.

Figure 2 is the main portion of a DARE program for solving a bank balance problem modeled by the differential equation:

\[
\frac{dBAL}{dt} = 0.05BAL; B(0) = 1000
\]

The code is separated into sections, each terminating with an END statement. First, derivatives are denoted by periods following variable labels. The first section headed by $D1$ is the operational segment and contains all the differential equations in the model. It also includes the $Mnn$ line that instructs DARE as to which of ten different integration routines it should employ. The second section is the specification segment including both the initial conditions and TMAX, the length of time the simulation should run. The last section specifies output, LIST for a table, PLOT for a graph. DARE does the rest, including solving the differential equations (here there is only one), and providing appropriately scaled graphs for all output variables.

DYNAMO, supported by Pugh Roberts Inc. of Cambridge, Massachusetts, differs from other continuous-simulation languages in that it is designed expressly for social scientists using the system-dynamics approach to modeling. DYNAMO con-
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Simulation and the Personal Computer

The exciting news in computer simulation is the same story sweeping the entire computer world: microprocessors. Some languages are already available, including micro-DYNAMO for both the Apple II and the IBM PC from Addison-Wesley; SIMAN, a discrete-simulation language for the IBM PC from System Modeling Corporation of State College, Pennsylvania; MicroNET, a discrete-simulation language for a variety of personal computers from Pritsker & Associates; ACES, a continuous-simulation language for the Apple II from Modulo 2 Company of Tukwila, Washington; and SIMSCRIPT for the IBM PC, and many others are sure to follow. Conferences, such as the 1982 Modeling and Simulation on Microcomputers Conference (sponsored by SCS), have encouraged further participation.

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Bibliography

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Simulating Reality with Computer Graphics

by Peter R. Sørensen

Since daguerreotypes became popular in the last century, we have assumed that "the camera doesn't lie." We still assume that the photos we see are accurate representations of reality. But before the invention of the camera, pictures were not taken at face value because they were hand-drawn and subject to the artist's interpretation.

The trust we place in photographs has had a profound impact on communications. It is already possible to create the appearance of metal, plastic, and glass so effectively with computers that the average viewer can't tell if the image is real or not. If techniques continue to improve at the current rate, by the 1990s it will be possible to conjure up almost any kind of scene from a digital description. The implications for entertainment, education, art, and even propaganda are worthy of note. Computer graphics is already one of the most exciting branches of computer science, and it promises to get only more exciting in the future.

Image Generation

You must accomplish two essential tasks very accurately to create believable pictures: perfect perspective and smooth, uniform shading. There are many other factors, of course, but if either one of these two is incorrect, nothing else matters. Any artist trying to paint realistically can attest to the accuracy required to fool the human eye. Although it's extremely difficult to execute flawless perspective with shadows and highlights by hand, the task can be done efficiently by computer.

To generate a picture, you must give the computer the measurements, colors, and reflective properties of the objects in the environment, the point of view of the imaginary camera, the type of imaginary lens (close-up, wide-angle, etc.), and the locations of any light sources. You give the locations in terms of X, Y, and Z coordinates, with X being the width (horizontal), Y the height (vertical), and Z the depth. Many people refer to this process and its products as 3-D because this is a three-dimensional description of the scene. In reality the images are two-dimensional, which is confusing because you can also create true three-dimensional stereo image pairs with parallax on a computer. If you want to animate the scene, you must also specify the motions of the camera and the objects. There are still two quite different software approaches to creating an image: boundary representation (B-rep), the most popular, and ray tracing.

With B-rep, the computer needs to determine first the distance of all the objects from the viewpoint and their orientation. Knowing where and how big the objects are (things appear smaller the farther away they are), the system projects a frame of view out into the scene and ignores everything else (called clipping). Next, the computer needs to decide which surfaces are

Photo 1: Jumping Skeleton, created by David Zeltzer of Ohio State University and done at Cranston/Csuri Productions. An artificial-intelligence program automatically animates the skeleton with realistic motion.
The line between fantasy and reality disappears.
visible and which are hidden behind other objects. This is necessary because the computer has an x-ray view, seeing everything at once. To discover how brightly lit the visible surfaces are, the computer must determine their orientation toward the light source. The computer then creates the picture with lines (like a television picture) made up of dots called pixels.

Ray tracing is less frequently used but is currently gaining in popularity. In ray tracing, the computer calculates the paths taken by the light rays. This is a more natural process, except that the computer performs the process backwards: from camera to object to light source. The imaginary film plane is divided like a pixel grid—each pixel is the origin of a ray. The ray emanates into the scene until it strikes an object while the computer traces its path. The angle at which the ray strikes the object determines the angle at which it bounces off and continues on its way. The ray may go on to strike another object or go off into space.

The system can now determine pixel color and brightness from how close the ray came to the light source and how many and what other objects it struck. Everything is calculated strictly according to the rules of physics—how light reflects off different materials or passes through transparent ones—except that things are figured in reverse. If you started tracing the rays from the light source, you'd find that very, very few of them wind up going into the camera, and a lot of effort would be wasted.

A major advantage of ray tracing is that it takes care of hidden surfaces and clipping automatically, just as in real life: you see only what's in your line of sight. This technique saves a lot of computer time; however, ray tracing is still generally slower than B-rep. It's faster to find out which surfaces you can see, calculate their color and intensity, and assign that color/intensity to the appropriate pixels (perhaps hundreds at a time) than it is to calculate each pixel separately with the ray-tracing method. For this reason, most computer-graphics people shy away from ray tracing. However, if you want the superb realism of reflection and transparency, you'll have to spend a little extra time. (This article is not an exhaustive comparison of software; there are exceptions to all the rules, and the intent here is to present only an overview.)

Picture generation with a computer is extremely time-consuming, no matter what method you use. Most of the animation in Tron took an average of 15 minutes per frame; some took considerably longer. The degree of resolution (the clarity) that you want a picture to have, determined by the number of lines and pixels used to make it, is an important factor in computation time. If you double the number of lines used to get a higher-quality picture, you quadruple the number of pixels used and the amount of time needed. Video pictures have 512 lines, or a quarter of a million pixels. That's very low resolution by the standards of motion pictures; the lowest resolution used in Tron was 1,200 lines. When the resolution is very low, you can see the pixels as little squares, which result in diagonal and curved lines having a stair-stepping appearance that's technically known as aliasing, commonly called the jaggies. Even at rather high resolutions where
the pixels aren't obvious, aliasing can cause edges to "crawl" as objects move, and very small details to flicker on and off.

There are two approaches to the aliasing problem: use very high resolution (tests show, however, that even at 6000 lines there is room for improvement) or try anti-aliasing (average the pixels out with their neighbors so the jaggies are blurred and less noticeable). Anti-aliasing tends to soften the whole picture, so you should attack only the offending pixels, which is a pretty tricky process. This smoothing process can save time but it requires some time itself. The decision to use anti-aliasing or high resolution is another point of disagreement among people involved in computer graphics.

Another graphics aspect that is far from being standardized is how a computer models objects. The approach usually used with B-rep is to describe objects in terms of polygons or patches, with front, side, top, and other views. This concept is relatively straightforward and makes even the oddest shapes definable. There are also more sophisticated methods of defining surfaces that rely on higher orders of mathematics, such as quadratics.

Another approach, *combinatorial geometry*, is like building with blocks—"primitive" geometric shapes such as cubes and spheres that are known to a computer—that you can add to or subtract from each other to make compound shapes. You can stretch and distort these shapes (creating an egg from a sphere, for example). You enter the instructions on the keyboard after you sketch the desired shape and think through the construction process. It's not nearly as natural a process as the B-rep method; in fact, you may need to input additional information on a data tablet to create complicated shapes such as type fonts. However, it has advantages: it requires very little memory space, and you get perfectly smooth surfaces without having to take a step to blend the edges of polygons. A sphere is defined by its center point and radius; the B-rep method requires a great many polygons to define a sphere.

Computing the way light reflects off things or passes through them is a subject in itself. The methods have been evolving and becoming more like a study of physics every year. It is now routine to define the subtle differences between the optical properties of plastic and glass, chrome and pewter, ceramic and plastic, and many subtleties in between. In the early days, all surfaces were considered mirrors, bouncing light off themselves and diffusing it equally in all directions according to Lambert's Law. Then Bui-Thong Phong created a more realistic formula that introduced more light-control variables. Now we have the Torrence-Sparrow model, which considers the object's surface to be covered with randomly oriented microscopic mirrors; this comes remarkably close to approximating real life.

What if you want to create a wooden or patterned object? You can scan a photograph or painting with a digital TV camera and project the image onto the surface of your object. This process is called mapping; it's the reverse of making a flat world map from the earth's curved surface. With a curved surface like a planet's, the
picture wraps around the object and gives it a natural-looking perspective as it moves about. You can also map certain kinds of textures onto surfaces, like the bumpiness of an orange, with each bump having its own shadow (a process known as perturbed normal texture mapping, developed by Dr. James Blinn of the Jet Propulsion Laboratory).

So far I have focused on generating a single realistic image. There are a few additional considerations if you want to animate a scene. You must choreograph the motion desired and describe it to the computer. You can trace it out on a data tablet or type in commands, like a movie director telling the actors what to do: "Go from point A to point B taking three seconds and accelerating as you move." Directions must be given in the language of the software. The motion becomes rather complicated when you have moving parts on moving objects in a scene observed by a moving camera. A classic example is a flea walking around on an elephant's head while the elephant nervously paces back and forth on a raft floating down a river. The camera's view is called the world space, the raft is a parent space, the elephant is a daughter space of the raft, and all the elephant's appendages, to say nothing of the flea, are daughter spaces of the elephant. All this is handled by a tree structure showing these various relationships.

Motion is an important element in making or breaking the believability of an image. When a ball bounces, its acceleration and trajectory tell a lot about it; a Super-Ball behaves one way, a Nurf Ball another. To more precisely portray motion, some computer-graphics designers are beginning to incorporate artificial-intelligence routines into their software.

The last step involves turning the millions of bytes into a picture on a monitor or a piece of film. Essentially it's a straightforward process of converting digital data to analog form. You can then record the signal on videotape or display it on a monitor. In the case of movie film, the signal paints the picture on a high-resolution monochrome video display mounted beneath a movie camera that shoots one frame at a time. The camera's shutter stays open while the computer generates three consecutive images, using color filters for each of the three primaries.

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Why not just take a camera and film the real thing? Obviously, if you can film the real thing, you should. But if you want to film a Model T turning into a Thunderbird, in an improbable but believable organic metamorphosis, scene simulation is the only answer. Or, if you want impossible camera angles, like an atom's-eye view of a molecule, or a tour around the inside of a computer chip (anything that defies the physically possible), image synthesis is often the only way to go. Frequently used in TV commercials, this technique promises to become in the near future an economical alternative to constructing movie sets and to some kinds of location shooting. Image synthesis is important in other fields too, such as medical CAT-scan imagery, product design, and flight simulation. As miniaturization progresses, we can look forward to many of the capabilities now available on mainframes becoming possible on microcomputers.

There are obviously a great many doors opening in computer graphics today. I interviewed several major figures in the field, including John Whitney Sr., generally regarded as the “Father of Computer Animation,” and Dr. Alvy Ray Smith, who is working on George Lucas's remarkable computer-graphics research and development project. The insights and advice from these experts cover all aspects of the field. They occasionally even contradict one another, which doesn't mean one is right and the other wrong, but rather indicates that this business is still very much in its formative years.

Alvy Ray Smith (Lucasfilm)

The work being done at Lucasfilm is revolutionary and almost certain to have a profound impact on the entire entertainment industry. George Lucas, creator of the Star Wars saga, became interested in the possibilities of computers several years ago, hired a team of the best software and hardware people he could get, and gave them a mandate to develop a system that would bring motion-picture special effects into the 21st century. He actually wanted several different systems to provide different capabilities: computer imagery, digital matting, sound synthesis and mixing, a laser scanner to print the final product onto film with first-generation quality, and a totally computerized editing studio called EditDroid, with all the footage shot for a film on video-discs, enabling totally interactive editing.

The team developing the Pixar image generator included Rodney Stock, Adam Levinthal, Mark Leather, Glenn Sharp, and Tom Porter on hardware; Alvy Ray Smith, Rob Cook, Bill Reeves, Sam Leffler, and Loren Carpenter on software; both groups were directed by Dr. Ed Catmull. They set a three-year goal and put their noses to the grindstone, pausing only briefly to create film footage—the “Genesis Demo” for Star Trek II and the display of the force field around the moon of Endor in Return of the Jedi. The work progressed on schedule despite the inevitable difficulties, but rumors of failure began to circulate among the competition.

My first question to Smith concerned whether the project was doomed. “These rumors probably came about because people have been expecting us to do all this in three weeks. All prototype devices have difficulties—that's normal. We said it would take about three years; the three years are just about up, and the system is just about to roll out the door. We’re very pleased. The boards for our Pixar are starting to come in, our laser scanner is now making color moving pictures, software systems are up, and we’re doing a little inhouse film with motion blur and all to demonstrate the system’s capabilities.” (Motion blur, sometimes called temporal anti-aliasing, is very difficult to simulate, but it adds a great deal to the natural quality of an object's motion.)

Why did Lucasfilm decide to build their own hardware from scratch, with all the time and risk involved, instead of buying a system off the shelf? “You can’t just buy something like that,” Smith said. “True, there are supercomputers that we would be glad to use, but even they are a little slow for what we want to do. So while we are waiting for the price of these machines to drop, we are building a machine especially designed to implement graphics algorithms—one that costs significantly less.

“You know, we are not limited to scene simulation, so I much prefer
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the term computer imagery. Reality is only a measure, not a goal.”

Advice? “It’s not easy to get into computer graphics, but I suspect it’s going to get easier. People will be making pictures with computers from now on, and anyone who knows how will be in demand. Go to school and learn how to program; find out how graphics algorithms work.”

Photos 2 and 3 are examples of Lucasfilm’s work.

Patricia Cole (Atari)
The people at Atari’s advanced graphics research and development division are interested in both games and motion-picture special effects and work at times with Lucasfilm. Pat Cole is in charge of the division and was previously with Lucasfilm, the Jet Propulsion Laboratory, and NASA.

The creation of the computer-generated visuals for Superman III in 1982 was one of her first jobs. “Superman needed the immediate visual impact of a video game, but with better than current game technology. We decided to do a two-and-one-half-dimension computer animation. [Flat images with some spatial aspects are called 2½-D.] We built a software system for this on top of an existing system we use to develop our games, programming in LISP on a Symbolics LM2 under Paul Hughett’s leadership. In the meantime we have also been establishing a full-blown three-dimension image synthesis animation facility—technology which is literally right around the corner for us. This is primarily oriented toward developing videodisc games, but we aren’t drawing too many boundaries. As the facility grows and develops a personality of its own, we want to be able to do other types of projects.”

Cole offered some advice. “The first decision a person has to make is whether they’re more interested in the creation aspect or the technical aspect. This isn’t necessarily an either/or situation, but the ideal is to have some people who are primarily creative and others who are primarily technical, knowing that talents overlap and merge. I don’t encourage artists to go back to school and get a degree in math, but you should get as much experience, even working on a home computer, and exposure—going to conferences and seminars, like SIGGRAPH—as you can. Become familiar with the jargon and with the capabilities and boundaries of the technology. Similarly, people with a technical background would benefit greatly from a basic course in design and from visiting art museums and getting an appreciation of the artistic world. The ideal goal is a common visual vocabulary, a common communication, so that this overlapping knowledge can increase.”

John Whitney Jr. (Digital Productions)
The world’s most powerful production computer, according to The Guinness Book of World Records, is the Cray XMP. The first of these magnificent beasts belongs to Digital Productions, a company founded by John Whitney Jr. and his associate Gary Demos. (Photo 4 was created by Digital Productions.)

Growing up immersed in state-of-the-art movie technology, Whitney did the first computer graphics for Hollywood movies, WestWorld and FutureWorld, at Information International Inc. (Triple-I), working with Demos. They coined the term Digital Scene Simulation*. In 1982, Whitney and Demos got the funding they needed to lease their first Cray 1/S. It had about one-third the power of the current model, but it was the most powerful machine available at the time. Soon after they opened shop, Lorimar Productions brought them their first job: to do about 40 minutes worth of simulation for The Last Starfighter.

“Getting the XMP is a major development. The combination of the new hardware and continued improvements in software will give Digital Productions a major thrust forward. Databases of 1 million polygons on the 1/S computer began to require an unacceptable amount of time per frame. We hope to compute scenes with the XMP on the order of 1 million polygons plus and still maintain a speed of 200 seconds per

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frame, where we like to be. Even so, our appetite for greater scene complexity never seems to end.”

To talk to the Cray, Whitney explained, “Digital Productions uses a VAX 11/782, which is a user-friendly, interactive front-end processor. The VAX provides a programming environment for software development and handles front-end operations for productions that are not practical on the Cray. We also have the Cray I/O [input/output] subsystem (a buffer memory and multiple-processor computer that provides access to the XMP high-speed channel) in operation at this time. The high-speed channel is required to optimize high-bandwidth data transfer, desirable for film recording and scanning operations, and to more efficiently utilize color-monitor workstations.

“Many organizations today claim to use computers for special effects, but the claims are often exaggerated. Using an Apple, for example, in a process- or numerical-control installation [i.e., a small computer running a mechanical process such as a motion-control rig] hardly constitutes computer graphics. Also, many creative and talented art directors are working with computer graphics where the computer output is only a small part of the end product. I would advise art directors not to become used to this sort of interim, transition-level computer graphics. Simulation implies an ability to create live action with a high-performance computer. In special-effects production, this means that the struggle to combine a half-dozen different techniques is as passe as a turn-of-the-century sweatshop. The challenge to the art director who wants to create something unique and refreshing is to remain open-minded in exploring mature simulation opportunities.”

Whitney’s advice: “A background in computer science oriented toward graphics is certainly a basic requirement. Beyond that, if someone is serious about pioneering in the field, then numerical analysis and very high-level mathematics are mandatory. There are a few institutions, MIT, Cornell, and the University of Utah, that offer graduate educational opportunities in computer graphics.”

Lance Williams (New York Institute of Technology)

People in the field consider the New York Institute of Technology (NYIT) to be one of the foremost centers for computer-graphics research and development. (See photo 5.) NYIT is also a hardware producer and a production facility for all kinds of state-of-the-art animation. The Computer Graphics Lab was founded in 1974 with Ed Catmull (now with Lucasfilm) in charge. Many greats in computer graphics, including Jim Blinn and Alvy Ray Smith, have passed through its doors and contributed to the evolution of very intensively. The company is building systems for industrial video applications capable of doing two-dimensional and some three-dimensional animation with the new Sony microcomputer. The system is a natural for a videodisc arcade game that overlays real-time graphics on top of the disc images.

I asked Howard Gutstadt, GESI’s vice president, why the company uses the Sony instead of a more popular machine. He responded, “One strong rationale is that the Sony is designed to interface more effectively with video-type applications than other micros. It combines an inexpensive approach to computer graphics with a reasonable color palette and a sophisticated approach to machine control of videodiscs. It contains all the necessary I/O to control the associated machines. In addition it has two other very important features: genlockable input for video (the computer can be on line between the source materials and resulting video materials and still give you video that meets the standards of the National Television System Committee; for microcomputers that’s a real pain to achieve) and specialized circuits (you can integrate the graphics you generate with the disc material, avoiding the need to buy a post-production switcher). In addition, you can write any interactive scenario in software and run it with graphics from a floppy. And it’s all relatively inexpensive—the central processor is less than a thousand dollars.”

Howard Gutstadt (General Electronic Systems Inc.)

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Photo 6: An X-Wing fighter done by Art Durinski at Information International Inc.’s now closed motion-picture division. (This image was created for the cover of IEEE Computer.) The successful simulation of the Star Wars spacecraft convinced George Lucas that scene simulation is an important special-effects tool.

NYIT has a computer-graphics course taught by Robert McDermott. In addition, there are computer painting facilities in the design department, computer special-effects facilities in the TV department, and an Evans & Sutherland Picture System with three-dimensional modeling capabilities in the architecture department. NYIT’s main facility, however, is an independent research and development department that is not part of the school proper. “We have hired students here to work as computer operators,” said Williams, “but there are not enough people involved to recommend this as an entry into a career.

“Usually I recommend that you get a technical background; even if your major interest is design, it will help a lot to have technical skills. You’ll be able to do more with the machine and to get jobs. You have to acquire some technical expertise. The first thing is to learn a trade, a basis you can build a career on, developing some sound, expensive skill. You want to become a good programmer and a good animator. Animation is a dying art. There aren’t many places that teach it anymore. [Exceptions include the California Institute for the Arts and the Rhode Island School of Design.] Also learn as much as you can about photography. Computer graphics is an exploding field. The opportunities are springing up everywhere, although the competition is stiff.”

Art Durinski (Freelance Designer)

Tron, unfortunately, wasn’t a blockbuster movie. Consequently, the moguls of motion pictures threw the baby out with the bath water and assumed that the public wasn’t interested in computer graphics. That was very unfortunate for many computer-animation companies. The firms were expecting a lot of business after Tron and some of them went out of business instead. Triple-I, which had done the Solar Sailer and the MCP for Tron, closed its motion-picture division within a year of the movie’s release, putting some of the most talented engineers and designers out on the street. This included designer/director Art Durinski. For a while he worked with Digital Productions, but eventually he decided to go independent as a freelance consultant.

“The popularity of computer graphics in entertainment,” he said, “isn’t rising as quickly as expected. It’s going to take a major successful movie. Hopefully, Starfighter or Gogol 13 will be nicely stylized and have a good story. That could do it. In four or five years, people will accept the computer look as a new kind of reality. (See photo 6.) I don’t agree with the philosophy that everything must look photographically real. Computer graphics should have its own unique and exciting look, and not necessarily try to pass itself off as real. Tron and Fantasia were never
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meant to look real, but they hold together beautifully.”

Durinski’s advice: “If you are excited about this field, just coming out of school, changing careers or whatever, I don’t think that there is an easy way into three-dimensional computer graphics in entertainment yet. You might get a job at an analog house first and then migrate into three-dimensional animation when a job opens up. The situation in TV is much better than in films right now, but the opportunities are not really there yet.”

James F. Blinn (Jet Propulsion Laboratory)

One of the foremost innovators in scene-simulation software, Dr. James F. Blinn, studied at the University of Utah in the early 1970s. Dr. Ivan Sutherland was teaching there then and it was a mecca at the time for people interested in computer graphics. Since then, Blinn has worked at a number of places including NYIT, Triple-I, and Lucasfilm, but mostly at the Jet Propulsion Laboratory at Cal Tech. There he combines his three loves: computer graphics, astronomy, and teaching. His animations of the Voyager missions to Jupiter and Saturn are very well known, having been broadcast by all the national networks when the spacecraft was passing those planets (see photo 7). The imagery was so realistic that many people were puzzled as to which were the synthesized pictures and which were the real ones sent back by the ship’s cameras.

Blinn is currently doing animations illustrating the laws of physics for Community College Television’s series, “The Mechanical Universe.” He is working with Cal Tech professor David Goodstein, the writer/designer of the series. One program, for instance, shows how the movement of the planets is a natural consequence of Newton's laws of motion, and why the planets have elliptical orbits. The animation is done on a VAX 11/780 with a DeAnza frame buffer and is recorded on 1-inch tape using a Lyon/Lamb controller.

When asked about the poor performance of Tron at the box office despite the beautiful special effects, Blinn pointed out, “A human being makes a good movie—not a committee. Powerful figures like a George Lucas or an Alfred Hitchcock make a good movie because it's their movie, their creative energy. They don't have a group of bankers telling them what to do.”

Although many people in computer graphics demand state-of-the-art systems, Blinn’s reaction to that approach was, “State-of-the-art
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Blinn recommended a formal education as the best way to get into the field. "I went to school and studied computer science."

David Em (Artist)

Probably the foremost computer-graphics artist in the world today is David Em, an eclectic whose interests include painting, theater, and dance. His fantastically complex digital creations (see photo 8) rely heavily on the computer's capability to take an existing image and work with it, making it three-dimensional, mapping it onto a cylinder or some other complex geometrical shape. Much of his work has been done at the Jet Propulsion Laboratory, using James Blinn's software. He builds gem-like environments of staggering complexity with a technique of repetition (pictures inside of pictures inside of pictures).

Em's artistic talent first bloomed as a child in Colombia. He gained a reputation as a painter and sculptor many years before becoming involved in electronic media. "It's been 10 years since I decided to go into the electronic side of things. But before I had even heard of computers I was making sculptures in factory environments. To do that I had to work with complex machines and establish relationships with the company president, the supervisor, and the worker who operated the machine. I didn't realize at the time that I was learning the skills that would enable me to work with programmers, managers, and high-tech scientists later on.

"You must learn to interface with personalities as well as with machines. There are three fronts that all have to be kept up: you have to have your machine act, your people act, and your creative act all working in parallel."
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"The first computer I actually worked with was at the Xerox Palo Alto Research Center in January of 1975. It had that first frame buffer that Dick Shoup got up and running. At that time Alvy Ray Smith was there with David DiFrancesco, and they had written one of the early Super Paint programs. I made my first picture about an hour after my introduction to the computer system. You don't need two years of technical study to make a picture. True, the more you know about the medium, the better off you are, but since the programs were fairly interactive, I was able to create a picture practically from scratch. I kind of discovered this new medium that I knew had to exist. The frame buffer was like a mystical revelation—I'd actually been looking for this specific instrument. Everyone said it didn't exist but there it was! Then the whole operation there shut down later in 1975 and eventually I came back to Los Angeles."

"Then I was at Triple-I for about a year after they did their historic simulation of Peter Fonda's head for the movie *FutureWorld*. That was a very different experience than I had with Xerox. The Triple-I system wasn't interactive at all. Even though it was a much more powerful system (high resolution and all), it was not a viable creative tool for me. I didn't know what a picture would look like until it came back from the film lab three days later. A frame buffer gives you instant, interactive control over what you're doing. When you make a picture, whether you're a designer or a filmmaker, you make millions of little decisions that you don't think about until you have to start specifying them."

During this time Em established a relationship with the Jet Propulsion Laboratory. Working late at night when the equipment was available, Em began using digital paint, texture mapping, and other leading-edge processes that had synthesized the solar system for NASA, to create his own fanciful universe.

"If you're pushing the state of the art, the process is more important than the parts. You have to get every-thing working and talking together. Some of these processes are as old as the hills, like storyboard, and some of them are the latest capabilities that civilization has brought us. The computer is just one of these elements."

Em offered some advice. "You might be surprised at how quickly you can apply your existing knowledge, expand it, and do the things that are peculiar to the high-tech medium. You don't need five years of programming or math. Those fears that creative people have are a psychological block more than anything. Just start doing computer graphics on any level, whether it's in a class or on your own. The actual action of doing it is very important even if it's in a very rough way. Once you start, one thing leads to another. Oddly enough, computer graphics is a scene, so go to things like SIGGRAPH in your town. Find out what's going on and who's doing it. Find out who the personalities are."

**John Whitney Sr. (Filmmaker)**

John Whitney Sr., with his brother James, and his three sons, Mark, Michael, and John, literally pioneered the craft of computer animation. Today he teaches at UCLA and lectures widely on the subject. (See photo 9.)

Whitney recalled the early days. "I started in the 1950s using the high-quality analog computer systems that came out of World War II. They were designed to solve the complex ballistic equations of fire control for the anti-aircraft gun batteries, and here I was making design machines out of them! I didn't have any engineering background at all when I began to adapt this kind of equipment. I didn't realize how significant it was that they represented the beginnings of the advanced problem-solving computers. In a sense, I stepped backward into computer graphics. Only after I became competent with the equipment did I begin to realize that I was really trying to build my own computer. By the 1960s, industrial computer graphics was underway and being used extensively in scientific circles. I applied to IBM for a research grant in 1965 and benefited from it until 1970."

"I would never claim to have foreseen the coming of computer graphics as it is now. It was the other way around—I could see that my vision of abstract design and color, in completely pure, fluid motion, was going to be quite possible with computer systems. In fact, a year or two after I started, I made a film showing the scene involved in making computer-graphics films! But I expected that the systems would become smaller, cheaper, and faster, and that one day I would have one, the size of a television set, in my home. Ten years later, that's exactly what I have."

"I am confident that we will be able, in a single system, to compose music and color design, bringing a brand new world of rhythm and action ready for a brand new breed of artists and composers. There's no question that it will start the same kind of cultural and social phenomenon that has always been true in music. The only reason we have outstanding rock singers and pop-music composers is because for every one that makes it to the top, there are hundreds of thousands of youngsters teaching themselves to play musical instruments and to sing, aspiring to succeed in music. It's important to have in the composer's hands the power to compose both sound and image in a totally interwoven and integrated relationship."

**Carl Rosendahl (Pacific Data Images)**

If you have a difficult time getting a job in computer graphics, you might consider Carl Rosendahl's approach. Fresh from school with a degree in electrical engineering, he started his own company on a shoestring. In a short time his company has grown to where it is doing work for national and international clients, including the opening animation for "Entertainment Tonight" (see photo 10).

"I started the company three years ago, and the first year and a half I was alone, trying to figure out computer graphics. I knew computers pretty well, and I knew film, because I grew
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In the case of our new (not to mention amazing) ShuffleBuffer, computer time is 60 seconds flat. Just give ShuffleBuffer one form letter and your address list, and it takes care of the mixing, the merging, and the printing. But that's not all ShuffleBuffer's stolen from the computer. Oh, no.

Who Changed and Rearranged The Facts?

Again, ShuffleBuffer's the culprit. You want to move paragraph #1 down where #3 is? Want to add a chart or picture? No problem. No mystery, either. Any buffer can give you FIFO, basic first-in, first-out printing. And some buffers offer By-Pass; the ability to interrupt long jobs for short ones. But only ShuffleBuffer has what we call Random Access Printing — the brains to move stored information around on its way to the printer. Something only a computer could do before. Comes in especially handy if you do lots of printing. Or lengthy manuscripts. Or voluminous green and white spread sheets. And by the way, ShuffleBuffer does store up to 128K of information and gives you a By-Pass mode, too.

And Who Spilled The Beans 239 Times?

Most buffers can't tell the printer to duplicate. If they can, they only offer a start/stop switch, which means you're the one who has to count to 239. Turn your back on your buffer, and your printer might shoot out a room full of copies. ShuffleBuffer, however, does control quantity. Tell it the amount, and it counts the copies. By itself.

So, What's The Catch?

There isn't any. Sleuth around. You won't find another buffer that's as slick a character as this one. You also won't find one that's friendly with any parallel or serial computer/printer combination. This is the world's only universal buffer.

With a brain.
up in Los Angeles and made movies all through high school. I spent that first year with a little Cromemco computer, reading the SIGGRAPH proceedings and figuring things out. Then I got a PDP 1134. That's when Glenn Estes and Richard Chong joined me, and we spent the next year developing software. Six months later we got the VAX 11/750, and although it took three weeks to get the VAX running, it only took about 36 hours to load all the software and have it up and running. Then in May of 1983 we opened our doors for production."

"We do everything in video resolution, 512 by 486, 24 bits per pixel, so it's full color and it's all anti-aliased so you don't get any jaggies. Each picture takes a quarter of a megabyte, so a 10-second spot generates about 225 megabytes of picture data. When you get into 60-second commercials, there are gigabytes of data. All our machines are running Unix, and all our code is written in C. There is no assembly language or microcode that allows us to develop code on one machine and run it on all the others."

Rosendahl's advice: "An understanding of the geometry and math involved and good three-dimensional visualization are really important because the modeling and motion design must happen in your head before they can happen in the computer. Being able to visualize what you're building is very necessary. If you want to work closely with the clients on production, you have to be able to communicate with them artistically rather than technically. There is also a big need for people doing development-creating the tools to use in production-where artistic ability isn't as necessary."

Bill Kovacs (Robert Abel & Associates)

Bill Kovacs is a software designer and vice president of Robert Abel & Associates. He came to Hollywood to work with Robert Abel on the special effects for Star Trek, The Motion Picture. He devised a way to use an Evans & Sutherland Picture System to preview choreography that would ultimately be filmed with models on a motion-control rig. Although politics and production problems eventually took the Star Trek work elsewhere, the computer-graphics work proved so successful that it became a mainstay of Abel's special-effects business.

Recently, Kovacs used the new IRIS computer from Silicon Graphics to assemble a raster system capable of scene previewing, which is a formidable tool in the hands of the company's designers. "It's the first unit shipped in the U.S.," he said, "and it's wonderful. It can do real-time shaded graphics of limited complexity, or it can do nonreal-time graphics of very high complexity. And it's totally compatible with our Unix system. It runs on Ethernet, the in way to connect one computer to another."

In addition to commercials for Corvette, 7-Up, and TRW, Kovacs and the Abel team recently did the animation for a videodisc arcade game, Cube.

Photo 9: Pioneer computer animator John Whitney Sr. in 1959, operating one of the first computer-graphics engines, a mechanical analog computer built largely from surplus World War II anti-aircraft guidance hardware. The camera is in the upper left, aiming down through the apparatus that "paints" the film with light. (Photo by Charles Eames.)
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The concept is to give them access to sophisticated programs that will teach them the fundamentals of two- and three-dimensional computer image generation. We are using software especially designed for this course and written for the school's Atari computers by Jim Blinn and Bob Schaff. The students are not learning programming, they are learning use. Until now, most computer-graphics courses have been in engineering schools because that's where the tools were. As a result, most people in computer graphics tend to be engineers. But computers have been liberated from the domain of the engineers and put in the hands of all kinds of people, including artists, with the advent of the personal computer.

“I believe that you should have an education in the process; you should learn about elementary programming—even if you're an artist. That doesn't mean you're going to be a programmer; it means you should be able to talk to programmers. Whatever industry you want to work in, people want to hire trained people. It's much more expensive to train people on the job, so it makes sense to go to a school where you can learn computer graphics. The question is, what is your background, and what do you want to do?

“The other way to get into the business (if you're not going to go through an organized program or the course doesn't exist) is to beg, borrow, or buy a small computer (an Apple or Atari being the low end) and teach yourself. There are a lot of books and tutorials on how to do it. Basically, it's a question of technique. That's the way to get started and find out if it's for you—because it's not for everybody.”

Charles Csuri (Cranston/Csuri)

For over a decade, Charles Csuri has taught computer graphics at Ohio State University. He and his students wrote a lot of highly interactive software that has advanced the state of the art. Recently he formed a company, Cranston/Csuri, that quickly caught everyone’s attention for its attractive ray tracing and sophisticated medical imagery. The firm's demo reel won several prizes, including grand prizes at the Tokyo International Computer Animation Competition and the London Competition. Cranston/Csuri is talking with several personal computer manufacturers about putting together a three-dimensional, key-frame animation system. The company currently uses VAXes but is “sticking to our guns and working on a multiprocessor system of our own design.”

Csuri, interested in artificial intelligence, said, “I have several excellent graduate students trying to put together an expert system for three-dimensional character animation that will control a figure so that it moves very smoothly. (See photo 1.) There is a lot of exciting discussion going on—what sorts of tasks does an animator do that could be automated in an expert system to facilitate decision making? As far as I am concerned, this is the future of character animation, but the problems are very difficult. The easy problems have been solved, but there are a whole bunch of nasty, difficult things that are still out there.”

Csuri advised, “It's really important to have a tutor or mentor, to be
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Photo 11: Chrome Dog, created by Gene Miller. A new mapping process being developed at MAGI by Miller is dramatically demonstrated here, along with the capability to digitally compose a synthetic image on a real background. First, an object is modeled from ellipsoids, the primitives are blended together using Miller's Fuse Body program and then surrealistcally combined with a shot of MAGI's parking lot scanned in video digitizing. Then, to get a wide-angle view of the parking lot, MAGI photographed a silver Christmas tree ball and scanned it in. Finally, the reflected image is mapped onto the object and voila!—instant chrome dog. (The author is grateful to MAGI for the use of this experimental image.)

around someone who has a lot of experience. That means getting access to this kind of person by joining a lab or company or by getting into an academic setting. In a recent meeting of 150 college deans in Dallas, we asked who would have jobs for our graduates, and over two-thirds of them raised their hands! It's very clear that there is a need for trained people in the field."

Phillip Mittelman (Mathematical Applications Group Inc./Synthavision)
The first company to do computer scene simulation was MAGI (Mathematical Applications Group Inc.), which produced a shaded picture for the cover of Computer World magazine's first issue, in 1967. (An example of MAGI's work is shown in photo 11.) Actually, MAGI sort of backed into its role as filmmaker because it originally conceived its ray-tracing software programs for civil and governmental studies of nuclear particles and radiation. Dr. Phillip Mittelman, the founder of MAGI, recalled, ""The technique we had developed was one where you describe the world as made of three-dimensional objects, and you trace radiation—neutrons and gamma rays—around through this three-dimensional environment. We observed that if we traced light rays around instead, we had, in effect, simulated photography. That's the basis of our whole idea: you track the light rays and find out what the color and intensity would be at each point on the film. Bob Goldstein was the person who adapted our radiation programs for picture making, working on it alone for a long time. So, MAGI's Synthavision process, which today is very fast and efficient for moviemaking, rests..."
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on a bedrock of radiation transport technology.

“We were totally independent and out of touch with the picture making that was going on at the University of Utah and places like that in the early days. At one time we showed some of our work to some IBM people and they said, 'My gosh, you've solved the hidden line problem!' We were really quite naive. We said, 'What's a hidden line problem?' With ray tracing, since you follow the ray until it hits something and then bounce it off, you don't concern yourself with what's behind that surface. There could be a thousand objects behind it; we didn't care. The first animation we did, probably the first shaded computer animation ever done on a commercial basis, involved three-dimensional lettering for IBM's Office Products Division. That was at least 12 years ago.”

MAGI recently got a new computer, a Gould SEL 3287, “a real number cruncher,” roughly one-third the speed of a Cray for a small fraction of what a Cray costs. “It's literally eight times faster than the computer we used for Tron,” said Larry Elin, an art director for 10 years with the company. “We find that we wind up making pictures that are eight times more complicated. It's interesting that when you get a faster computer, you don't make faster pictures—you make better pictures!” MAGI is also working on a system called Synthamation for rapidly combining computer animation with hand-drawn animation for large-scale productions. It gives the animator unprecedented freedom to move around in the scenes and gives the characters an airbrushed, three-dimensional look.

Richard Moszkowski

Having discussed the state of the art with so many movers and shakers in the computer-graphics business, it seems appropriate to wrap up the story with a young man in the trenches. He is a self-described hacker/survivor/dreamer whose talent in programming graphics has led him to some enviable jobs. In just a few years he has gained experience and an excellent overall vision of the field. Richard Moszkowski, a student at UCLA in the late 1970s, started as a programmer for John Whitney Sr. He then worked for some game companies (designing a game built into a watch) and Digital Productions (where he worked around the Cray). Now back to games again, he is designing a light pen and stereo three-dimensional glasses for the Vectrex machine.

A free agent and therefore uncommitted to plugging the virtues of any particular system, Moszkowski was a likely candidate to offer an unbiased assessment of where things are and where they’re going.

“One indicator of how things are now is that the equivalent of Ivan Sutherland's Sketchpad program is running on microcomputers. That software marked the beginning of computer graphics for mainframe machines in the 1960s at MIT. On the other hand, we now have the use of supercomputers for motion-picture animation. And this year we have the 32-bit computer-on-a-chip, such as...
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the 68020. DEC [Digital Equipment Corporation] is coming out with their Micro-VAX, National is introducing their 32032, and there are 256K RAMs coming out. Finally, the Weitek array-processor chip has hit the scene, capable of doing 10 million floating-point instructions per second—for 600 bucks! Weitek is developing what we want: supercomputers on VLSI [very-large-scale integration] technology.

"There are two ways that the super graphics machines of the future will be built," Moszkowski said. "One is bigger and faster computers, single-instruction, hundred-megahertz machines. In this case you're limited by the heat dissipation. As you go faster and faster, the heat rises incredibly, and so does the cost. The other, what we're going to witness in the next three or four years, is micrographics engines one-tenth the speed of a Cray, 10-megahertz machines made of off-the-shelf components. They will consist of a 32-bit VLSI chip, about 8 megabytes of RAM [random-access read/write memory], some kind of floating-point coprocessor, a floating-point array processor, and possibly also some cheap little Z-buffers.

All this will fit onto one or two boards and will cost a few thousand dollars. That's great—a real number crunching microcomputer as opposed to just a data-processing micro. The next thing they will do is put a couple of these together, and then another and another. Pretty soon there'll be scores of them together in racks. Each of them will process individual frames of film, and working together they'll crank out film faster than a supercomputer. So, when you walk into the room, it will be like walking into the Disney studios where you see a lot of little baldheaded guys with glasses, each doing their own frame, only you'll see rows and rows of little blinking LEDs [light-emitting diodes] instead.

"I grew up on micros, I've seen them grow, and they are really going to take over. When you can put a hundred thousand gates on a single integrated circuit and sell it for under 50 dollars a chip, there's no way to stop it. That's just what the future is going to be. We are taking grains of sand, which are common and cheap, produced with more efficiency than anything in our society. When you start putting them together, they become an entity that is more than the sum of its parts. I don't think the day is too far away when you will be able to make your own computer-animated movies at home."
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Simulation of Weighted Voting: The Banzhaf Index

Sometimes the little guy carries the big stick

by Philip A. Schrodt

In this election year it is fascinating to try to determine how major political parties choose their candidates and get them elected. The candidates must please as many people as possible and make involved political deals and trades. The Banzhaf index, an approximation of voting power, explains how the dark horse can end up as the front runner.

Consider the following situation: a parliament containing four parties meets to form a government. The parties control the following votes:

<table>
<thead>
<tr>
<th>Party</th>
<th>Votes</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>225</td>
</tr>
<tr>
<td>B</td>
<td>198</td>
</tr>
<tr>
<td>C</td>
<td>73</td>
</tr>
<tr>
<td>D</td>
<td>42</td>
</tr>
</tbody>
</table>

The party that can assemble a coalition containing a majority of the votes (270) chooses the prime minister. From which party is the prime minister chosen? Looking at party sizes, you would assume party A, with 41 percent of the votes, or possibly B, with 37 percent, because these are considerably larger than the others. In fact, the prime minister comes from party C, with only 14 percent of the votes. Why? Because of coalitions.

There are a total of seven possible coalitions with more than 270 votes: AB, AC, ABC, ABD, ABCD, BC, and BCD. No other coalition has enough votes to form a majority. You can reduce the number of coalitions even further because the parties want to keep the coalition as small as possible. You form coalitions by promising ministerial posts to potential partners. Only a limited number of posts exist, and each party wants to control as many ministries as possible. Therefore, the practical number for a coalition is just enough votes to form a majority, but no more. These are called “minimum winning coalitions,” or MWC, a concept developed in detail by William Riker (see reference 3).

The MWC principle reduces the coalitions to AB, AC, and BC. Notice that party D entirely disappears from the calculations. There are no circumstances in which a minimum winning coalition needs to include D, so even with 8 percent of the votes, party D is irrelevant. The remaining parties are equal, despite the disparity of votes, because each one must join another to make a majority. If, in addition, you rule coalition AB out because the two major parties don’t want to share power, party C becomes the sole determining party and, therefore, claims the prime minister position. Party C, with only 14 percent of the votes, plays a pivotal position.

This situation is not hypothetical; it is a simplified version of the Italian Chamber of Deputies after the June 1983 election. The large parties are the Christian Democrats (A) and the Italian Communist party (B). Party C is the Socialist party. The prime minister of Italy, Bennito Craxi, is a Socialist.

Table 1 analyzes the Italian Chamber of Deputies with Banzhaf indexes, measuring the proportion of the time a party is pivotal in an MWC. In the 1983 election the two leading parties had roughly 67 percent of the parliamentary votes between them. However, since they were unwilling to form a coalition, they had less than 40 percent of the Banzhaf power. The Socialists had 27 percent of the Banzhaf power even though they had a mere 7 percent of the votes. They used that power to gain the prime minister position. The Banzhaf power is by no means the sole determining factor here, but it provides a better guide than simple vote distribution.

The Banzhaf Index

The Banzhaf index is named after John F. Banzhaf III, who first used it in a study of voting in the Nassau County, New York, legislature. In 1964 this legislature had six members with the following number of votes: 31, 31, 28, 21, 2, and 2. Banzhaf noted that in this situation the members with two votes were essentially powerless. Their votes made no difference whatsoever in the final outcome of the election. Surprisingly, this was also true of the member with 21 votes. You could have a winning majority (58 votes) with the two-member combinations [31,28] and [31,31], but even the four-member combination [31,21,2,2] did not constitute a majority. Therefore, the six-

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member legislature was effectively a three-member legislature.

The Banzhaf index is simply the probability that a particular voter or party will be a pivotal member in a winning coalition (when all coalitions are assumed equally probable). A pivotal member is one whose departure can cause the coalition to lose. A member who is not pivotal has little political pull because the other coalition members lose nothing if he or she leaves. The Banzhaf index is one measure of the influence that a member or party has on a legislative body.

If every member has a single vote, then all Banzhaf indexes are equal to 1/n, where n is the number of votes. The index becomes more interesting in weighted voting situations, where members or parties have different numbers of votes.

Weighted voting situations occur in a number of different situations. The most familiar one for political scientists is the multiple-party parliamentary system, like the Italian example above, in which parties must assemble a winning coalition to form a government. In Israel the Likud coalition has a bare majority in parliament; thus, tiny fringe parties in that coalition become pivotal and have substantial power over government policy.

Weighted voting occurs in a variety of other situations, such as corporate stockholders' meetings, where the voting is based on the number of shares owned. A variety of international organizations, including the International Monetary Fund and the European Economic Community, use weighted voting. Even the United Nations Security Council, with its veto power for the five permanent members, can be analyzed with the Banzhaf index. As Riker and Ordeshook (reference 4) show, the five permanent members have 98 percent of the Banzhaf power while the 10 nonpermanent members share the remaining 2 percent.

The electoral college used in presidential elections in the United States is another example of weighted voting. Table 2 gives the Banzhaf power of the various states in determining the outcome of presidential elections. Two things are clear. First, the Banzhaf power does not differ dramatically from the proportional power—as is usually the case when large numbers of voters are involved. Second, the Banzhaf power favors large states over small. This partially compensates for the electoral college itself, which favors small states over large. The Banzhaf power per person in the larger states is more evenly balanced than the proportional power per person.

“Quarreling members” affect the Banzhaf indexes as well. In Italy the two largest parties, the Christian Democrats (DC) and the Communists (PCI), will not enter a coalition together. The small parties of the political center—the Socialists, Republicans, and Liberals—therefore have a disproportionate amount of Banzhaf power, roughly double their proportional power. Italian parliamentary coalitions are extraordinarily unstable because of the impossi

<table>
<thead>
<tr>
<th>Political Party</th>
<th>Votes</th>
<th>Proportion</th>
<th>Banzhaf Index</th>
<th>Banzhaf without DC-PCI Coalitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Christian Democrats</td>
<td>255</td>
<td>.357</td>
<td>.324</td>
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<tr>
<td>Communist</td>
<td>198</td>
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<tr>
<td>Socialist</td>
<td>73</td>
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<td>.270</td>
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<td>Italian Social Movement</td>
<td>48</td>
<td>.067</td>
<td>.074</td>
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<tr>
<td>Republican</td>
<td>29</td>
<td>.046</td>
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<td>Democratic Socialist</td>
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<td>Liberal</td>
<td>16</td>
<td>.017</td>
<td>.020</td>
<td>.028</td>
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<tr>
<td>Radical</td>
<td>11</td>
<td>.017</td>
<td>.020</td>
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<tr>
<td>Proletarian Democrats</td>
<td>7</td>
<td>.011</td>
<td>.014</td>
<td>.019</td>
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<tr>
<td>Small regional parties</td>
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<td>.010</td>
<td>.012</td>
<td>.016</td>
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Table 1: The proportion of time a party is pivotal in an MWC.

<table>
<thead>
<tr>
<th>States</th>
<th>Votes</th>
<th>Proportion</th>
<th>Banzhaf Power in the United States, 1984</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>47</td>
<td>.0873</td>
<td>.0932</td>
</tr>
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<td>NY</td>
<td>36</td>
<td>.0669</td>
<td>.0710</td>
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<td>TX</td>
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<td>.0539</td>
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<tr>
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<td>3</td>
<td>.1033</td>
<td>.0553</td>
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</table>

Table 2: The Banzhaf power of each state in determining the outcome of the 1984 presidential election.

* Based on 150,000 Monte Carlo experiments. Population ratios are multiplied by 1,000,000,000.
Even so, the political center prefers to keep these two major parties at odds with each other. Coalitions must be rounded out with an assortment of small parties that control only one or two votes each. This arrangement keeps the small parties in business and gives them their power.

**Calculating Banzhaf Indexes**

You can calculate Banzhaf indexes in one of two ways. If there are only a few parties, a computer can quickly go through all possible coalitions. For a set of \( n \) parties, the number of possible coalitions is \( 2^n - 1 \). So, for example, a 10-party system involves calculating only 1023 coalitions.

For a larger system, however, exhaustive calculation becomes impossible. For example, in the 51-state United States electoral college, there are about 2,251,800,000,000,000 possible coalitions. Even at computer speeds, the time required for these calculations is prohibitive. For one coalition could be evaluated each microsecond (and it can't), the computation would require 71 years to complete. That's a bit long to wait for results. Instead, you can obtain approximate results using what is known as Monte Carlo simulation.

In Monte Carlo simulation, a random-number generator sets up coalitions randomly. The system evaluates each coalition first to see if it contains enough votes to win; if so, it determines the pivotal members. After the system generates a large number of random coalitions, the percentage of times a party is pivotal should be roughly equal to its Banzhaf index. I've used this method on systems with as many as 200 voters (presidential nominating conventions). The indexes converge fairly rapidly.

The time it takes to evaluate each coalition is greater for the Monte Carlo method than it is for the exhaustive method. For example, it takes about 1.5 times as long to run 1023 Monte Carlo experiments as it does to compute them exhaustively (53 seconds versus 35 seconds on an Apple II). The additional overhead comes from setting up the coalitions. You may need to experiment to find the most efficient means of evaluation. The 150,000 experiments used to generate table 2 took about six hours, running the Apple II with a "Mill" coprocessor. It took only 30,000 experiments, however, to produce reasonably similar results.

**The Program**

Running the program (see listing 1) is fairly straightforward. You simply enter the vote data, choose the Monte Carlo or exhaustive method, and then let the program compute the indexes. You may repeat this as often as necessary.

The first prompt in the program asks you whether you want to enter information from a .TEXT file. If you have prepared the vote data beforehand, respond "yes" to this question and give the program the filename; otherwise, enter the data directly from the keyboard.

The input consists of identification and vote information. Up to 10 lines can identify the file. Terminate this with a "null record"—a line consisting of only a Return Text continued on page 152
### VIDEO TERMINALS

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### MODEMS

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### COMPUTER SYSTEMS

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### COMPUTERS

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<tr>
<td>Transtar</td>
<td>$1445</td>
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- Corona
- Eagle
- Northstar
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Listing 1: A program to compute Banzhaf indexes using either Monte Carlo simulation or an exhaustive evaluation.

```pascal
PROGRAM BANZDEMO;
(* program for computing Banzhaf indices using Monte-Carlo simulation or exhaustive evaluation. *)
Apple II Pascal (*
(*C copyright (C) 1983, Philip A. Schrodt *)
uses applestuff;
(* Two procedures used from applestuff: *)
randomize: randomly set seed of random number generator
random: function generating random numbers with a Uniform[0,1] distribution *)
const maxvot=200; (* maximum number of partys allowed *)
var votes: array[1..maxvot] of integer; (*votes by party*)
ncex,totpivots,nid,np, mwcvote:integer; (* number of coalitions evaluated; total pivots,number of id lines, number of parties,votes required for mwcv*)
numpivots: array[1..maxvot] of integer;(*number of pivots*)
name: array[1..maxvot] of string; (* party names *)
id: array[1..101] of string; (* run identification information*)
mem: array[1..201] of boolean; (*coalition membership*)
(* Warning: change 201 to maxvot+1 if maxvot is changed *)
bi: array[1..maxvot] of real; (* Banzhaf indices*)
printflag:boolean;
totvot,nex,kz,ka,kb,nppl: integer;(* assorted counters *)
inf,pr: text; (*input file,printer*)
sta:string;
procedure banzprint;forward;
function answer(S:string):boolean;
(* writes question S and checks for 'Y' answer *)
var C:char;
begin write(S,'? -->');read(C);write ln;
if C=chr(27) then Exit(program);
answer:=((C='Y') or (C='y'))
end;
function iconv(S:string):integer;
(* converts string S into integer, ignoring all chars except numerals, and '-' . No error checking. Warning-- this is an extraordinarily forgiving integer input procedure...*)
var i,p,k:integer;
neg:boolean;
begin
i:=0;neg:=false;
for k:=1 to Length(S) do begin
p:=ord(S[k]);
if (p<58) and (p>47) then i:=i*10 + (p-48)
else if p=45 then neg:=true;
end;
if neg then iconv:=-i else iconv:=i;
end;
procedure sortfile;
(* bubble sort 'name' and 'votes' by votes *)
var ka,kb,kc:integer;
sta:string;
begin
write('Sorting data');
for ka:=1 to np-1 do begin
```

Listing 1 continued on page 144
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```
write('.'');
for kb:=ka to np do
  if votes[kb]>votes[ka] then
    begin sta:=name[ka];name[ka]:=name[kb];name[kb]:=sta;
    kc:=votes[ka];votes[ka]:=votes[kb];votes[kb]:=kc;end;
end;
writeln;
end;

procedure readstring(s:string;var n:string;var v:integer);
(* breaks out the party name and votes from input string *)
var ka:integer;
begin
  ka:=pos(';',s);
  if ka=0 then begin n:='error';v:=0;
    exit(readstring);end;
  n:=copy(s,1,ka-1);
  if ka=length(s) then v:=0
    else v:=iconv(copy(s,ka+1,length(s)-ka));
end;

procedure readdata;
(* read vote data *)
var ka,kb:integer;
sta:string;

procedure readfile;
(* read from a file *)
begin
  write('Enter file name--');readln(sta);
  if (pos('.text',sta)=0) and (pos('.TEXT',sta)=0) then
    sta:=concat(sta,'.TEXT');
  reset(inf,sta);
  nid:=O;
  repeat
    nid:=nid+1;
    readln(inf,id[nid]);
    writeln(id[nid]);
  until (length(id[nid])=0) or (nid=10);
  if nid=10 then begin
    writeln('Sorry, maximum of ten lines allowed...');
    repeat readln(inf,sta) until length(sta)=0;end
  else nid:=nid-1;

  (* read vote data *)
  readln(inf,sta);
  ka:=0;
  while (not eof(inf)) and (length(sta)>0) and (ka<=maxvot) do begin
    ka:=ka+1;readstring(sta,name[ka],votes[ka]);
    readln(inf,sta);
  end;
  if ka>=maxvot then writeln('Read stopped at ',maxvot,' parties');
  close(inf);
end;

procedure read2;
(* tail-end of READDATA procedure, which is otherwise too long *)
begin
  nex:=O;
  for ka:=1 to np do nex:=nex+votes[ka];
```
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writeln('Total votes entered: '); 
write('Enter number of votes of minimum winning coalition: '); 
readln(mwcvote); 
sortfile; 
end;

begin
  if answer('Is vote data on a .TEXT file') 
  then readfile 
  else begin (* read from keyboard *) 
    writeln('Enter identification info (null to stop):'); 
    nid:=0;
    repeat
      nid:=nid+1;
      readln(id[nid])
      until (length(id[nid])=0) or (nid=10);
    if nid=10 then writeln('Sorry, maximum of ten lines allowed...') 
      else nid:=nid-1;
    writeln('Enter party id and number of votes separated');
    writeln(' by : for each party; null record to finish');
    ka:=0;
    repeat
      readln(sta);
      if length(sta)>0 then begin
        ka:=ka+1;
        readstring(sta,name[ka],votes[ka]);
        if votes[ka]<>0 then begin
          ka:=ka-2;
          writeln('Backspace -- next entry will replace');
          writeln('name[ka], votes[ka]);
        end;
      until (length(sta)=0) or (ka=maxvot);
    if ka=maxvot then writeln('Maximum of ',maxvot,' parties allowed');
    end;
    np:=ka; npp1:=np+1;
    read2;
  end;

procedure init; (* initializes assorted parameters *)
begin randomize;
  for ka:=1 to maxvot do numpivots[ka]:=0;
end;

procedure randcoal; (* creates a random coalition and counts pivots*)
var pr,ka:integer;
begin pr:=random;
  for ka:=1 to np do mem[ka]:=(random<pr);
end;

procedure allcoal; (* this increments the mem array to get the next coalition. 
  Cycles through all coalitions by treating 'mem' as though it were 
  a sequence of binary numbers 1 to 2^np -- 'allcoal' in effect does 
  a binary add of "1" to "mem" *)
var ka:integer;
begin ka:=1; mem[ka]:=(not mem[ka]);
  while not mem[ka] do begin
    ka:=ka+1;
    mem[ka]:=(not mem[ka]);end;
end;

procedure countpivot; (* determines the pivotal members in the current coalition *)
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Circle 3 on inquiry card.
and increments numpivot array t

var totvot,ka:integer;
begin totvot:=0;
for ka:=1 to np do if mem[ka] then totvot:=totvot+votes[ka];
if totvot>= mwcvote
then begin
   for ka:=1 to np do
      if mem[ka] then if (totvot-votes[ka]) < mwcvote
         then numpivots[ka]:=numpivots[ka]+1
         else ka:=np; (*note: this shortcut assumes sorted votes...*)
   end;
end;

procedure exhaust;
(* evaluation of Banzhaf indices by computing all coalitions *)
var ka:integer;
begin ncex:=0;
for ka:=1 to npp1 do mem[ka]:=false;
repeat ncex:=ncex+1;
   allcoal;
   countpivots;
   if (ncex mod 20)=0 then write('...');
until mem[npp1];
(* stop when np+1 element of mem is 'true' *)
end;

procedure randcomp;
(* evaluates Banzhaf indices using Monte-Carlo methods *)
var ka:integer;
begin
   write('Enter number of random coalitions to generate:');
   readln(sta);
   nex:=iconv(sta);
   writeln('A "." is printed for each 20 coalitions');
   for ka:=1 to nex do begin
      randcoal;
      countpivots;
      if (ka mod 20)=0 then begin write('...');
         if (ka mod 500)=0 then write('Total coalitions: ',ka);
      end;
      ncex:=nex;
   end;

procedure banzcomp;
(* computes Banzhaf indices*)
var ka:integer;
begin
totpivots:=0;
for ka:=1 to np do totpivots:=totpivots+numpivots[ka];
if totpivots=0 then begin
   writeln('Error -- no pivots recorded');
   exit(banzprint);end;
for ka:=1 to np do bi[ka]:=numpivots[ka]/totpivots;
end;

procedure print(st:string);
begin
   writeln(st);
   if printflag then writeln(pr,st);
end;
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Circle 392 on inquiry card.
procedure banzprint;
(* computes and prints results *)
var ka:integer;
    sta, stb, sty:string;

procedure printres;(* prints individual results *)
var rato, dif, prop:real;
begin
    for ka:=1 to np do begin
        prop:=votes[ka]/totvot;
        dif:=bi[ka]-prop;
        rato:=bi[ka]/prop;
        stb:=copy(concat(name[ka],',','10'),1,10);
        write(stb,',','votes[ka]=5',' ','prop=8:5',' ','bi[ka]=8:5');
        writeln('','dif=8:5',' ','rato=8:5',' ',stb);
        if (not printflag) and ((ka mod 20)=0) then begin
            writeln('PRESS RETURN');
            readln(sta);
        end;
        writeln(sty);
    end;
end;

begin
    writeln;
    printflag:=answer('Do you want hard copy');
    if printflag then rewrite(pr,'printer:')
    writeln(' »;
    for ka:=1 to nid do print(id[ka]);
    writeln(' ');
    str(mwcvote,sta);
    writeln(concat('Votes for minimum winning coalition= ',sta));
    str(nex,sta);
    writeln(concat('Total Experiments= ',sta));
    banzcomp;
    str(totpivots,sta);
    writeln(concat('Total Pivots= ',sta));
    print(' ');
    totvot:=0;for ka:=1 to np do totvot:=totvot+votes[ka];
    sty:=concat('NAME VOTES PROP VT BANZHAF DIFF RATIO NAME');
    print(sty);
    printres;
    if printflag then close(pr);
end;

(* main program *)
begin
    writeln(chr(12)); (* clear screen *)
    writeln(' BANZHAF INDEX DEMONSTRATION PROGRAM');
    writeln(' (c) 1983, Philip A. Schrodt');
    writeln;
    repeat
        init;
        readdata;
        writeln;
        writeln('Enter Y for exhaustive evaluation,');
        if answer(' N for Monte-Carlo evaluation') then exhaust else randcomp;
        banzprint;
        writeln;
        until (not answer('Do you wish to compute additional indices'))
end.
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Circle 119 on inquiry card.
The system truncates names to 10 characters in the final index printout but they may be any length on input. The vote entry is "bullet-proofed," so if you accidentally enter a letter in the vote count, the program doesn't crash—it ignores the error. The entry \\
#%3$%#%5''") (6)
is read as 356. Terminate the vote information with a null record as before. If you enter data directly from the keyboard and find a mistake after pressing Return, enter a negative vote in the next entry to void the error. Then you can retype the previous entry. For example,

Communist: 290
Republican: 40
Liberal: 30
Christian Democrats: 320

The system puts the names to 10 characters in the final index printout but they may be any length on input. The vote entry is "bullet-proofed," so if you accidentally enter a letter in the vote count, the program doesn't crash—it ignores the error. The entry \\
#%3$%#%5''") (6)
is read as 356. Terminate the vote information with a null record as before. If you enter data directly from the keyboard and find a mistake after pressing Return, enter a negative vote in the next entry to void the error. Then you can retype the previous entry. For example,
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The system also prints file-identification information, the total number of coalitions evaluated, and the number of votes needed for a minimum winning coalition. It formats the output for an 80-column screen; if you have only 40 columns, press control-A to get the DIFF and RATIO information.

Final Remarks
I have not included any procedures for leaving out impossible coalitions, but they are easy to add. For example, to run the Italian system without the DC-PCI coalition, simply change "countpivots;" to

if not (mem[1] and mem[2])
then countpivots;

in the "exhaust" procedure. You can use this to check through a list of prohibited coalition partners before counting the pivots.

Banzhaf indexes are not a perfect measure of voting power; they are only an approximation. Their chief weakness is assuming that all coalitions are equally probable. In reality, coalitions are more likely to form along ideological lines. (The indexes can be recomputed easily with this restriction.) Second, the Banzhaf index does not take into account political maneuvering based on past favors or future promises among potential coalition partners. A skilled politician can have influence despite a weak Banzhaf position. Finally, the difficulty in computing Banzhaf indexes means that most negotiators have only a vague notion of their true power. Nevertheless, the Banzhaf index probably measures influence more accurately than the simple proportion of votes.

The upcoming presidential nominating conventions in the United States provide opportunities for parliamentary-style weighted voting, though this has not happened for a number of years. But if, for example, the Democratic party is unable to nominate a candidate on the first ballot, and if the various candidates can keep their delegates under control, then some interesting bargaining could occur to assemble a winning coalition. Jesse Jackson could easily be in a pivotal position. As these various examples illustrate, it is not the individual number of votes but the number of pivots that is important. It is misleading to look at vote totals alone. The use of Banzhaf indexes casts a light on political power that makes the unexpected a little less of a surprise.

Philip A. Schrodt (Dept. of Political Science, Northwestern University, Evanston, IL 60201) is an associate professor in the political science department at Northwestern University. He also teaches mathematical methods in the social sciences program. His book, Microcomputer Methods in Social Science Research, has just been published by Sage Publications. Dr. Schrodt, who holds an M.A. in mathematics and a Ph.D. in political science, is the originator of the generic wordprocessor concept (April 1982 BYTE).

REFERENCES

Program Availability
The program in listing 1 is available as part of a set of three mathematical political science programs. The other two programs cover the Richardson arms race model (July 1982 BYTE, page 108) and alternative voting methods. The set is available for $25 postpaid in either Apple or IBM format and includes additional documentation. It is available from the author at Polymath Associates Software, Route 1, Box 380, Clinton, NY 13323.
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Queue Simulation

A microcomputer can help you manage waiting lines

by E. Hart Rasmussen

When we wait at the supermarket checkout counter, are stuck in rush-hour traffic, or have trouble getting a telephone call through, we are in a queue. Queue is another word for "waiting line." If we could get a firm handle on how queues work, we would be able to manage them better and perhaps even eliminate them.

Simple waiting lines can be analyzed mathematically, but most queuing situations are so complex that they defy precise description. For these situations, a computer can help us. Specifically, we can use a computer to model and simulate a queuing situation so that we can make predictions about it and learn how it behaves.

There are many sophisticated commercial queue-simulation programs available, but they are expensive and for large computers only. In this article, I present an Applesoft BASIC program that can simulate many queuing problems.

Know Your Ps and Qs (Probabilities and Queues)

My doctor's nurse knows that the average examination takes 17 minutes, so she schedules three patients an hour, one every 20 minutes. At first glance, it looks as if I should never have to wait for the doctor. In reality, he needs a sizable waiting room. Why? Because examinations may take more time than expected, and patients don't always arrive on time.

A queue formation occurs when a unit that seeks a service must wait because the service facility is busy servicing another unit. To simulate a queue formation, we need to break it into its basic components.

The basic components are: the arrival of units seeking service, the interval between arrivals, the number of service facilities, and the rate at which the service facilities operate. Figure 1 illustrates some basic ways in which service facilities, or stations, and units may be combined.

We next need to make some assumptions about these components. For instance, we must assume that the overall capacity of the service facility exceeds the overall demand. (In queue terminology, we say that the mean service rate exceeds the mean arrival rate for a single channel.) If we didn't assume this, our queue would theoretically grow to infinite size. We also assume that the intervals between arrivals and service times are variable. To study the queue, we must be able to describe these patterns of arrivals and service times, even if they seem to be unpredictable. Research has shown that the patterns of arrivals and service times often are completely random and can be described with the Poisson distribution. The formula for the Poisson distribution is shown in figure 2. With this formula, we can easily program the random element that we need in our simulation.

Queues of the type shown in parts a and b of figure 1 (that is, with service provided on a first-come, first-served basis with Poisson distribution for an infinite number of arrivals and services) can be described by the mathematics shown in table 1.

The Program

The flowchart in figure 3 shows the logic of a program that simulates a multichannel, single-phase service problem. The Advance module provides the executive control that keeps track of time and events; it passes control to the appropriate action module as successive events are simulated. In the Arrival module, as one arrival occurs, the time for the next arrival is calculated in accordance with the specified algorithm. The arriving unit then joins the queue if all service stations are occupied, or it moves on to seize an available station. The Departure
instructions given during data input, the program uses either a Poisson distribution or a user-defined probability distribution. Arrival intervals and service times can have different distributions, and the random-number generator is used to calculate the randomly varied event intervals in accordance with the specified distributions.

The Advance module determines the earliest event by first assuming that the event is an arrival (line 2000) and then checking if any departure occurs earlier (lines 2100-2130). The clock is then advanced to the earliest event (line 2300). Counters necessary to the calculation of queue statistics are incremented (lines 2310-2420), and control passes to the appropriate event module.

The Arrival module counts the total number of arrivals (line 3000) and calculates the time of the next arrival (lines 3050-3130). If no station is open, the queue length is incremented by line 3230 and the program checks to see if the new queue length exceeds the previous maximum (line 3240).

The Departure module frees the station (line 4000), increments counters (lines 4010-4050), and checks to see if the sample size has been reached (line 4100). If the simulation has not been completed, a unit waiting in the queue (if any) is allowed to seize the free station. The Seize module sets the key that indicates a particular station is in use (line 4250) and then calculates the departure time from that station (lines 4300-4430).

When the sample size has been reached, the program leaves the simulation loop at line 4100 and passes to the section that calculates the statistics for the simulation (lines 5000-5199). After the calculations are completed, the user is given a choice (lines 5200-5399) of sending output to the screen or to a printer. If screen output (lines 5700-5999) is chosen, the user gets a second opportunity to get a printed report (lines 5400-5699). If any non-Poisson distributions have been used, that fact and the parameters for the distributions(s) are recorded on the report (lines 6500-6799).

module frees a station when the service is completed and terminates the simulation if the sample size has been reached. Otherwise, it checks to see if any units are waiting in the queue and, if so, lets a unit leave the waiting line. The Seize module seizes an available service station and calculates the service time in accordance with the prescribed algorithm.

Listing 1 shows the AppleSoft BASIC queue-simulation program. The listing is grouped in sections that correspond to the flowchart in figure 3. All variable names used in the program are listed in table 2.

I've dimensioned the arrays to allow 10 service stations, but they can easily be changed to accommodate a larger number. The opening screen and data input (lines 7000-7999) and the start of the simulation (lines 8000-8799) are at the end of the program so the sections of the program that are executed over and over can have the lowest possible line numbers.

The keyboard is used to input data. The only exception is the data for non-Poisson distributions, which is input through DATA statements.

The times for the first arrival and the departure times for any units in a service station are calculated in lines 8000-8799. Depending upon the
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When the printing is completed, control is passed back to screen output (line 5690) and the user is given an opportunity to run additional simulations without restarting the program (lines 6000-6499).

The program length is about 7000 characters; it uses a total of about 8200 bytes of memory during execution. The run-time depends somewhat on the type of probability distribution (it runs faster when the formalized Poisson distribution is used). On my Franklin 1000, one simulation takes from 0.33 to 0.47 second, which means that a 2000-sample simulation takes 10 to 15 minutes.

**User-Defined Probability Distributions**

The program can evaluate queuing situations with unique, user-defined probability distributions. The arrival intervals and service intervals can have different distributions, independent of each other. The choice of the type of distribution to be used is made from the keyboard in lines 7200-7599. The program logic can most easily be explained by table 3, which lists the values that the key P assumes for the various possible combinations.

Figure 2 shows the shape of the Poisson distribution curve (curve 1) and two arbitrary, user-defined curves. The distribution of curve 2 was used in the simulations reported in parts e and f of figure 4. The user must input this nonstandard distribution via DATA statements starting at line 9000. The DATA statements provide the coordinates for the line segments that represent the special distribution. As an example, the distribution shown as curve 3 should be input as follows:

```
9000DATA0.25,.1,.25,.35,.5,.65,1.5, .9,1.75,1.75
```

If arrival and service intervals have identical, non-Poisson distributions, we define the interval only once. If they have different, non-Poisson distributions, the definition of the arrival-interval distribution precedes the definition of the service-time distribution. For example,

```
Variable | Equation
---|---
Mean arrival rate | \( \lambda \)
Mean service rate | \( \mu \)
Mean arrival interval | \( \frac{1}{\lambda} \)
Mean service time | \( \frac{1}{\mu} \)
Number of stations | \( S \)
Utilization factor | \( U \)
Average length of queue | \( L_1 \)
Average waiting time in queue | \( \frac{1}{\lambda} \)

Table 1: Queuing theory variables and equations. Sl and nl are the factorial values of these variables.

---

Text continued on page 168

![Figure 2: Probability distributions. Curve 1 shows the Poisson probability distribution. Curves 2 and 3 are arbitrary distributions that can replace the Poisson distribution.](image)
START
 INITIALIZE OFTEN-USED VARIABLES
 SHOW TITLE SCREEN
 ESTABLISH PROBABILITY DISTRIBUTIONS
 INPUT MEAN VALUES NUMBER OF STATISTICAL CONDITIONS
 STARTING CONDITIONS
 CALCULATE FIRST ARRIVAL TIME DEPARTURE TIME FOR ANY STATION IN USE
 DETERMINE EARLIEST EVENT
 ADVANCE TIME TO EARLIEST EVENT
 ACCUMULATE QUEUE TIME TIME FOR STATIONS IN USE
 ADVANCE MODULE
 NEXT EVENT A DEPARTURE?
 YES
 DEPARTURE MODULE
 FREE STATION
 ADD 1 TO COUNTERS OF DEPARTURES
 HAS SAMPLE SIZE BEEN REACHED?
 YES
 IS A STATION OPEN?
 NO
 ADD 1 TO COUNTER OF "NO-WAIT-TIME"
 ADD 1 TO QUEUE LENGTH
 QUEUE LONGER THAN "Q MAX"?
 YES
 REDUCE QUEUE LENGTH BY 1
 REDUCE STATION
 SEIZE STATION
 SEIZE MODULE
 CALCULATE DEPARTURE TIME FOR THAT STATION
 SET "Q MAX" TO CURRENT QUEUE LENGTH
 NO
 Figure 3: A flowchart for the author's queue-simulation program.
Listing 1: A program, written in Applesoft BASIC, for queue simulation.

```
QUEUE SIMULATION

LISTO,1999 START
1000 DIM FA(25,2),FS(25,2),TD(10),ST(10),CSX(10)
1010 R = 0:Z = 0:A = 0:TA = 0:S% = 0:T = 0:QLX = 0:C1% = 0:C2% = 0
1020 ONERR GOTO 8800
1100 GOTO 7800

LIST2000,2999 ADVANCE MODULE
2000 A = TA - T:N = 1
2100 FOR Z = 1 TO S%
2110 IF S%(Z) = 0 THEN 2130
2120 IF A > TD(Z) - T THEN A = TD(Z) - T:N = 1:S = Z
2130 NEXT
2300 T = T + A
2310 QT = QT + QL% * A
2400 FOR Z = 1 TO S%
2410 IF S%(Z) = 1 THEN ST(Z) = ST(Z) + A
2420 NEXT
2500 IF N = 1 THEN 4000

LIST3000,3999 ARRIVAL MODULE
3000 C1% = C1% + 1
3050 IF P < 3 THEN R = RND (1):F = LOG (1 - R): GOTO 3130
3100 R = RND (1):X = 0
3110 IF R > FA(X,1) THEN X = X + 1: GOTO 3110
3120 F = FA(X - 1,2) + (R - FA(X - 1,1)) * (FA(X,2) - FA(X - 1,2)) / (FA(X,1) - FA(X - 1,1))
3150 TA = T + F * A1
3200 FOR Z = 1 TO S%
3210 IF S%(Z) = 0 THEN S = Z:CO% = CO% + 1: GOTO 4250
3220 NEXT
3230 QLX = QLX + 1
3240 IF GM% < QLX THEN GM% = QLX
3250 GOTO 2000

LIST4000,4249 DEPARTURE MODULE
4000 SS(S) = 0
4010 CSX(S) = CSX(S) + 1
4050 C2X = C2X + 1
4100 IF C2X = > C1 THEN 5000
4150 IF QLX = 0 THEN 2000
4200 QLX = QLX - 1

LIST4250,4999 SEIZE MODULE
4250 SS(S) = 1
4300 IF P = 2 THEN 4400
4310 IF P = 4 THEN 4400
4320 IF P = 5 THEN 4400
4340 R = RND (1):F = - LOG (1 - R): GOTO 4430
4400 R = RND (1):X = 0
4410 IF R > FS(X,1) THEN X = X + 1: GOTO 4410
4420 F = FS(X - 1,2) + (R - FS(X - 1,1)) * (FS(X,2) - FS(X - 1,2)) / (FS(X,1) - FS(X - 1,1))
4430 TD(S) = T + F * S1
4600 GOTO 2000

LIST5000,5199 CALCULATE AVERAGES AND PERCENTAGES
5000 FOR Z = 1 TO S%: IF CSX(Z) = 0 THEN 5030
5010 TS(Z) = INT (100 * ST(Z) / CSX(Z) + .5) / 100
5020 US(Z) = INT (10000 * ST(Z) / T + .5) / 100
5030 NEXT
5040 QA = INT (10000 * COX / C1% + .5) / 100
5050 QS = INT (1000 * QT / C1% + .5) / 100
5060 IF C1% = COX THEN Q2 = 0: GOTO 5080
5070 Q2 = INT (1000 * QT / (C1% - COX) + .5) / 100
5080 QA = INT (1000 * QT / T + .5) / 100
```

Listing 1 continued on page 164
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Listing 1 continued:

JLIST5200,5399  SELECT OUTPUT DEVICE
5200 HOME : PRINT CHR$ (7): PRINT CHR$ (7); VTab (7)
5210 PRINT TAB(10)"SIMULATION COMPLETED"
5220 PRINT PRINT TAB(13)"READY TO REPORT"
5230 PRINT PRINT TAB(11)"Shall Report go to"
5240 PRINT PRINT TAB(7)"SCREEN (S) or PRINTER (P) ?"
5250 PRINT PRINT TAB(19)"": GET A$
5260 IF A$ = "S" THEN 5700
5270 IF A$ = "P" THEN 5400
5280 PRINT CHR$ (7): PRINT "Please answer 'S' or 'P':" GOTO 5250

JLIST5400,5699  OUTPUT TO PRINTER
5400 HOME : PRINT INPUT "What is Date of Report? ":D$
5410 PRINT PRINT "What is Project Identification?"
5420 PRINT INPUT I$
5430 PRINT PRINT "Press RETURN when PRINTER is ready ";: GET A$
5440 PR# 1
5450 PRINT PRINT TAB(12):D$: PRINT
5460 PRINT PRINT TAB(12)"SAMPLE SIZE IS ";I$: DEPARTURES
5470 PRINT PRINT TAB(12)"TIME ELAPSED FOR SIMULATION IS "; INT (.5);" TIME UNITS"
5480 PRINT PRINT TAB(12)"STATUS OF SERVICE STATIONS AT END IS:"
5490 PRINT PRINT TAB(12)"SAMPLE SIZE IS ";CY.;" DEPARTURES PER SERVICE"
5500 FOR Z = 1 TO SY.: IF A$(Z) = "Y" THEN S$(Z) = "USED"
5510 IF A$(Z) < > "Y" THEN S$(Z) = "OPEN"
5520 PRINT PRINT TAB(23);TAB(37);S$(Z): NEXT
5530 PRINT PRINT TAB(12)"ALL ENTRIES";TAB(40)"UNITS ENTERING QUEUE"
5540 PRINT PRINT TAB(18);Q1;TAB(48);Q2
5550 IF P > 1 THEN 6500
5560 PRINT PRINT TAB(12)"QUEUE SIMULATION"
5570 PRINT PRINT TAB(12)"MEAN ARRIVAL T; TAB(15);A; TAB(24);MEAN SERV T; TAB(36);S1
5580 PRINT PRINT TAB(2)"MEAN SERV T; TAB(15);A; TAB(24);MEAN SERV T; TAB(36);S1
5590 PRINT PRINT TAB(2)"SAMPLE SIZE; TAB(15);A; TAB(24);TOT TIME; TAB(35);INT (.5)
5600 PRINT PRINT PRINT "STAT DEPART UTILIZ AVG TIME STATUS": PRINT
5610 PRINT PRINT PRINT "STAT DEPART UTILIZ AVG TIME STATUS": PRINT
5620 FOR Z = 1 TO SY.: IF SY.(Z) = 0 THEN S$(Z) = "OPEN"
5630 IF SY.(Z) = 1 THEN S$(Z) = "USED"
5640 PRINT PRINT PRINT "MEAN TIME PER SERVICE": PRINT
5650 PRINT PRINT PRINT "MEAN TIME PER SERVICE": PRINT
5660 IF P = 1 THEN CLEAR : DIM FAC25,21,FS(25,2): RESTORE : GOTO 7200
5670 IF A$ = "N" THEN END
5680 PRINT PRINT "Please answer 'Y' or 'N':" GOTO 5560

JLIST5700,5999  OUTPUT TO SCREEN
5700 HOME : PRINT
5710 PRINT " QUEUE SIMULATION"
5720 PRINT PRINT PRINT TAB(2)"MEAN ARR T; TAB(15);A; TAB(24);MEAN SERV T; TAB(36);S1
5730 PRINT PRINT PRINT TAB(2)"MEAN SERV T; TAB(15);A; TAB(24);MEAN SERV T; TAB(36);S1
5740 PRINT PRINT PRINT TAB(2)"SAMPLE SIZE; TAB(15);A; TAB(24);TOT TIME; TAB(35);INT (.5)
5750 PRINT PRINT PRINT PRINT "STAT DEPART UTILIZ AVG TIME STATUS": PRINT
5760 FOR Z = 1 TO SY.: IF SY.(Z) = 0 THEN S$(Z) = "OPEN"
5770 IF SY.(Z) = 1 THEN S$(Z) = "USED"
5780 PRINT PRINT PRINT PRINT PRINT "MEAN TIME PER SERVICE": PRINT
5790 PRINT PRINT PRINT PRINT PRINT "MEAN TIME PER SERVICE": PRINT
5800 NEXT
5810 PRINT PRINT PRINT PRINT PRINT "QUEUE CONTENT ENTRIES X"
5820 PRINT PRINT PRINT PRINT PRINT "AVG MAXI AVERAGE TOTAL ZEROS ZERO"
5830 PRINT PRINT PRINT PRINT PRINT "AVG MAXI AVERAGE TOTAL ZEROS ZERO"
5840 PRINT PRINT PRINT PRINT PRINT "AVG MAXI AVERAGE TOTAL ZEROS ZERO"
5850 PRINT PRINT PRINT PRINT PRINT PRINT "AVG MAXI AVERAGE TOTAL ZEROS ZERO"
5860 PRINT PRINT PRINT PRINT PRINT PRINT "AVG MAXI AVERAGE TOTAL ZEROS ZERO"
5870 IF A$ = "Y" THEN 5400

JLIST6000,6499  SELECT MORE SIMULATIONS OR END
6000 HOME : PRINT PRINT
6010 PRINT PRINT "Want to do another Simulation (Y/N)?"
6020 PRINT PRINT TAB(19)"": GET A$
6030 IF A$ = "Y" THEN CLEAR : DIM FA(25,2),FS(25,2): RESTORE : GOTO 7200
6040 IF A$ = "N" THEN END
6050 PRINT PRINT PRINT "Please answer 'Y' or 'N':" GOTO 6020

Listing 1 continued on page 166
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Listing 1 continued:

JLIST6500,6999 AUXILIARY PRINTER OUTPUT

6500 PRINT : PRINT : PRINT TAB(12) "NOTE:"
6510 ON P GOTO 5690,6520,6550,6580,6610
6520 PRINT TAB(12) "SERVICE TIME HAD PROBABILITY DISTRIBUTION:": PRINT
6530 GOSUB 6750
6540 PRINT : GOTO 5690
6550 PRINT TAB(12) "ARRIVAL TIME HAD PROBABILITY DISTRIBUTION:": PRINT
6560 GOSUB 6700
6570 PRINT : GOTO 5690
6580 PRINT TAB(12) "ARRIVAL AND SERVICE HAD IDENTICAL NON-POISSON DISTRIBUTION:": PRINT
6590 GOSUB 6700
6600 PRINT : GOTO 5690
6610 PRINT TAB(12) "SERVICE TIME HAD PROBABILITY DISTRIBUTION:": PRINT
6620 GOSUB 6750
6630 PRINT : PRINT
6640 PRINT TAB(12) "ARRIVAL TIME HAD PROBABILITY DISTRIBUTION:": PRINT
6650 GOSUB 6700
6660 PRINT : GOTO 5690
6670 X = 0
6680 PRINT TAB(12) FA(X,1); " ; FA(X,2); " ;
6690 IF FA(X,1) = 1 THEN RETURN
6700 X = X + 1: GOTO 6690
6710 PRINT TAB(12) FSCX,1l; " ;FS(X,2l; " ;
6720 IF FS(X,1) = 1 THEN RETURN
6730 X = X + 1: GOTO 6720
6740 x = 0
6750 PRINT TAB(12) FA(X,1); " ; FA(X,2); " ;
6760 IF FA(X,1) = 1 THEN RETURN
6770 X = X + 1: GOTO 6760

JLIST7000,7199 OPENING SCREEN

7000 HOME
7010 PRINT : PRINT : PRINT : PRINT
7020 PRINT " ****************************
7030 PRINT " * * QUEUE SIMULATION *
7040 PRINT " * BY *
7050 PRINT " * * E HART RASMUSSEN *
7060 PRINT " * p M S *
7070 PRINT " * *
7080 PRINT ****************************.."
7090 PRINT PRINT
7100 PRINT " Press RETURN to start"
7110 PRINT : PRINT : PRINT
7120 PRINT " Press RETURN to start"
7130 PRINT : PRINT : PRINT
7140 PRINT : PRINT TAB(19): GET AS

JLIST7200,7599 ESTABLISH PROBABILITY DISTRIBUTIONS

7200 HOME
7210 PRINT " Shall ARRIVAL and SERVICE have"
7220 PRINT : PRINT " identical Distributions (Y/N) ": INPUT AS
7230 IF AS = "Y" THEN P = 1: GOTO 7260
7240 IF AS = "N" THEN P = 2: GOTO 7300
7250 PRINT CHR$(7): PRINT " Please answer 'Y' or 'N' ": INPUT AS: GOTO 7230
7260 PRINT : PRINT " Are they both Poisson ": INPUT AS
7270 IF AS = "Y" THEN 7260
7280 IF AS = "N" THEN P = 4: GOTO 7300
7290 PRINT CHR$(7): PRINT " Please answer 'Y' or 'N' ": INPUT AS: GOTO 7270
7300 PRINT : PRINT " Does ARRIVAL have Poisson ": INPUT AS
7310 IF AS = "Y" THEN 7260
7320 IF AS = "N" THEN P = 3: GOTO 7300
7330 PRINT CHR$(7): PRINT " Please answer 'Y' or 'N' ": INPUT AS: GOTO 7310
7340 PRINT : PRINT " Does SERVICE have Poisson ": INPUT AS
7350 IF AS = "Y" THEN 7260
7360 IF AS = "N" THEN P = 5: GOTO 7300
7370 PRINT CHR$(7): PRINT " Please answer 'Y' or 'N' ": INPUT AS: GOTO 7370
7380 ON P GOTO 7200,7410,7420,7430,7440
7400 GOSUB 7550: GOTO 7600
7410 GOSUB 7500: GOTO 7600
7420 GOSUB 7500: GOTO 7600
7430 GOSUB 7500: RESTORE : GOSUB 7550: GOTO 7600
7440 GOSUB 7500: GOSUB 7550: GOTO 7600
7500 X = -1
7510 X = X + 1: READ FA(X,1),FA(X,2)
7520 IF FA(X,1) < 1 THEN 7510
7530 RETURN
7540 X = -1
7550 X = X + 1: READ FS(X,1),FS(X,2)
7560 IF FS(X,1) < 1 THEN 7560
7570 RETURN

Listing 1 continued on page 168
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Listing 1 continued:

7600 HOME : PRINT
7610 PRINT : INPUT "What is AVERAGE Arrival Interval? ": AI
7620 PRINT : INPUT "What is AVERAGE Service Time? ": SI
7630 PRINT : INPUT "How many Service Stations are used? ": S%
7640 PRINT : INPUT "Is there a waiting Queue at Start ": INPUT AS
7650 IF AS = "N" THEN PRINT : GOTO 7680
7660 IF AS < > "Y" THEN PRINT CHR$(7): PRINT "Please answer 'Y' or 'N' ": INPUT AS: GOTO 7690
7670 PRINT : INPUT "How many are waiting? ": QL%: QL% = QL%; QM% = QL%; PRINT
7680 PRINT : INPUT "Are any Service Stations in Use ": INPUT AS
7690 IF AS = "N" THEN 7900
7700 IF AS < > "Y" THEN PRINT CHR$(7): PRINT "Please answer 'Y' or 'N' ": INPUT AS: GOTO 7690
7710 IF S% 1 THEN AS$(1) = "Y": GOTO 7900
7720 PRINT : PRINT "Service Station Ii "
7730 FOR X 1 TO S%
7740 PRINT "X": INPUT "X": AS$(X)
7750 NEXT
7900 PRINT : PRINT INPUT "Size of Simulation Sample: ": C%
JLIST8000, 8799

C~LCULATE FIRST ARRIVAL AND DEPARTURE(S) TIMES

8010 PRINT : PRINT TAB (10) "SIMULATION RUNNING"
8020 NORMAL
8090 IF P < 3 THEN R = RND(1): F = - LOG(1 - R): GOTO 8130
8100 R = RND(1): X = 0
8110 IF R > FA(X, 1) THEN X = X + 1: GOTO 8110
8120 F = FAX - 1, 2) + (R - FA(X - 1, 1)) * (FAX - 1, 2) / (FAX - 1, 1))
8130 TA = F * A1
8140 FOR Z = 1 TO S%
8150 IF AS$(Z) = "Y" THEN S%(Z) = 1
8160 IF S%(Z) = 0 THEN TD(Z) = S% * 100 * AI: GOTO 8300
8170 IF P = 4 THEN 8240
8180 IF P = 5 THEN 8240
8190 IF P > 5 THEN 8240
8200 R = RND(1): F = - LOG(1 - R): GOTO 8270
8210 R = RND(1): X = 0
8220 IF R > FS(X, 1) THEN X = X + 1: GOTO 8250
8230 F = FSX - 1, 2) + (R - FS(X - 1, 1)) * (FSX - 1, 2) / (FS(X - 1, 1))
8240 TD(Z) = F * SI
8250 NEXT
8300 GOTO 8000
JLIST8800, 8799

ERRORS IN DATA STATEMENTS

8800 HOME : PRINT : PRINT : PRINT : PRINT "PLEASE CORRECT THE DATA STATEMENTS"
8810 FOR X = 1 TO 3: PRINT CHR$(7): NEXT
8820 PRINT "SHOULD BE IN DATA STATEMENTS"
8830 PRINT "STARTING AT LINE 9000"
8840 PRINT "NON-POISSON DISTRIBUTIONS"
8850 PRINT "IN DATA STATEMENTS"
8860 PRINT "IN DATA STATEMENTS"
8870 END

Text continued from page 160:

9000DATA0, .25, .25, .35, 5, .5, .65, 1.5, .9, 1.75, 7.75
9010DATA0, .75, 1.75, 2.25

assigns a distribution according to curve 3 to arrival intervals but distributes service times according to curve 2. Make sure that the defined distribution averages a value of 1.

Some Sample Problems

Parts a through f of figure 4 show examples of printed output from simulations done by the program. Notice that all input data is repeated on the printed report. Parts e and f of the figure show simulations using non-Poisson distributions. This is noted at the bottom of the report; and the coordinates for the specified distribution curve(s) are shown. Part c of the figure shows a simulation of three parallel service stations. Notice that station 1 has been used most often. This is because of the way the program chooses open stations. The average utilization factor of 91.6 percent for all three stations is close to the theoretical, overall utilization factor of 90.9 percent.

The results of the simulation are summarized in table 4 and compared with the theoretical values (where this is possible), which can be calculated using the formulas listed in table 1. Notice that even with 5000 simulations there is up to 20 percent difference between the analytical and the simulated results. This does not
Table 2: Queue simulation variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Time advance</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>AI</td>
<td>Mean arrival interval</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>AS</td>
<td>Answer to yes/no question</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>AS(Z)</td>
<td>Station status at start</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>C%</td>
<td>Sample size</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>C0%</td>
<td>Number of arrivals with no wait time</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>C1%</td>
<td>Total number of arrivals</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>C2%</td>
<td>Total number of departures</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>CS%Z(Z)</td>
<td>Number of departures from Station Z</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>D$</td>
<td>Date of report</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>F</td>
<td>Simulation factor, a function of random</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>FA(a,2)</td>
<td>Probability distribution for arrival intervals</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>FS(b,2)</td>
<td>Probability distribution for service intervals</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>IS</td>
<td>Project identification</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>N</td>
<td>Switch for next event (0 = arrival; 1 = departure)</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>P</td>
<td>Switch for type of probability distributions</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Q0</td>
<td>Percent of arrivals with no wait time</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Q1</td>
<td>Average wait time, all arrivals</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Q2</td>
<td>Average wait time, arrivals entering queue</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>QA</td>
<td>Average length of queue</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>QL</td>
<td>Length of queue at start</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>QL%</td>
<td>Length of queue</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>QM%</td>
<td>Maximum length of queue</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>CT</td>
<td>Cumulative queue time (i.e., SUM QL% - T)</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>R</td>
<td>Random number = RND(1)</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>S</td>
<td>Station number with earliest departure</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>S%</td>
<td>Number of service stations</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>S%Z(Z)</td>
<td>Station status; 0 = open, 1 = used</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>S$(Z)</td>
<td>Station status</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>ST(Z)</td>
<td>Total time Station Z has been in use</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>SI</td>
<td>Mean service time, all stations</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>T</td>
<td>Time, cumulative from start</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>TA</td>
<td>Time for next arrival</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>TD(Z)</td>
<td>Time for departure from Station Z</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>TS(Z)</td>
<td>Average service time at Station Z</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>US(Z)</td>
<td>Percent of utilization of Station Z</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>X</td>
<td>General counter</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Z</td>
<td>Counter for stations</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

Table 3: P values.

<table>
<thead>
<tr>
<th>Arrival Interval</th>
<th>Service Interval</th>
<th>Value of P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poisson</td>
<td>Poisson</td>
<td>1</td>
</tr>
<tr>
<td>Poisson</td>
<td>Non-Poisson</td>
<td>2</td>
</tr>
<tr>
<td>Non-Poisson</td>
<td>Poisson</td>
<td>3</td>
</tr>
<tr>
<td>Non-Poisson</td>
<td>Same non-Poisson</td>
<td>4</td>
</tr>
<tr>
<td>Non-Poisson</td>
<td>Different non-Poisson</td>
<td>5</td>
</tr>
</tbody>
</table>

A comparison of lines 1, 2, and 3 in table 4 shows that multiple service channels with identical total capacity provide slightly improved service as more channels are used. A comparison of lines 1 and 4 shows the dramatic reduction in queue length and waiting time when a second ser-

Text continued on page 17A.
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Figure 4: Simulation results with (4a) one service station, (4b) two service stations, (4c) three service stations, (4d) doubled service capacity, (4e) service time has probability function from curve 2 of figure 2, and (4f) both service and arrival times have probability functions from curve 2 of figure 2.

(4a) 1 (One) QUEUE SERVED BY 1 PARALLEL SERVICE STATIONS
AVERAGE ARRIVAL INTERVAL WAS SPECIFIED AS 11 TIME UNITS
AVERAGE SERVICE TIME WAS SPECIFIED AS 10 TIME UNITS
QUEUE LENGTH AT START OF SIMULATION WAS 8

STATUS OF SERVICE STATIONS AT START WAS:

<table>
<thead>
<tr>
<th>STATION</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>USED</td>
</tr>
</tbody>
</table>

SAMPLE SIZE IS 5000 DEPARTURES
TIME ELAPSED FOR SIMULATION IS 55470 TIME UNITS

STATUS OF SERVICE STATIONS AT END IS:

<table>
<thead>
<tr>
<th>STATION</th>
<th>NUMBER OF UTILIZATION</th>
<th>AVERAGE TIME</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DEPARTURES % PER SERVICE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5000</td>
<td>91.98</td>
<td>10.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QUEUE CONTENT</th>
<th>ENTRIES</th>
<th>TOTAL</th>
<th>ZEROS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CURRENT MAX</td>
<td>36</td>
<td>46</td>
<td>10.81</td>
<td>5027</td>
</tr>
<tr>
<td>MAX AVERAGE</td>
<td>1.2</td>
<td>1.8</td>
<td>27.06</td>
<td>370</td>
</tr>
<tr>
<td>AVERAGE TOTAL</td>
<td>70</td>
<td>80</td>
<td>14.38</td>
<td>7.36</td>
</tr>
</tbody>
</table>

AVERAGE WAIT TIME
ALL ENTRIES UNITS ENTERING QUEUE
119.25 128.73

(4b) 1 (ONE) QUEUE SERVED BY 2 PARALLEL SERVICE STATIONS
AVERAGE ARRIVAL INTERVAL WAS SPECIFIED AS 11 TIME UNITS
AVERAGE SERVICE TIME WAS SPECIFIED AS 20 TIME UNITS
QUEUE LENGTH AT START OF SIMULATION WAS 8

STATUS OF SERVICE STATIONS AT START WAS:

<table>
<thead>
<tr>
<th>STATION</th>
<th>NUMBER OF UTILIZATION</th>
<th>AVERAGE TIME</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DEPARTURES % PER SERVICE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2531</td>
<td>92.05</td>
<td>20.01</td>
</tr>
<tr>
<td>2</td>
<td>2469</td>
<td>88.93</td>
<td>19.82</td>
</tr>
</tbody>
</table>

SAMPLE SIZE IS 5000 DEPARTURES
TIME ELAPSED FOR SIMULATION IS 55025 TIME UNITS

STATUS OF SERVICE STATIONS AT END IS:

<table>
<thead>
<tr>
<th>STATION</th>
<th>NUMBER OF UTILIZATION</th>
<th>AVERAGE TIME</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DEPARTURES % PER SERVICE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2531</td>
<td>92.05</td>
<td>20.01</td>
</tr>
<tr>
<td>2</td>
<td>2469</td>
<td>88.93</td>
<td>19.82</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QUEUE CONTENT</th>
<th>ENTRIES</th>
<th>TOTAL</th>
<th>ZEROS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CURRENT MAX</td>
<td>2</td>
<td>36</td>
<td>7.12</td>
<td>4993</td>
</tr>
<tr>
<td>MAX AVERAGE</td>
<td>1.2</td>
<td>1.8</td>
<td>27.06</td>
<td>370</td>
</tr>
<tr>
<td>AVERAGE TOTAL</td>
<td>70</td>
<td>80</td>
<td>14.38</td>
<td>7.36</td>
</tr>
</tbody>
</table>

AVERAGE WAIT TIME
ALL ENTRIES UNITS ENTERING QUEUE
78.42 91.59
1 (ONE) QUEUE SERVED BY 3 PARALLEL SERVICE STATIONS
AVERAGE ARRIVAL INTERVAL WAS SPECIFIED AS 11 TIME UNITS
AVERAGE SERVICE TIME WAS SPECIFIED AS 30 TIME UNITS
QUEUE LENGTH AT START OF SIMULATION WAS 0

STATUS OF SERVICE STATIONS AT START WAS:

<table>
<thead>
<tr>
<th>STATION</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>USED</td>
</tr>
<tr>
<td>2</td>
<td>USED</td>
</tr>
<tr>
<td>3</td>
<td>OPEN</td>
</tr>
</tbody>
</table>

SAMPLE SIZE IS 5000 DEPARTURES

TIME ELAPSED FOR SIMULATION IS 55615 TIME UNITS

STATUS OF SERVICE STATIONS AT END IS:

<table>
<thead>
<tr>
<th>STATION</th>
<th>NUMBER OF DEPARTURES</th>
<th>UTILIZATION %</th>
<th>AVERAGE TIME PER SERVICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1709</td>
<td>93.9</td>
<td>30.56</td>
</tr>
<tr>
<td>2</td>
<td>1646</td>
<td>91.71</td>
<td>30.99</td>
</tr>
<tr>
<td>3</td>
<td>1645</td>
<td>89.11</td>
<td>30.13</td>
</tr>
</tbody>
</table>

QUEUE CONTENT
CURRENT MAXIMUM AVERAGE ENTRIES
0 33 6.06 4998 774 15.49

AVERAGE_WAIT TIME
ALL ENTRIES
67.47

AVERAGE_WAIT TIME
UNITS ENTERING QUEUE
79.83

1 (ONE) QUEUE SERVED BY 2 PARALLEL SERVICE STATIONS
AVERAGE ARRIVAL INTERVAL WAS SPECIFIED AS 11 TIME UNITS
AVERAGE SERVICE TIME WAS SPECIFIED AS 10 TIME UNITS
QUEUE LENGTH AT START OF SIMULATION WAS 0

STATUS OF SERVICE STATIONS AT START WAS:

<table>
<thead>
<tr>
<th>STATION</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>USED</td>
</tr>
<tr>
<td>2</td>
<td>OPEN</td>
</tr>
</tbody>
</table>

SAMPLE SIZE IS 5000 DEPARTURES

TIME ELAPSED FOR SIMULATION IS 55796 TIME UNITS

STATUS OF SERVICE STATIONS AT END IS:

<table>
<thead>
<tr>
<th>STATION</th>
<th>NUMBER OF DEPARTURES</th>
<th>UTILIZATION %</th>
<th>AVERAGE TIME PER SERVICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2973</td>
<td>54.6</td>
<td>10.25</td>
</tr>
<tr>
<td>2</td>
<td>2027</td>
<td>36.27</td>
<td>9.98</td>
</tr>
</tbody>
</table>

QUEUE CONTENT
CURRENT MAXIMUM AVERAGE ENTRIES
0 9 .24 5000 3556 71.12

AVERAGE_WAIT TIME
ALL ENTRIES
2.72

AVERAGE_WAIT TIME
UNITS ENTERING QUEUE
9.42
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Straight out of the box, it's ready to get down to business with single-entry general ledger, accounts payable and receivable, payroll, inventory control and order entry.

<table>
<thead>
<tr>
<th>Canned Accounting vs. The Sensible Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The Typical Accounting Package</strong></td>
</tr>
<tr>
<td>Can the program be changed to suit special needs?</td>
</tr>
<tr>
<td>Can you use your business's existing forms?</td>
</tr>
<tr>
<td>Is source code included in the program's price?</td>
</tr>
<tr>
<td>Can you easily transfer your data when you buy a new computer?</td>
</tr>
</tbody>
</table>

But instead of locking you in to our way of accounting, we also supply you with source code and The Sensible Solution Language so you can modify the program to take into account your needs.

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service line is opened. (I hope the manager of my local supermarket reads this.)

The significance of the probability distribution is clearly demonstrated by comparing lines 1, 5, and 6. The average waiting time is reduced by 60 percent or more when the service interval follows a narrow, linear distribution rather than the Poisson distribution. This shows that good scheduling reduces wasteful waiting time without having to change the service capacity.

**Conclusion**

The program I have presented cannot compete with the very powerful, special-purpose simulation languages that are commercially available. But it does give you the ability to analyze queuing situations with your own probability distributions. My program only simulates single-phase service. But with the program's modular structure, you should be able to expand it to include other queuing models. A second Departure module with a second Seize module can be added for simulation of multiphased service. Or a switch can be inserted in the Arrival module to activate an additional service station whenever the queue length exceeds a specified value.

Other possible variations include putting a limitation on the queue length (limited parking space, for example) and counting the number of customers lost because they leave without joining the queue. You could use this information to justify more parking space. In short, the program is flexible; you should be able to adapt it to many queuing situations.

**Bibliography**


E. Hart Rasmussen is a professional engineer and the president of Project Management Services, 81 Fawn Hill Rd., Upper Saddle River, NJ 07458.

---

### Table 4: Analytical and simulated solutions of queuing problems. The superscript 1 indicates that the service interval had linear probability distribution. The superscript 2 indicates that both the arrival and the service interval had linear probability distribution.

<table>
<thead>
<tr>
<th>Number of Stations</th>
<th>Mean Interval</th>
<th>Percent of Utilization</th>
<th>Average Queue Length</th>
<th>Average Waiting Time</th>
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</thead>
<tbody>
<tr>
<td>Stations</td>
<td>Arrival</td>
<td>Service</td>
<td>Analytical</td>
<td>Simulated</td>
</tr>
<tr>
<td>1</td>
<td>11</td>
<td>10</td>
<td>90.9</td>
<td>92.0</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
<td>20</td>
<td>90.9</td>
<td>90.5</td>
</tr>
<tr>
<td>3</td>
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<td>91.6</td>
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<tr>
<td>2</td>
<td>11</td>
<td>10</td>
<td>45.5</td>
<td>47.2</td>
</tr>
<tr>
<td>1</td>
<td>11</td>
<td>10^2</td>
<td>90.9</td>
<td>89.7</td>
</tr>
<tr>
<td>1</td>
<td>11^2</td>
<td>10^2</td>
<td>90.9</td>
<td>90.6</td>
</tr>
</tbody>
</table>

---

**ULTRA-RES™ GRAPHICS**

**IEEE-696 S-100**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 X 512 X 512</td>
<td>$495</td>
</tr>
<tr>
<td>3 X 512 X 512</td>
<td>$1250</td>
</tr>
<tr>
<td>1 X 1024 X 1024</td>
<td>$995</td>
</tr>
<tr>
<td>CONSOLE EMULATOR</td>
<td>550</td>
</tr>
<tr>
<td>PLOT 10</td>
<td>150</td>
</tr>
</tbody>
</table>

**Features**

- Software drivers, Hardware zoom, Programmable Display Resolution, Windowing, Multi-Controller Capability, NEC UPD7220 Graphic Controller

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A Risky Business—An Introduction to Monte Carlo Venture Analysis

A simple method for analyzing business risks

by Pat Macaluso

A business enterprise is aptly named a venture. It is a ship launched on a sea of uncertainty. The business of business is the taking of intelligent risks. Precious resources are committed to what can only be a hope of future gain. To reduce the risk, it would be helpful and profitable to have some insight as to possible future events.

It turns out that future prospects, elusive as they are, can be estimated in a way that is surprisingly useful for business purposes. The method involves four steps: (1) formulate a model of the venture; (2) distribute appropriate data in the model; (3) sample from the model data; (4) analyze the sample.

The Monte Carlo Method

Aside from an investor's knowledge of a proposed venture, the Monte Carlo method requires nothing more than a personal computer and a program that is almost trivial in its simplicity. I'll use an example to illustrate how it works. We take at random a possible selling price, a possible sales volume, and so on. The selections are made from a range of possible values in each case according to the estimated probability of their occurrence. From this sample data, a corresponding outcome is calculated. This process is repeated for the entire range of possibilities. The resulting collection of outcomes is then arranged in sorted order. Examination of this distributed result yields information on the range of future outcomes and the relative chance of their occurrence. We'll see how this is done in detail later on, but the analysis might run something like this: in this business venture there is a 10 percent chance you will lose your shirt; a 65 percent chance you will achieve a 15 percent return on investment after taxes; a 5 percent chance you will really clean up, and so forth.

Such a formulation, even if stated less colorfully or dressed up in graphs and tables, may sound strange or even unsettling. Wouldn't it be simpler and more understandable to take the most likely selling price, sales volume, etc., and come up with a most likely result? Unfortunately that is not the case. Such an approach tends to underestimate the risks. It also throws away most of the information we have that bears on future possibilities.

In projecting sales figures for a product, sales managers can say that a realistic sales level will be 50,000 units. They can also say that there's little chance of 80,000 and no chance of more than 90,000 units being sold. Further, they might add that it is very likely that at least 15,000 units and quite certain that 5000 units will be sold. The manager is expressing a wealth of hard information along with his uncertainty. He is weighing the size of the total market, the effect of competition, replacement rates, captive markets, limits on plant capacity, and so on. In other words, estimates by an informed person, though couched in uncertainty, contain valuable information that bears on future outcomes.

Faced with an investment decision, would you throw such information away, especially if it is easily expressed in a form suited to quantitative analysis? The most likely value or single-point methods do just that. They are quite inferior to the Monte Carlo sampling approach that allows us to use the extra information.

The most likely value method of risk analysis has tended to persist since calculations could be made by
hand and managers felt they understood the result. It certainly seemed more definite and less threatening than a distribution that told of possible bad outcomes as well as the desired profitable ones. Times have changed. Many executives, aided by easier access to computers, have responded with increased sophistication as the safety of investments has become harder to gauge.

We can better understand the nature of the Monte Carlo method with the aid of a simple example. Suppose we wanted to determine the chance of getting "snake eyes," or two ones, in the roll of dice. We can calculate this precisely from probability theory as being one out of 36 tosses on the average. But what if we had no theoretical solution, as is the case with business ventures? There is another way to estimate the chance of getting "snake eyes." We can tally the result of thousands of rolls of the dice. Even better, we can simulate it on a computer. The result will, in general, not be exactly 1 in 36 but it will tend to approach it more and more closely as the size of the sample increases. We will have performed a random-sampling experiment. It is easy, it works, and it is more than adequate when applied to business situations.

How Do I Get Started?

We present here three useful items for anyone who wishes to explore this method of risk analysis: (1) a simple technique for building a model of the venture; (2) a way to construct a sample from a distribution that is universal in its application; (3) a complete but elementary venture-analysis program to carry out the calculations. The program (see listing 1) can serve as a core upon which a more sophisticated or customized system can be built. More details are supplied in the author's book (see text box at the end of this article) but all the essentials are provided in this article.

A word of caution is in order. Compared to the sometimes mind-boggling complexity of actual business ventures, the model shown here will appear quite simplistic. Perhaps crude would be a better description.

Listing 1: Monte Carlo Venture Analysis program, written in Microsoft BASIC, can be modified for your own use by programming your own model equation and changing the numbers in the DATA statements accordingly.

```
1000 'MONTE CARLO VENTURE ANALYSIS
1010 CLEAR
1020 GOSUB 11000 'Specify runs, samples, etc.
1030 'Continued...
```

Listing 1 continued on page 181
What good then is such an approach, aside from tutorial use? The answer may be somewhat surprising unless you are already well into this subject. Simple models work remarkably well to the extent that they embody the essentials of the enterprise they represent. There are advantages to stripping away nonessentials. At the very least, the act of analysis sharpens our understanding of the venture. It reveals what weaknesses may exist in the data, which factors are most critical, and so on.

The outcome of a simulation is a way to integrate the complexity of distributed values in a model. It is a tool that helps the entrepreneur make the actual decision. That decision will weigh factors that the model did not or could not include. The user must also decide exactly what the problem is and frame the model accordingly. For example, is a product to be made in new, expanded, or shared facilities? If the latter, how will the effect of displaced products and production turnaround be handled in the model? Is the venture analyzed on its own merits or in comparison with other projects? It is clear that the real work is done both before and after the simulation. The program is just a convenient calculation tool.

Building a Model

The example we will use here is an estimate of the gain (or loss) to be expected in the production and sale of an item with a small-to-modest market. The model we will use is a simple one. Our purpose is to illustrate the technique without getting lost in the details. This will make it easier to highlight the possible weaknesses, as well as the strengths, of this approach.

As a starter, we need a model in the form of an equation that represents the venture. How do we develop such an equation? We can start at the top by noting that our objective, expected gain, can be taken as the difference between total income and total expense before taxes. Thus: Gain = Income - Expense. We proceed with our top-down design by detailing income as: Income = Selling Price x Sales Volume, or SP*SV

Listing 1 continued:

```
41020 D=NS
41030 IF X<1 THEN RETURN
41040 D=INT(D/2):R=NS-D:EX=0
41050 FOR I=1 TO RDI=D+1
41060 IF OU(I)<OU(DI) THEN GOTO 41080
41070 OT=OU(I):OU(I)=OU(DI):OU(DI)=OT
41080 NEXT I
41090 IF EX=0 THEN GOTO 41030
41100
41200 '--- Avg, sum of sq devns, std devn for each run
41220 T=NS:AV=T/ST(L,0)=AV
41230 GOSUB 12000:ST(L,1)=SS#
41240 GOSUB 13000:ST(L,2)=SD
41250 SS=0:RETURN
41260
41300 '--- Extract and store cum. distn in steps of 10%
41320 PF=INT(NS/10+.5)
41330 FOR I=1 TO 10:CD(L,1)=OU(I*PF)
41340 NEXT I
41350 SD=SS/(NS*NR-1)"5
41360 RETURN
41370
41400 '--- Avg and std devn over all samples and runs
41410
41420 IF=0:SS=0:FOR I=1 TO NR
41430 S+=SS=SS+ST(I,0)-AV:SS+=SS+(ST(I,0)-AV)^2
41450 NEXT I
41460 RETURN
41470
41500 '--- Std devn of avg outcomes for NR runs
41510
41520 SS=0:FOR I=1 TO NR
41530 SS=SS+(ST(I,0)-AV)^2
41550 SD=SS/(NR-1)"5
41560 RETURN
41570
41600 '--- Final distribution in steps of 10%
41610
41620 FOR I=1 TO 10:SS=0
41630 FOR M=1 TO NR
41640 S+=SS=CD(M,1) NEXT M
41650 FD(I)=SS/NS:NEXT I
41660 RETURN
41670
51000 '--- Display statistics for NR runs
51010
51020 PRINT "STATISTICS FOR NR;RUNS OF NS;SAMPLES EACH. SEED=";RS
51030 PRINT
51040 PRINT "RUN AVG OUTCOME STD DEVN"
51050 PRINT-------------------------------------------------------------
51060 PRINT
51070 FOR I=1 TO NR
51080 PRINT I,ST(I,0),ST(I,1)
51090 PRINT
51100 PRINT "AVG=";AV,"STD DEVN=";SD
51110 PRINT
51120 PRINT "PRESS RETURN TO CONTINUE":X$=X$+" 
51130 PRINT
51140
51200 '--- Display outcomes over all samples and runs
51210
51220 PRINT CHR$(26)
51230 PRINT "OUTCOMES FOR NR;NS;SAMPLES. SEED=";RS
51240 PRINT
51250 PRINT "CHANCE OUTCOME WILL EXCEED"
51260 PRINT-------------------------------------------------------------
51270 PRINT
51280 FOR I=0 TO 10:FD(I)=ST(I,1)
51290 PRINT
51300 PRINT "AVG=";AV,"STD DEVN=";AD
51310 PRINT
51320 PRINT "PRESS RETURN TO CONTINUE":X$=X$
51330 PRINT
51340
51400 '--- Data statements in order as per subr. 23000
51410
51420 DATA 1,.90,.50,.10,0,'SP prob';discounted selling price
51430 DATA 3.00,.34,.40,.20,.50,0,'UC prob.'
51440 DATA 1,.85,.50,.15,0,'SV prob'
51450 DATA 1,.50,.05,.70,0.90,'Unit distrn cost
51460 DATA 1,.85,.50,.20,0,'SV prob'
51470 DATA 4000,8000,12000,15000,15000,'Sales volume
```
using BASIC notation. Likewise we can assume that: Expense = Fixed Cost + Variable Cost, or FC+VC. The latter can be expressed as: Variable Cost = Unit Cost \times Sales Volume, or VC=UC*SV. Putting it all together, we have:

\[ G = SP*SV - UC*SV - FC \]

Thus, the formidable phrase “formulate a model of the venture” requires nothing more than a simple equation. Some arbitrary decisions will have to be made on just what stance, variable costs versus fixed costs in a way that reflects the quantity produced rather than the quantity sold. Likewise, it may be necessary to use a fraction of the anticipated selling prices to allow for discounts. Every venture has its own scenario. The user needs to adjust either the model or the data to allow for the specific case. This can be done in stages by continuing the top-down expansion of the model.

**Constructing a Distribution**

Each value that may be assigned to a variable, for example, the sales volume, has a probability of occurrence associated with it. We have seen an example of this in the game of dice where a die has possible values of one through six, each with an equal chance of occurrence. The collection of values and their associated probabilities for a given variable is called a distribution. In this case, many tosses of a single die produce a uniform distribution, since each value has the same chance of occurring.

A more common type of distribution is represented by the heights of people. We usually find many people in the five- to six-foot range, somewhat fewer in the four- to five- or the six- to seven-foot range, and many fewer at other heights. If we tabulate and plot the count of the heights, we get something like a bell-shaped curve. This is called a normal or Gaussian distribution. There are a rather large number of different kinds of formal distributions, each with a different shape. Some of them represent actual collections of specific things quite well. The problem with formal distributions is that they require various constants to be determined and specified. It would also be necessary to select a suitable distribution and perform special calculations or transformations to use them.

We present here a simple distribution that avoids all of these complications. It will approximately fit your data, whatever it may be. To illustrate its construction and use, we will con-
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Speeds: 110, 300, 1200 baud

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BYTE March 1984 183
Consider the number of units of a product that might be sold from a total production of 15,000 units.

<table>
<thead>
<tr>
<th>Number sold</th>
<th>Probability</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>4000</td>
<td>1.00</td>
<td>Certain to sell 4000 or more</td>
</tr>
<tr>
<td>8000</td>
<td>0.85</td>
<td>85 percent chance of 8000 or more sales</td>
</tr>
<tr>
<td>12,000</td>
<td>0.50</td>
<td>Even chance of 12,000 or more sales</td>
</tr>
<tr>
<td>15,000</td>
<td>0.20</td>
<td>20 percent chance of selling all units</td>
</tr>
<tr>
<td>15,000</td>
<td>0.00</td>
<td>No chance of sales exceeding units produced</td>
</tr>
</tbody>
</table>

Several points of interest should be noted. First, we start and end with two certainties, namely 100 percent and 0 percent situations. This is not at all difficult for someone who knows the business area being simulated. In our example, the user knows from experience that the established outlets will absorb at least 4000 units. The other limit of 15,000 units is also quite certain. In this example, the user has decided to accept a 20 percent risk of loss of sales in excess of 15,000 units, perhaps counting on a second production run if all goes well. This illustrates an immediate advantage of this method of representing distributions. It naturally and easily takes care of cutoffs at both extremes, including special situations such as captive outlets and lost opportunity.

Another important feature is that the distribution is in cumulated form. This is a great advantage since other distributions must be converted to cumulative distributions before they can be used practically. A cumulative distribution in effect adds up all the chances on one side of any particular value. Instead of saying there is one chance in six of getting a four on the toss of a single die, we say there is a 50 percent chance of getting a four or higher. We can see why we need cumulative estimates in the case of a "continuous" distribution such as the number of units sold. It would be difficult to deal with the 1 out of 10,000 chance that we will sell exactly 8000 units. Much the same applies to the 35 percent chance that between 8000 and 12,000 units will be sold. It's much easier to deal with the 85 percent chance that sales will be greater than 8000. This will become evident when we see how the actual calculations are carried out.

A close look at the estimated sales and their probabilities shows that they are not symmetrically distributed around the 50 percent (or even) chance point. This is often a problem with formal distribution functions since there are many varieties of skewed or nonsymmetric distributions. Again we have an advantage in that our estimate of the probable distribution is directly applied. Another feature is that the 50 percent estimate need not be one of the five cumulative points. The three middle estimates can be any that are suited to the data. It is not uncommon for the second and fourth estimates to be something like 95 percent and 5 percent or 90 and 10, etc. These correspond to easily visualized chances such as one out of twenty, one in ten, and so on. These might correspond to a pessimistic and optimistic estimate in addition to a more central or fifty-fifty estimate.

**Sampling from the Distribution**

We now have a distribution, that is, a quantitative expression of the uncertainties affecting a variable in our model of the business venture. The question is: how do we use it? In our example, the Monte Carlo method requires us to select at random one of the possible sales levels between 4000 and 15,000. The random selection must conform to the distribution, which is not uniform and for which we have only five points. The simplest method is to assume that the distribution between two successive levels or points is uniform. This allows us to obtain intermediate values by simple or linear interpolation. A plot of our sales volume distribution in figure 1 illustrates the process. If we compare the tabulated distribution with the plot in figure 1 and with the formula

\[ V = (((P_1 - P)/(P_1 - P_2))\times(V_2 - V_1)) + V_1 \]

we should be able to see how this works. Thus, using the BASIC ran-
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  - Microdrive
    - Model 315: $399.00  

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  - EZwriter
    - Model 2000: $359.00  
  - Microdrive
    - Model 315: $399.00  

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dom-number generator, a random
probability P between P1 and P2
selects a sales volume V between V1 and V2.

There are several ways you could
arrange such tables relating possible
values to their probability of occurrence.
The important thing is to be consistent so that your tables, formulas, program, interpretation, and logic all hang together. In the sample
venture analysis we are developing here, we will use the format of our
sales volume example. The specifications
for a variable are: (1) use five
levels with probabilities of 1 and 0 at
the extremes; (2) estimate values in
terms of "equal to or greater than";
(3) always start with the estimate for
which the probability equals 1. That's
almost all there is to it.

We need to develop similar tables
for each of the variables in the equation
representing the venture. These are shown as DATA statements at the
end of listing 1. The program is now ready to sample them using a succession
of random numbers. Each sampled value gets plugged into the
equation. This yields one possible
outcome. The program does this
repeatedly, saving the results in a
table of outcomes for further analysis.

Note how the fixed cost, which is
a constant, is represented in the
DATA statement on line 62140 of the
program. This wastes random numbers and running time but it
simplifies programming and is very flexible. With this arrangement any
variable can be treated as either a
constant or a distribution without re-
programming.

**Does It Really Work?**

At this point you may be wondering whether we can really get away with fitting or representing the smooth curve of a distribution of expected values with straight line segments, and only four of them at that. It turns out that, in almost all cases, the use of precise distributions, or of more points, makes little significant difference in the results. This has also been my own experience with venture analysis in the chemical industry over many years.

If we think about it we can see why this is so. The most obvious consideration is that any estimate of future events is subject to error, however informed it may be. As Murphy, who by the workings of his own law must be counted an optimist, would put it, "The future is uncertain; you can count on it." There is a deeper reason, however, why this simplified approach works. It lies in the use of a distribution or spread of values. The mere fact that an informed estimator has set approximate upper and lower limits adds far more information to the simulation than any refinements in the detailed form of the distribution.

It is the introduction of distributions that transforms the formerly popular (but wrong) single-point estimates into a sound and informative analysis. This does not mean that the forecast of outcomes is necessarily correct. Even when wrong, the method provides good information on which of the variables are most important. It may show that a doubling of promotional expenses will have very little effect, whereas a 10 percent increase in inventories can turn a profit into a loss. Such a use of venture analysis is called sensitivity analysis.

**A Venture-Analysis Program**

Now we know how to sample a
distribution by going in with a ran-
dom probability P and coming out with a corresponding value V. The
program shown in listing 1 imple-
ments this and does a complete risk
analysis. It embodies our specific
model example. The program is easily
modified for other venture analyses by simply replacing the
equation, or model, in subroutine
31000. It is a no-frills program
designed for ease of understanding.

The style of programming followed here consists of putting everything possible into subroutines. These are invoked by a short calling section at the start of the program.

It looks simple and that's the way it should be. We are looking at the main features of the program, avoiding all detail at this level. We see that the program starts with a specification section and ends with a sorted
tabulation and display. The simulation is performed in three nested FOR...NEXT loops. The task carried out by each called subroutine is described in the remarks to the right.

Subroutines are used even if they are called only once. There are many advantages to this. Each subroutine performs a single task, which is described in its header. This makes it easy to follow the flow of the program. Another feature is that GOTOs, whether explicit or implied, never branch out of a subroutine. If such an excursion is necessary, a call
is made to another subroutine. This
is not a dodge since a subroutine always returns to the point immediately following its invocation. We could say that this programming style produces a bunch of grapes (GOSUBs) instead of a bowl of spaghetti (GOTOs). It is much easier to pick your way through a cluster of grapes than a tangle of spaghetti.

GOTOs are used, of course, but they branch to points within their own routines. This makes it much safer to modify the program when necessary. It's about the closest approach we can make to structured programming in Microsoft BASIC.

As a further aid to understanding the program, the meaning of the pro-
gram variables is shown in table 1. The Monte Carlo sampling is carried out in subroutines 21000 through 23000 and is applied to the model equation in subroutine 31000. The outcomes are stored in the array variable OU. They are converted to a
Table 1: Variables used in the Monte Carlo Venture Analysis program.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO</td>
<td>Standard deviation over all samples.</td>
</tr>
<tr>
<td>AV</td>
<td>Average or mean.</td>
</tr>
<tr>
<td>CO</td>
<td>Array of cumulative distribution values.</td>
</tr>
<tr>
<td>FC</td>
<td>Fixed costs.</td>
</tr>
<tr>
<td>FD</td>
<td>Array of averages for selected cumulative distribution points.</td>
</tr>
<tr>
<td>NR</td>
<td>Number of runs.</td>
</tr>
<tr>
<td>NS</td>
<td>Number of samples per run.</td>
</tr>
<tr>
<td>NV</td>
<td>Number of variables in model equation.</td>
</tr>
<tr>
<td>OU</td>
<td>Array of outcomes for a single run.</td>
</tr>
<tr>
<td>P</td>
<td>Probability.</td>
</tr>
<tr>
<td>P1</td>
<td>Probability estimate point in a distribution.</td>
</tr>
<tr>
<td>P2</td>
<td>Probability estimate point in a distribution.</td>
</tr>
<tr>
<td>PA</td>
<td>Store of selected P1.</td>
</tr>
<tr>
<td>PB</td>
<td>Store of selected P2.</td>
</tr>
<tr>
<td>PF</td>
<td>Step increment for summary cumulative distribution.</td>
</tr>
<tr>
<td>RS</td>
<td>Random seed.</td>
</tr>
<tr>
<td>S#</td>
<td>Sum.</td>
</tr>
<tr>
<td>SD</td>
<td>Standard deviation.</td>
</tr>
<tr>
<td>SO</td>
<td>Single outcome calculated from the model equation.</td>
</tr>
<tr>
<td>SP</td>
<td>Selling price (effective).</td>
</tr>
<tr>
<td>SS#</td>
<td>Sum of squared deviations from the average.</td>
</tr>
<tr>
<td>ST</td>
<td>Array of run statistics.</td>
</tr>
<tr>
<td>SV</td>
<td>Sales volume.</td>
</tr>
<tr>
<td>UC</td>
<td>Unit distribution cost.</td>
</tr>
<tr>
<td>V</td>
<td>Sample value calculated from a distribution.</td>
</tr>
<tr>
<td>V1</td>
<td>Estimated value point in a distribution.</td>
</tr>
<tr>
<td>V2</td>
<td>Estimated value point in a distribution.</td>
</tr>
<tr>
<td>VA</td>
<td>Store of selected V1.</td>
</tr>
<tr>
<td>VB</td>
<td>Store of selected V2.</td>
</tr>
<tr>
<td>XS</td>
<td>Sink for dummy read, input, etc.</td>
</tr>
</tbody>
</table>

cumulative distribution by a Shellsort in subroutine 41000.

All that remains after this is to display the results. We could simply list our 200 outcomes in a table with their associated probabilities. Thus, the 20th outcome in the list would represent the minimum result of 90 percent of the trials. Such a table would not be very appealing. A better solution is to show probable outcomes in steps of 10 percent.

Some Results

With our program complete, our model specified, and our estimates in hand, we can now launch our venture thousands of times and see what the future promises. A typical run of 2000 samples gives the following pro-
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projection. All values are rounded to the nearest $100.

<table>
<thead>
<tr>
<th>Percent Chance</th>
<th>Gain Exceeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>-1900</td>
</tr>
<tr>
<td>90</td>
<td>800</td>
</tr>
<tr>
<td>80</td>
<td>15,300</td>
</tr>
<tr>
<td>70</td>
<td>19,900</td>
</tr>
<tr>
<td>60</td>
<td>24,300</td>
</tr>
<tr>
<td>50</td>
<td>27,900</td>
</tr>
<tr>
<td>40</td>
<td>31,100</td>
</tr>
<tr>
<td>30</td>
<td>35,000</td>
</tr>
<tr>
<td>20</td>
<td>39,400</td>
</tr>
<tr>
<td>10</td>
<td>45,600</td>
</tr>
<tr>
<td>0</td>
<td>58,400</td>
</tr>
</tbody>
</table>

Not surprisingly, Monte Carlo simulation with its distributed inputs gives a corresponding spread of outcomes. The first thing we note is that there is a possibility of a small loss. If we were to plot the above results we would find the chance of a loss is about 2 percent. The traditional single-point method would ignore the possibility of loss and come up with an overestimation of the gain as a most likely $30,400. This is very reassuring to people who like to keep their head in the sand.

We have achieved our objective of placing a probability estimate on a range of possible outcomes. Remember that we are dealing with essentially a one-shot proposition, and therefore the information in the two extremes is meaningful. If we were really dealing with the long run, then the extremes would hardly matter. We could be virtually certain of achieving something close to the long-term expectation or average of $27,600.

In spite of all that has been and can be said, many users still feel uncomfortable with this form of analysis. The reason is a basic one. This is the human predilection for twisting the facts of uncertainty into something that seems more certain. The analyst can help here by working up the results into a form the decision maker can relate to more easily. One type of analysis that is guaranteed to spark interest is a sensitivity analysis. Simply rerun the analysis with the same random seed but with a small percentage increase in sales. Do the same for each variable in turn and show which variable is most important in affecting the outcome. In models with more variables than in our example, such sensitivities are not always obvious.

Another possibility is to do some "what if?" simulations in which different possible estimates are used. The results can then be presented as a statement of conditions or scenarios required to avoid a loss or make a given profit. Presenting the results in the form of charts or curves can also help.

**Have We Taken Enough Samples?**

You may have wondered why the program carries out ten runs of 200 samples each. Why not one run of 2000 samples? By making several small runs instead of one large run we obtain information on the adequacy of our sample size. Recall that a Monte Carlo simulation is in the nature of an experiment. It does not give a precise answer even when one is possible. By examining the results of several runs we can get a measure of how well we are zeroing in.

Here's how it works for our example: the following averages are for ten runs of 200 samples each. All the figures, including the standard deviations, are supplied by the program. The standard deviation is a statistical measure of the amount of variation or spread in the data represented by an average:

<table>
<thead>
<tr>
<th>Run</th>
<th>Average</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28,100</td>
<td>14,100</td>
</tr>
<tr>
<td>2</td>
<td>28,000</td>
<td>14,000</td>
</tr>
<tr>
<td>3</td>
<td>28,700</td>
<td>13,900</td>
</tr>
<tr>
<td>4</td>
<td>27,400</td>
<td>13,200</td>
</tr>
<tr>
<td>5</td>
<td>26,800</td>
<td>14,000</td>
</tr>
<tr>
<td>6</td>
<td>26,700</td>
<td>13,200</td>
</tr>
<tr>
<td>7</td>
<td>26,100</td>
<td>12,500</td>
</tr>
<tr>
<td>8</td>
<td>29,000</td>
<td>12,700</td>
</tr>
<tr>
<td>9</td>
<td>28,100</td>
<td>13,900</td>
</tr>
<tr>
<td>10</td>
<td>25,900</td>
<td>13,200</td>
</tr>
</tbody>
</table>

As expected, we find a fair amount of fluctuation. What about our overall average and standard deviation? For the 2000 samples we have:

- **27,600 Average**
- **13,400 Standard Deviation**

We appear to have gained nothing from our ten-part breakdown. But there is more information to be squeezed from this data. Suppose we take the average of the ten averages and, again courtesy of our program, take a standard deviation. This time it is for the average of the averages. We can do this since each average represents the same sample size. As expected, we get the same average but note the new standard deviation:

- **27,600 Average**
- **1000 Standard Deviation**

Statistical theory tells us that the true average has a 68 percent chance of being within one standard deviation or $1000 of our estimated average. If we had made only one run of 2000 samples, we would have little idea of how we were doing. The large standard deviation of $13,400 would have left us with a range of about $14,000 to $41,000 in which to expect the average in 2 out of 3 chances.

Note that we have given no hard criteria or explicit formula for determining an optimum or safe sample size. Experience shows that a venture analyst should have and does have a feel for what is acceptable. For example, if you had made several ten-run simulations with different sample sizes, you might have come up with:

<table>
<thead>
<tr>
<th>Samples per Run</th>
<th>Overall Average</th>
<th>Overall Standard Deviation</th>
<th>Standard Deviation of Ten Averages</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>28,100</td>
<td>13,700</td>
<td>3300</td>
</tr>
<tr>
<td>100</td>
<td>27,800</td>
<td>13,700</td>
<td>1700</td>
</tr>
<tr>
<td>200</td>
<td>27,600</td>
<td>13,400</td>
<td>1000</td>
</tr>
</tbody>
</table>

In view of the approximate nature of the estimates, a sample size of 200 appears adequate. Should your model have more variables you might need to increase the sample size beyond 200. Fortunately, even fairly involved business-risk simulations need no more than five or six of their variables to be distributed. The other variables that are treatable as constants can be directly programmed as such into the model. This saves space and conserves the supply of nonrepeating pseudorandom numbers. It allows a realistic but no-frills simulation to be run on a microcomputer.

**Conclusion**

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This article includes material from the author's book Learning Simulation Techniques on a Microcomputer Playing Blackjack and other Monte Carlo Games published by Tab Books.

Pat Macaluso (9 Church Ct., White Plains, NY 10603) is a consultant, teacher, and writer on microcomputers with special interests in APL and applications software development.
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Some graphic examples that may be worth a thousand words

by Ronald R. Miller

It is difficult to relate the output of a simulation model to the physical system it describes. Graphic representations of results can make simulations more credible and more interesting. On most large computers, however, there are software and hardware barriers between the user and graphical output. Microcomputers, on the other hand, are easy to use, and simple graphics are easy to produce without help from a programmer or systems specialist. Examples show bar charts, snapshots, dot plots, bit density plots, and contour plots of simulation results generated using an Atari 800 microcomputer, a color television, and an Epson MX-80 printer (costing about $600) with graphics capability. All the user must do to obtain such plots is write short programs (less than 100 statements) in BASIC.

Simulations Need Graphics

Vendors of graphics software have spent a lot of money advertising the benefits of graphics in displaying computer output. Virtually every computer installation boasts of some graphics capability. Yet those of us who use computers and their output see very little graphics in practice. That is unfortunate because graphics is a tremendous aid in validating, verifying, and making credible simulation models.

Just how hard is it to determine whether a simulation model behaves properly? Consider the usual path (see figure 1) a model follows in going from concept to computer output.

Figure 1: Distance between the simulation user and the underlying system. It is difficult to relate the result of a simulation to the physical system it describes.
Step 1 is usually the translation of the concept, say of a physical system, into a mathematical model. There are many pitfalls in this translation. It takes a mathematician of great skill to build a model of a physical system that adequately captures its essential features.

There are even more pitfalls in building computer models from mathematical models. The computer model requires a translation from traditional mathematics to numerical methods and discrete computations. Most simulation specialists are aware of the problems computers have with rounding and truncating numbers. Some are aware of the fact that computer solutions of perfectly good equations can go bad without any warning. Few simulation specialists realize, however, that a computer model of any complexity can never be fully tested. For example, each branching condition in a computer program creates two different execution paths. It is not uncommon for a small simulation program to have over 100 branching conditions. This represents a potential of two to the hundredth power or $1.27 \times 10^{30}$ paths through the program. Even at today's computer speeds, one could never test every path.

Finally, there is the interpretation of model results. Each person usually has a different idea of what the results mean and whether they are valid in a particular situation. This problem is compounded by the fact that the mathematical modeler, the programmer, and the user are often different people, and each typically understands little of the others' areas of expertise. Under these conditions, believing the results of a simulation is like believing a rumor after 100 people have passed it on.

Graphics provides a window through which one can observe the behavior of a simulation. Everyone agrees that this is useful. Yet even with a lot of motivation and money, there is still not much graphics. Why? The answer is simple. Graphics is difficult to generate. The layers of hardware, software, and people between the computer and its users are a barrier that few can afford to penetrate.

Most users are not aware of how much hardware (see figure 2) there is between a computer terminal and the typical plotter. When problems occur, it is hard to determine if their source is hardware, software, or administrative (e.g., failure to activate a communications channel). When everything is working properly, the software forms the largest barrier to the computer user. For users to produce graphics on most systems, they must understand an installation's administrative procedures, operating system commands, editor commands, a programming language or the graphics vendor's software commands or both, and postprocessor commands that drive a particular graphics device (see figure 3). The 12-inch stack of documentation on the software layers forces most graphics customers to look for technical help.

The problem in finding technical help is that the user needs information from two different groups of people (see figure 4). One group is the operating system specialists who implement an installation's administrative procedures, install software packages, and determine the source of system problems. The other group is the computer programmers who use these software packages as components in computer models. Assembling a team to implement graphics for a simulation is thus expensive. The cost and complexity limit graphics to projects that have the required time and budget.

### Producing Graphics on Microcomputers is Easy

The best approach to penetrating the hardware, software, and people barriers is to eliminate them partially or completely. This is exactly what microcomputers do. The following characteristics of micros make them accessible:

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**Figure 2:** Layers of hardware between a computer user and a plotter. Many layers of hardware make systems inflexible and unreliable.

**Figure 3:** Layers of software between the user and graphical output. Lack of knowledge of software layers denies most users access to graphics.

**Figure 4:** Layers of people between the user and the computer form a barrier. This barrier is difficult to penetrate.
The direct driving of displays (see figure 5) is what makes micros such powerful graphics machines. Direct drive means part of the computer’s memory is devoted to maintaining the screen. There is a mapping of memory onto the video display. Dot matrix printers with graphics capability can also access this section of computer memory to produce a hard copy of the display. What you see on the display is what you see on the printer, dot for dot. The contents of memory can also be stored on disk or transmitted over telephone lines. This means pictures can be stored, transmitted, and retrieved just like any other data.

**Micros Do Have Limitations**

Micros cannot replace expensive graphics systems costing over $20,000 because of limitations in speed, memory size, and display resolution. Typical microcomputers address between 64K bytes and 256K bytes of memory and have a maximum graphics resolution of 200 by 300 dots using one color. A typical minicomputer-based graphics system has more than two megabytes of memory and a graphics resolution of 1024 by 1024 dots using eight colors. Microcomputers have no graphics standards, and graphics is normally not transportable between micros, particularly ones from different manufacturers. Many small applications, however, do not need more capability than the micros provide and most applications require only an hour or two of programming time to produce pictures. Since the investment in programming time is small, users who switch computers are generally willing to rewrite graphics programs from scratch.

Users can learn about microcomputer graphics easily from hobby-level magazine articles and books. These articles and books give simple explanations and nice comparisons between graphics methods and systems. However, these sources do not help the user determine whether micros are suitable for a given application. The best approach is to employ common sense. Even if an application turns out to be unsuitable for microcomputers, the education gained will be valuable in software design for a larger system.
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Some Very Graphic Examples

The following examples demonstrate the kinds of graphics that micros can produce. One obvious application for this capability is in education where small-scale problems are studied in detail. However, any simulation that fits on a micro can use these graphic techniques.

Figure 6 shows a conventional bar chart. The resolution of this picture is 61 dots/in horizontally and 76 dots/in vertically. The maximum resolution of the printer is 120 dots/in horizontally and 216 dots/in vertically. It takes about 30 BASIC programming statements to produce this plot, representing about 30 minutes of programming effort.

Queuing problems are perfect targets for graphical output. It is much more informative to see queues evolve in time than to have only peak and average statistics as outputs. A good enhancement to the plot of figure 7 would be to place the results of many simulation runs on the same graph. This plot was produced with about 30 BASIC statements representing about 30 minutes of programming time.

Figure 8 is a snapshot of the state of a small bank simulation. Snapshots provide information in a form that is easy to understand. Snapshots can even be changed 60 times per second to produce real-time output. The user could then watch customers arrive at the bank and be served. If the waiting line gets too long, the user can easily add another teller and rerun the simulation. This kind of

Figure 6: Bar chart representation of simulation output. Conventional bar charts can be generated easily on a video-display terminal and reproduced on a dot matrix printer.

Figure 7: Time plot of the state of a queuing system. The fine resolution of the graphics screen allows compact summaries of the results of a simulation.

Figure 8: Graphical representation of the current state of a queuing system. The ability to redefine the computer’s character set simplifies the graphic representation of objects involved in a simulation.

Figure 9: Dot plot representation of simulation output. The dot plot capability of dot matrix printers allows printing of simulated displays from test equipment such as a spectrum analyzer.

Figure 10: Bit density plot of wave propagation. Two-dimensional wave propagation can be displayed using bit density plots on a grid of over 60,000 discrete points.

Figure 11: Contour plot using varied dot densities. Some computer output is not numerical and only has meaning when displayed graphically as in this moiré.
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simulation has high credibility since anyone can observe and understand the behavior of the model.

In the analysis or simulation of electronic circuits, we could present results in the form that test equipment displays would produce for real circuits. This makes it easy to compare theoretical and actual circuit performance. Figure 9 shows an example derived from a spectrum analyzer. Simulation of test equipment displays is also useful in computer-aided instruction.

The resolution of raster displays is good enough to generate plots using red and blue dots and print them using color separation and color carbon paper. The plots would appear to be three-dimensional when viewed through red-green glasses.

The plot in figure 11 looks complex, but was generated by about 30 BASIC statements. It shows the effect on the eye of varying dot densities. In color, this plot is spectacular because of the blending that occurs when colors are plotted next to each other on a television. Even in black and white, one sometimes sees brown bands in the dot patterns. This kind of plot would be useful in producing contours or surface maps. It is another way to produce the illusion of three dimensions.

Figure 12 was produced with 100 BASIC statements that access a file of 8800 coordinates representing the surface of Earth. The program plotted this map in 12 minutes and printed it in .45 seconds. This program with data costs about $21.

Figures 12 and 13 were produced by the same program. Figure 13 demonstrates zooming in on a selected part of Earth's surface. Once these maps are plotted, they can be saved on disk and used repeatedly. It takes about 60 seconds to save or retrieve a map from disk.

References

This article was reprinted from the June 1982 Simulation—a publication of the Society for Computer Simulation, La Jolla, CA.
Microsoft® Pascal may be the most powerful software development environment available for the MS®DOS system. It combines the programming advantages of a structured high-level language with the fast execution speed of native code compilation.

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*Introductory price
Going Further

A compendium of conferences, organizations, books, and software for simulationists

by Charles A. Pratt

Simulation is one of the oldest and best established applications for computers. Engineers in the aerospace field began work on simulation with analog computers in the early 1950s. As a result of this relatively long history, in computer terms, simulation has developed a body of literature and a methodology shared by few other application areas. The conferences, organizations, books, and software list that follows should get you off to a good start on the subject.

Conferences

Until recently, simulationists were just not interested in anything except very large computers, because the size of their programs was far beyond the capacity of the first microcomputers. This sentiment has changed radically in the last few years due to the increased capacity of microcomputers.

The first real sign of this acceptance was the conference called Modeling and Simulation on Microcomputers, held in San Diego by the Society for Computer Simulation (SCS) in January of 1982. Initiated by Dr. Lance A. Leventhal (at the time the technical editor for SCS’s monthly journal, Simulation) and me to encourage communication between the experienced simulationist and people working with microcomputers, it remains the only existing conference on this specialized subject. Dr. David M. Chereb responded to the need by becoming chairman of that first conference. At that meeting, he presented an econometric model of the U.S. that ran on a 48K-byte TRS-80. The variety of applications presented in 1982 astounded all of us. Some of those applications involved computational fluid dynamics, a model of the educational system in Mexico, a weather-impact model, a physiological model, a model of army mobilization, and robot kinematics.

The second year of the conference, 1983, continued with the presentation of several serious engineering simulations on microcomputers. Several languages specifically designed for modeling on microcomputers were introduced: Micro-Sim, Micro-Passim, Tabletop Simscript, Tutsim, and Micro-Rsmm.

The titles of some of the papers planned for the 1984 conference further demonstrate the diversity of uses for simulation:

• Microplan: A Microcomputer-Based Traffic Control Plan Generator
• Can an Early Retirement Incentive Program Pay for Itself?
• Transist: Route Scheduling and Performance Optimization
• Microcomputer Modeling and Simulation in Government Tax Revenue Estimation
• Microcomputer Seismic Signal Simulation
• M-CUPS: A Chemical Process Simulation Written in UCSD Pascal
• Consistency of Price Cycles in the Dow Jones Industrial Average

Two other conferences covering simulation on both microcomputers and larger machines are the Summer Computer Simulation Conference (Boston, July 23–25, 1984) and the Winter Simulation Conference (Dallas, November 28–30, 1984). Contact the Society for Computer Simulation, POB 2228, La Jolla, CA 92038, (619) 459-3888 for more information on these conferences.
Organizations

The Society for Computer Simulation is the only organization made up exclusively of people interested in computer simulation. The SCS has several active regional councils that have one or more meetings each year.

The IEEE Computer Society has a simulation technical committee that publishes the quarterly journal, Modeling. The society can be contacted at 1109 Spring St., Suite 300, Silver Spring, MD 20910, (301) 589-8142. The SIGSIM group (Special Interest Group—Simulation) of the Association for Computing Machinery (ACM) can be contacted at 11W. 42nd St., N.Y., New York.

Several in organizations

International Association for Mathematics and Computers in Simulation (IMACS)
(has representatives in many countries)
c/o Prof. A. W. Bennett
Dept. of Electrical and Computer Engineering
Clemson University
Clemson, SC 29632
U.S.A.

Scandinavian Simulation Society (SIMS)
Technical Research Centre of Finland
VTT/Sah, 02150 Espoo, Finland

Japan Society for Simulation Technology (JSST)
c/o Dr. Michio Nakano
Dept. of Control Engineering
Tokyo Institute of Technology
12-1 Oh-okayama, 1
kyo 152, Japan

Association Francaise d'Intelligence Artificielle et des Systemes de Simulation (AFIAS)
211, Rue Saint-Honoré
75001 Paris
France

Dutch Benelux Simulation Society (DBSS)
~ H. Kerckhoffs
University of Technology
Informatics
Julianalaan 132
2628 BL Delft, The Netherlands

Arbeitsgemeinschaft für Simulation (ASIM)
Prof. Dr.-Ing. W. Ameling
Lehrstuhl für Allgemeine Elektrotechnik
und Datenverarbeitungssysteme
RWTH Aachen
Schinkerstrasse 2
D-5100 Aachen, West Germany

Table 1: The Society for Computer Simulation's latest list of simulation software available for microcomputers, originally published in the SCS journal Simulation. Contact the manufacturer for definitive data.

<table>
<thead>
<tr>
<th>Item Name</th>
<th>Brief Description</th>
<th>Contact</th>
<th>Computer</th>
<th>Operating System/ Other Software Required</th>
<th>Peripherals Required</th>
<th>Cost</th>
</tr>
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<tbody>
<tr>
<td>ACES: All-Purpose Continuous Equation Simulator</td>
<td>Graphics solution to over 100 coupled first-order nonlinear differential equations using powerful fourth-order integration routine. Over 100-page manual.</td>
<td>Jay Wilson, Modulo 2 Company, POB 58781, Tukwilla, WA 98188, (206) 271-9258</td>
<td>Apple II work-alike</td>
<td>DOS 3.3</td>
<td>disk drive</td>
<td>$199.95</td>
</tr>
<tr>
<td>ASSE: Ada Simulation Support Environment</td>
<td>Package system for combined discrete-event activity scanning and process interaction (trans-action flow) modeling in Ada.</td>
<td>Dr. Heimo H. Adelsberger, Institut für Statistik, Augasse 2-6, Vienna, Austria A-1090, 347541, ext. 757</td>
<td>CP/M</td>
<td>64K bytes, screen, printer</td>
<td></td>
<td>$5000</td>
</tr>
<tr>
<td>EZQ Differential Equation Solver</td>
<td>Solve differential, difference, and algebraic equations on an Apple II with graphical and tabular output.</td>
<td>Acme Software Arts, Box 6126, Evanston, IL 60204, (312) 942-6412</td>
<td>Apple II DOS 3.3</td>
<td>64K bytes of memory, one disk, printer optional</td>
<td></td>
<td>$799.5</td>
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<td>Item Name</td>
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<tr>
<td>H-Champ</td>
<td>Helmsman's application environment software package, supporting users of hard disk, multiuser micros, and Unix minis.</td>
<td>Helmsman Systems Inc. Mr. Silverstein 1030 S. Winchester #205 San Jose, CA 95128 (408) 246-8300</td>
<td>Z80, 8080, 8085, 8088, 8086, 68000, Z8000, etc.</td>
<td>CP/M 8-bit, CP/M 16-bit, MS-DOS 2.0, and Unix</td>
<td></td>
<td>$695</td>
</tr>
<tr>
<td>ISG: Interactive Scientific Graphics</td>
<td>Package of UCSD Pascal procedures, with interactive features, plots sets of functions with full labeling.</td>
<td>Thomas H. Bleakney 18537 Arrow Hwy. Suite D-105 Covina, CA 91722 (213) 339-8716</td>
<td>Apple II, II Plus</td>
<td>Pascal 1.1</td>
<td>language card or other 16K-byte RAM card</td>
<td>$95</td>
</tr>
<tr>
<td>ISL-Apple</td>
<td>Ideal for educators. Solves nonlinear differential equations up to 10 times faster than Apple BASIC. Uses game paddles and graphics.</td>
<td>R. D. Benham 5312 W. Tucannon Kennewick, WA 99336 (509) 783-3829</td>
<td>Any Apple II with 48K bytes of memory</td>
<td>Apple DOS version 33</td>
<td>disk drive available upon request</td>
<td></td>
</tr>
<tr>
<td>m-CPS: Chemical Process Simulation</td>
<td>A hydrocarbon simulation using the SRK equation of state. Includes a database of over 60 compounds. Free format input file.</td>
<td>Ofelt and Associates 8007 Oak Moss Dr. Spring, TX 77379 (713) 376-3614</td>
<td>Apple II Plus/IIe, 64K</td>
<td>Pascal</td>
<td>two disk drives, optional printer</td>
<td>$250</td>
</tr>
<tr>
<td>Micro-Dynamo System Dynamics Modeling Language</td>
<td>Micro-Dynamo compiles and simulates complex models of cause-and-effect relationships over time. It lets you create your model and specify what variables are printed and plotted — without complicated format statements. Interprets model internally to produce both tabular and plotted results.</td>
<td>Software Sales Addison-Wesley Publishing Company Inc. Jacob Way Reading, MA 01867 (617) 944-3700</td>
<td>Apple II, IBM PC</td>
<td>Pascal operating system</td>
<td>two disk drives, color or b/w monitor; printer recommended</td>
<td>$245</td>
</tr>
<tr>
<td>Micronet</td>
<td>A network-based discrete-event language that operates as a simulation system for microcomputers.</td>
<td>Pritsker &amp; Associates Inc. POB 2413 A West Lafayette, IN 47906 (317) 463-5557</td>
<td>Apple II Plus, Apple IIe, IBM PC, IBM PC XT</td>
<td>various</td>
<td></td>
<td>$2500</td>
</tr>
<tr>
<td>Micro-Passim</td>
<td>A simulation support package for combined discrete-event and continuous models in UCSD Pascal. Both process interaction and event scheduling world views are implemented. Example models included in the documentation.</td>
<td>Dr. Claude C. Barnett Physics Dept. Walla Walla College College Place, WA 99324 (509) 527-2881</td>
<td>Apple II and III, PDP 11/23, IBM PC, etc.</td>
<td>UCSD Pascal</td>
<td>disk drive</td>
<td>$125</td>
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<tr>
<td>Micro-Sim</td>
<td>Simulation package for simulating queuing networks. Has graphics and is interactive.</td>
<td>Stewart Hoover</td>
<td>Terak, Apple</td>
<td>UCSD Pascal</td>
<td>some graphics capability</td>
<td>$50</td>
</tr>
<tr>
<td>Scheduling Simulator</td>
<td>A system especially designed to simulate the orders being processed in a job shop environment such that trial schedules may be run and analyzed.</td>
<td>Lionel Poizner</td>
<td>Apple II and other such microcomputers</td>
<td>DOS 3.3</td>
<td>four disk drives, printer</td>
<td>$535</td>
</tr>
<tr>
<td>SIMAN simulation package</td>
<td>General-purpose simulation language with special manufacturing systems features. Three modeling orientations available, graphical and statistical output.</td>
<td>Dennis Pegden System Modeling Corporation</td>
<td>MS-DOS microcomputers</td>
<td>Standard FORTRAN</td>
<td>190K bytes of RAM</td>
<td>$900</td>
</tr>
<tr>
<td>Sim-By-Int</td>
<td>“Simulation-By-Interview”… Program examples of code for user-interactive definitions of dynamic systems.</td>
<td>G. R. Marr Jr. POB 143</td>
<td>various</td>
<td>CP/M, UCSD Pascal, dBASE II</td>
<td>KB/CRT/printer</td>
<td>$5</td>
</tr>
<tr>
<td>Simscript 11.5</td>
<td>Language for computer modeling.</td>
<td>C.A.C.I.</td>
<td>IBM PC</td>
<td></td>
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</tr>
<tr>
<td>SMP: System Modeling Program</td>
<td>A continuous-time system simulation language with direct equation input for the Apple computer.</td>
<td>Dr. Steven E. Reyer 8664 N. Pelham Pkwy. Bayside, WI 53217</td>
<td>Apple II Plus, DOS 3.3</td>
<td>optional printer</td>
<td>optional printer</td>
<td></td>
</tr>
<tr>
<td>TDKIN: Three-Dimensional Kinematics</td>
<td>Computer program that assembles and solves the equations resulting in the solution of kinematics of three-dimensional mechanisms.</td>
<td>Harry W. Townes 514 North 10th Ave. Bozeman, MT 59715 (406) 994-6297</td>
<td>Microcomputers or mainframes written in FORTRAN 66</td>
<td>FORTRAN compiler or CP/M</td>
<td>optional printer</td>
<td>variable; depends on purchase of source code or CP/M relocatable files</td>
</tr>
<tr>
<td>Transit</td>
<td>Estimates and traces future performance of transport systems.</td>
<td>Y. J. Stephanedes 500 Pillsbury Dr. SE Minneapolis, MN 55455</td>
<td>IBM PC, Apple II</td>
<td>UCSD Pascal</td>
<td>screen for graphics</td>
<td>$100</td>
</tr>
<tr>
<td>Tutsim</td>
<td>Interactive simulation program for continuous dynamic systems on mini- and microcomputer systems with block diagram and bond graph model input.</td>
<td>Applied i 200 California Ave Palo Alto, CA 94306 (415) 325-4800</td>
<td>Apple, CP/M-based, PDP-11, LSI-11, IBM PC</td>
<td>variable according to computer used</td>
<td>graphical output</td>
<td>$350-$2000</td>
</tr>
</tbody>
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BOOKS

Although many good books on simulation are available, few cover microcomputers. Tab Books Inc. (Blue Ridge Summit, PA) published two in 1983 that can be very helpful. A good introduction is Learning Simulation Techniques on a Microcomputer Playing Blackjack & Other Monte Carlo Games by Pat Macaluso, for $10.95. It covers a good deal of the terminology and concepts used in designing models. The title may mislead you; blackjack is used as an example, but the other program is a simulation that can be applied to business ventures. (See Mr. Macaluso's article on page 179.) The other Tab Book, Forecasting on Your Microcomputer by Daniel B. Nickell ($14.95), concentrates on forecasting and uses modeling as one of several techniques. A chapter on the mathematical principles involved is written in a way that makes the clear even to one without a mathematical background.

CHARLES PRATT has served as executive director of the Society for Computer Simulation (POB 2228, La Jolla, CA 92038) since August of 1980. He has a bachelor's degree in economics from Guilford College in North Carolina.
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Reviewer's Notebook

by Rich Malloy

The really big item this month is the Tandy TRS-80 Model 2000, which is described in an article on page 306 of this issue. From the brief experience I've had with the 2000, I have been much impressed. Let's hope that Radio Shack makes available a good technical reference manual so that the hackers can turn it into an even better machine.

Wang's Professional

Lately, we've received a few systems that are obviously not meant for hackers. Most prominent among them is a hard-disk version of the Wang Professional Computer (see Elaine Long's review of the floppy-disk version on page 360 of the December 1983 BYTE). This is a fairly well designed system. In fact, I used it to write this month's column, but not without some difficulty. This machine takes some getting used to. The keyboard, in particular, has a touch that is a little too light. Also, it's hard to make the machine work correctly with a non-Wang printer. But overall the system is pretty good.

I particularly like the monitor support arm, which allows the monitor to hover a few inches over your desk. This should be great for people like me whose desks are already covered with a few inches of various materials.

Again, although it is a fairly powerful machine (it has an 8-MHz 8086 microprocessor), the Wang PC is not meant for hackers. It is clearly designed for the office. And although it is disk-compatible with the IBM PC, you will probably have to buy all your software and accessories from Wang itself. The software selection is of good quality. We have Multiplan, 1-2-3, TK Solver, and version 2.0 of Wang's dedicated word processors. But the number of packages available is rather small. Also, the user-friendly menu system that leads you through MS-DOS version 2.0 can drive experienced computerists batty. The Wang PC is probably a good machine for your cousin the lawyer.

DEC's Rainbow

In response to a previous column, Digital Equipment Corporation has sent us a new version of its Rainbow, this one called the Rainbow 100 Plus. I can tell because it came with a little plastic sticker saying "100 Plus" that we're supposed to stick onto the front of the machine.

Also, we've finally received a copy of MS-DOS for the Rainbow, with a Format program included. Now we can format our own disks, but few other MS-DOS machines can read them. The Rainbow uses single-sided, quad-density disks. Fortunately, the Rainbow can read other MS-DOS disks, but only if they're single-sided. And in my experience, it can't read all the files on a single-sided PC-DOS disk all the time.

As for software compatibility, this machine cannot run many of the IBM PC programs. You will probably have to buy most of your software from DEC. And as for expansion slots, after you install a hard-disk drive, some extra memory, and a color graphics board, there are no slots left.

The Rainbow is a slick, good-looking office computer with a number of nice features. But, like the Wang PC, this is not a hacker's machine. In time, however, the Rainbow will probably evolve into a very impressive system.

The Compaq Plus

Another recent entry into our computer room is the Compaq Plus, the 10-megabyte version of the original IBM PC clone. This machine sports a 3½-inch hard disk, which reportedly is surrounded by a sizable cushioning system. This, too, is an office machine, but it is built to travel.

Unlike the Wang and the Rainbow, the Compaq should have no problems with any IBM PC software. The Compaq has traditionally scored very high in most IBM PC-compatibility tests, and at $4995 it represents a serious alternative to the IBM PC XT.

The Tava

We also received the Tava computer, another IBM PC clone, but with Asian roots. The Tava has been raising a few eyebrows by advertising a price of $995. But before you sell your shares of Big Blue, you should note that that price doesn't include any disk drives or a monitor. Two double-sided disk drives with a controller will set you back an additional $670.

As for performance, our Tava was not completely without problems. First, we couldn't get it to turn on because its fan was stuck. Then we didn't have an operating system, or a serial port or parallel port for that matter. We tried PC-DOS, and most IBM programs ran without a problem. Some programs, however, didn't recognize the Tava's color graphics adapter as a bona fide board. Tava sent us a parallel port (just a connector that plugs into the motherboard), and the serial ports (there are two) should arrive any day.

I really like the Tava's documentation—a single piece of paper saying, in effect, that you should insert a disk into one of the drives and turn the machine on.
Hardware Review

Compupro's System 816/C and System 68K—the Two and Only

Take a look at Compupro's new reversibles—they're 8085/8088 on one side and 68000 on the other

by Ed Teja

Compupro's two new computer systems, the System 816/C and the System 68K, are based on the same S-100 bus enclosure, and they both use the same memory and I/O (input/output) boards. When loaded with the same options, they differ only in their microprocessors. The System 816/C uses an 8-bit, 6-MHz 8085 microprocessor and a 16-bit, 8-MHz 8088 microprocessor. The System 68K, on the other hand, uses a 16-bit, 4- or 8-MHz 68000 microprocessor. The systems come with different versions of CP/M.

Both systems feature two solidly built metal enclosures, the Desktop Enclosure 2 and the disk-drive enclosure. The Desktop Enclosure 2 houses a 20-slot motherboard, the central processing unit, memory, I/O boards, a constant-voltage power supply, a line filter, and a large fan. The disk enclosure contains the disk drives and another fan. Photos 1 and 2 show the front and back of the enclosures, respectively.

Each system costs $8995—not expensive as business systems go, but definitely not economical enough for most hobbyists. Besides the hardware and software, though, you also get repair service under Xerox's Americare program. This program gives you free on-site service for one year if you are within a 100-mile radius of one of Xerox's 82 service centers. Outside that radius, you either pay a service charge for on-site work or you can take the system into a service center. This bundled-in service program beats any other available form of technical support hands down and makes the package a better risk for businesses. That is, it's a better risk if these are the right computers. Let's take a closer look at the machines and see.

Photo 1: The front of Compupro’s System 816/C computer. The System 68K looks the same. (All photos were taken by Carey Hillhouse.)

Photo 2: The rear of the System 816/C. The system operator (user 0) plugs into the bottom right connector. The wide connector at the top center connects to the disk drives.
System 816/C Hardware

The heart of the System 816/C is the 8085/8088 central processing unit, shown in photo 3. This board allows the computer to run either 8-bit or 16-bit CP/M programs at high execution speeds.

Most of the System 816/C’s I/O functions are handled by the System Support 1 and Interfacer 3 boards. The System Support 1 board provides an RS-232C port and most of the I/O support features, such as the clock/calendar, dual-interrupt controllers, and triple interrupt timers. The Interfacer 3 board furnishes eight fully programmable asynchronous serial channels to which the user's terminals are connected. The System 816/C comes configured to support three users; however, you can expand it to handle 15 users. There are two parallel ports: one handles the endless variety of Centronics/Epson-type printers, while the other is an untyped port to use as you will.

The system comes with 512K bytes of CMOS (complementary metal oxide semiconductor) RAM (random-access read/write memory) dwelling on two of Compupro's RAM 22 cards. These cards act as a byte-wide memory for 8-bit systems and then switch automatically to a word-wide configuration for 16-bit operation by reading the state of the SXTRQ signal on the S-100 bus. A single DIP (dual in-line package) switch assigns each memory board a starting address that is a multiple of 256K bytes, within the 16 megabyte address space specified by the IEEE-696 standard. If you want to add memory, simply buy additional RAM 22 cards ($2495 each), set the switch, and plug the boards in. You don't have to reconfigure the system—an autoconfiguration routine takes care of that.

Compupro designed its RAM 22 cards especially for use with 8086/8088 processors at speeds exceeding 10 MHz. In particular, the RAM 22 is suitable for DMA (direct memory access) operations. DMA is critical in multiuser systems, because you can't expect a processor to handle multiple users and I/O as well.

For more permanent storage, the System 816/C comes with two 8-inch, double-sided, double-density floppy disks in a separate cabinet. The system I used came with Qume Trak 842 drives. Together, the floppy disks give you 2.4 megabytes of storage, formatted in 1024-byte sectors. These drives also read single-sided, single-density disks.

Compupro's Disk 1 board handles the disk operations and houses the phantom boot EPROM (erasable programmable read-only memory) that can handle eight different processors or boot routines. The board furnishes fully arbitrated DMA data transfers that can cross 64K-byte boundaries.

An Intel 8272 floppy-disk-controller chip is the heart of the disk-controller board. According to the manual, this lets the controller format disks with a true IBM 3740/System 34 disk format. But this presents a problem if you try to use the controller with a disk that was formatted using a 1791 disk-controller chip, because the 1791 inserts a byte of zeros immediately after the header CRC (cyclic redundancy check) bytes. The zeros can confuse the 8272. I didn't have a 1791-formatted disk with which to test this, and it isn't clear what the confusion ultimately does. But this could lead to some interesting service calls for the Americare folks.

One of the System 816/C's most powerful features is its optional M-DRIVE/H solid-state disk emulator, shown in photo 4. A solid-state disk emulator configures and uses RAM as if it were a disk drive, but without the slow access times inherent in a disk drive. Even the 30- to 65-millisecond average access times offered by many Winchester seem slow next to solid-state disk access times.

The system I used came equipped with a single 512K-byte M-DRIVE/H board. You can add 4 megabytes worth of RAM disk (on eight boards) if you need it. Compupro's software recognizes the presence of the RAM disk
At a Glance

**Name**
System 816/C

**Manufacturer**
Compupro
3506 Breakwater Court
Hayward, CA 94545
(415) 786-0909

**Price**
$58995

**Processors**
8085 and 8088

**Memory**
512K bytes of RAM

**Data storage**
Two double-sided, double-density 8-inch floppy drives furnishing up to 24 megabytes of storage

**Hardware needed**
Terminal, printer

**Software supplied**
CP/M-80, CP/M-86, MP/M 8-16, Supercalc-86, dBASE II

**Options**
512K bytes of solid-state disk ($1895)

**Audience**
System developers and professional users

---

and treats it as drive M when you boot the system. Addressed as two I/O ports, the board takes up none of the system's 16 megabytes of address space. The board formats as 504K bytes of disk space. Although not cheap ($1895 per 512K-byte board), this is one of the few system-performance options that carries its own weight. The RAM disk can make the difference in whether the System 816/C, or any other computer, works fast enough for your application. It's hard to imagine using a powerful computer system such as the 816/C without a solid-state disk of some sort. The disk-access bottlenecks that naturally occur when several users share the same resources would eliminate any advantage that the system offers. You'd be better advised to buy individual desktop computers for each user than one powerful system that doesn't offer a solid-state disk.

**System 816/C Software**

Each System 816/C comes with CP/M-80, CP/M-86, MP/M 8-16, Supercalc-86, and dBASE II. These programs should prove adequate for the business that is just becoming computerized. If they aren't, other applications programs are available from many sources.

To take full advantage of the System 816/C, you'll want to use the multiuser MP/M 8-16 operating system. This is Compupro's proprietary implementation of Digital Research's MP/M-86. MP/M 8-16 lets you run 8-bit and 16-bit programs simultaneously, and it is compatible with all CP/M and MP/M operating environments.

To make the user interface—called the Terminal Message Process (TMP)—more useful, Compupro has modified it as a system shell. This shell has six functions:

1. It makes terminal, printer, user, and drive assignments during log-in.
2. It lets the system operator make changes in printer default assignments.
3. It lets the system operator make changes in the user default number.
4. It lets the system operator make changes in the default drive for each user.
5. It accepts and executes user command lines.
6. It handles user log-in and log-out.

The system operator (user 0) can reset any of these characteristics every time the system is booted. In this way, the system operator controls which users have access to which system resources. You can give every user access to every resource if you want, but you might want to protect certain files or other resources.

Unfortunately, MP/M isn't the answer for all multiuser applications. If you are running a manufacturing program that requires every operator to have access to files on a record-by-record basis, MP/M can't handle the job, because it has no record-locking feature. On a file-by-file basis, however, it performs well. MP/M 8-16, in particular, is convenient because it allows one user to run an 8-bit program at the same time that another user is running a 16-bit program.
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The only problem with this software package is that you’ll have to format and copy all of your disks under CP/M. For some unexplained reason, the Diskcopy utility doesn’t run under MP/M, but that is a minor inconvenience.

System 68K Hardware
The only real difference between the System 816/C and the System 68K is the central processing unit’s 68K-byte board, shown in photo 5. As the name implies, this board is an S-100 processor card that uses the 68000 processor. It upgrades any IEEE-696/S-100 computer system from 8 to 16 bits. The 68000 runs at either 4 or 8 MHz (standard at 8 MHz) and works with a variety of 8- and 16-bit memory and peripheral devices. Another version that runs at 5 or 10 MHz is available. The board furnishes two sockets for up to 16K bytes of ROM (read-only memory), a jump-on-reset feature, and it even has provisions for an optional memory-management unit. A 24-bit addressing scheme accommodates up to 16 megabytes of memory, including a 64K-byte block of I/O addresses.

For $695, you can add the central processing unit’s 68K bytes to your System 816/C. You simply unplug the old processor board, plug in the new board and change a few DIP switch positions, and change a jumper on the Disk 1 card.

Once you’ve made these changes, you’ve turned your System 816/C into a System 68K. Buying the System 68K does have one advantage over upgrading a System 816/C, however—it already comes with 1.5 megabytes of M-DRIVE/H.

System 68K Software
Compupro’s version of CP/M-68K comes on two disks. The first disk contains CP/M-68K and its C compiler configured for the System 68K. The second disk gives you everything you need to create a customized system, including the source, library, and submit files needed to modify the BIOS (basic input/output system) to meet your system requirements. Thus, one System 68K can act as a development system for other CP/M-68K systems.

The CP/M-68K operating system that Compupro provides requires at least 256K bytes of RAM addressed at 0; a floppy-disk drive connected to the Disk 1 board (addressed at hexadecimal C0); a terminal set for 9600 bps (bits per second) with an 8-bit word length, no parity, two stop bits, and, to accommodate system I/O, Compupro’s System Support 1 board with its I/O address set to hexadecimal 50.

You also get a third disk containing another standalone system, MAPFORTH. The system includes the operating system, a FORTH compiler and interpreter, and a variety of precompiled utilities written in FORTH. You can’t use FORTH and CP/M-68K together, but at least for the moment you can write FORTH programs. Later, these should port over to other operating systems with little problem.

Using CP/M-68K proved straightforward. The only bug appears in the Diskcopy utility. You can only Diskcopy a single-sided disk to a single-sided disk. You can copy individual files to a larger disk with PIP (peripheral-interchange program), but you cannot use the Diskcopy routine. This problem occurs with the System 816/C version of CP/M, too.

Performance
“A High-Level Language Benchmark” (September 1981 BYTE, page 180) and “Eratosthenes Revisited: Once More through the Sieve” (January 1983 BYTE, page 283) compared the computational speed of a variety of 8- and 16-bit computer systems. The benchmarks with which the comparisons were performed were all written in high-level languages, such as FORTRAN, FORTH, Pascal, and C. Digital Research’s CP/M-68K operating system comes with a C compiler, so I was able to make a direct comparison with the machines already reviewed.

In the September 1981 article, the fastest execution time recorded was logged by a 68000 programmed in assembly language. It executed the program in 1.12 seconds. A PDP-11/70 running C came in second place, executing the benchmark in 1.52 seconds. Also in the 4.00 seconds-and-under category was an 8086 (assembly language), a PDP-11/70 running NBS Pascal, a Z8000 running Onyx C (Unix), and a 5-MHz 8088 programmed in assembly language. According to my testing, the System 68K should fit in next, because it ran the benchmark in 4.5 seconds, tying for seventh place with a PDP-11/60 running NBS Pascal. A PDP-11/40 running C placed ninth with an execution speed of 6.1 seconds. This puts Compupro in the top third of the 26 16-bit machines tested (25 reported in the article, plus the Compupro).

The much more comprehensive 1983 survey tested 17 different 68000-based machines, with the same benchmark used earlier. Four of these executed the program in less than 4.5 seconds, the fastest being an 8-MHz machine programmed in assembly code. Only one other 68000-based machine ran faster than 4.0 seconds—a machine programmed in SMPL that ran in 2.6 seconds.

In short, the Compupro System 68K compares favorably with other systems. It isn’t the fastest or most efficient, but it is competitive.
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Using the System

In spite of the documentation problem, the system proved simple to configure and begin using. There really isn't much to know, and there is plenty of information in the MP/M 8-16 Technical Manual and Installation Procedures to get you up and running in half an hour. The system doesn't come with a terminal, but I pressed an Addx Viewpoint terminal into service and it worked well.

Playing with a new system with no regard for the consequences can uncover some interesting anomalies. By trying thousands of things that didn't work, I discovered a minor problem with the shell program; it is possible to create a user interface that doesn't allow any users to sign on. All passwords become invalid, but the system insists on a password. The situation produces the kind of frustration experienced by Wordstar users who have just been told the disk is full. You know what you want to do, but there's no way to tell the system.

There is one other trap that is easy to fall into. Using the M-DRIVE/H is so much like using a fast disk drive, it is hard to remember that, when you turn off the power, the files on the M-DRIVE/H go away. Rebooting is no problem, because the boot routine doesn't reformat the M-DRIVE/H; but turning the power off without first putting the files you want to keep on a real disk is a definite mistake.

There seems to be no safeguard against making that error. A provision in MP/M 8-16 allows the system to automatically back up working files to the hard disk if you have one, but it has nothing that will rescue a user from the folly of turning off the power with data on the M drive. You could use the Sched (schedule) utility to cause the system to PIP all of the files from drive M to one of the floppy disks periodically, but that might prove disconcerting to unsuspecting users.

Conclusions

Although the System 816/C has a fairly high price tag ($10,890 with M-DRIVE/H), in a multiuser application it provides high performance at only about $3600 per user. Converting the System 816/C to a System 68K is simple and takes but a few minutes. And the System 68K's performance compares favorably to that of other 68000-based computers and PDP-11/60 minicomputers. The M-DRIVE/H solid-state disk emulator eliminates disk-access bottlenecks and the dual processor scheme of the System 816/C works well and is totally transparent to the user. The Americare program makes either computer a good bet for business and professional users. On the minus side, the System 816/C needs a Diskcopy routine that will run under MP/M. But the MP/M 8-16 shell will let you create exactly the system you want for each user. Well designed and executed, both computers are easy to love.

Ed Teja (238 Swift St., Santa Cruz, CA 95060) writes extensively about computers and peripherals. His latest book, A Designer’s Guide to Disk Drives, will soon be published by Reston Publishing Company Inc.
Do you feel stifled by your operating system? The p-System from NCI will release you. It is the complete program development environment for the IBM Personal Computer and compatibles. This is the fast p-System with the special p-machine emulator developed by NCI.

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This operating system is stable, friendly and easy to use. Command options are presented on a menu requiring only a single keystroke. The 8867 Numeric Coprocessor Support allows extremely fast floating point calculations and the asynchronous I/O lets you use serial printer and communications routines. With the p-System you can choose either UCSD Pascal, Fortran 77 or Basic as your programming language. NCI also offers hard disk support for the IBM XT.

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Microsoft Flight Simulator

Even experienced pilots will find this program useful and challenging

by Stan Miastkowski

As any programmer knows, simulations are one of the toughest programs to write. The seemingly endless list of interacting variables that comprise events that happen in the “real world” makes for a programmer’s nightmare. That’s why simulations used by serious researchers are often run on mainframe computers or even supercomputers like the Cray-1. Their incredible speeds and megamemories make them capable of processing the numerous variables and the endless streams of data used in such advanced fields as weapons and weather research—not to mention that the government is often the only entity capable of laying down the substantial bucks required for systems like these.

Despite the inherent roadblocks, programmers of minicomputers and microcomputers are forging new ground in simulations. Not all of the work is being done in esoteric scientific fields. In fact, microcomputer-based simulations are becoming increasingly common in the entertainment arena. Some of the most advanced work has been done by Atari’s Chris Crawford (see “Chris Crawford: Artist as Game Designer,” June 1982 Popular Computing, page 55), who’s responsible for such groundbreaking games as Eastern Front.

Flight simulators for microcomputers have been around almost since the beginning. Most have been rather crude, relying on slowly updated primitive graphics or an instrument panel only. Although fun for the nonpilot, they haven’t had enough features for an experienced pilot to find them useful or challenging. The Microsoft Flight Simulator is a refreshing exception, a fast-moving, realistic package that makes you consider all the variables and make the fast decisions that a pilot must make.

Flight

Although highly experienced pilots with tens of thousands of hours “behind the stick” often tell you that flying becomes boring, don’t be deceived. Flying an airplane, be it a Cessna trainer or a Boeing 747, is an exhilarating experience that requires complete concentration on the numerous visual and sensory cues (sound, movement, etc.) that assail the senses from the instruments, radios, and outside world. It truly uses the brain’s ability to parallel-process large amounts of data. But how do you develop a flight simulator?

The complete-environment simulators used by the airlines for training pilots are one extreme. Sometimes costing nearly as much as a real airplane, these closed-cockpit simulators are mounted on hydraulic legs to simulate movement and utilize high-resolution computer-generated graphics projected onto a large screen that sits in front of the pilots. The mind-boggling array of instruments in a modern jet cockpit are all there, and the whole thing is usually controlled by a superminicomputer such as a Digital Equipment Corporation VAX. So realistic are these simulators that the FAA (Federal Aviation Administration) recognizes them as equal to flying a real aircraft for part of a pilot’s training program.

Obviously, more than a couple of compromises are in order for a flight simulator that uses a personal computer. Movement must be simulated on the screen only, and computer-generated representations of the instruments also must be on the screen. In addition, the programmer must be well aware of the limitations of the processor, memory, and graphics capability of the computer used.

The Microsoft Simulator

The Microsoft Flight Simulator runs on the IBM Personal Computer (along with the Corona [with graphics board], the Chameleon, the Compaq, and several other PC clones), a logical choice because of its 16-bit processor and high-resolution graphics. It comes on a single 5¼-inch floppy disk, so it can be used on a single-drive
system. The disk's built-in copy-protection scheme allows you to make a single backup copy, a wise thing to do because the simulator quickly can become habit forming and the disk will get heavy use. It requires only the minimum memory (64K bytes), although you'll need the color/graphics card.

A word about the video display: although when you boot the disk the flight simulator asks you which type of display you're using (color TV/composite monitor, black-and-white TV/monitor, or RGB monitor), the realism of the simulator depends highly on the use of color. It will work in full color only with a color TV or composite monitor; an RGB (red-green-blue) display will display black and white. Although a color composite monitor is by far preferred, I found a color TV adequate (though a bit tiring on the eyes). You need color for one good reason: a pilot uses color to sort out the visual cues, both from the instruments and the view out the window. The one exception is night flying (available in the simulator) where, in real conditions, instruments are red-lighted to ensure that night vision isn't affected. In the simulator's night-flying mode, the instruments remain the same color they are in the “daylight,” not exactly realistic but still quite usable.

I strongly recommend staying away from this package if you don't have access to a color video display. Although you can still use it, it will soon become frustrating. Lack of color takes away a large degree of its realism. Besides, if you're color blind, the real world denies you the medical certificate needed to fly as pilot in command.

The simulator comes with a complete 93-page manual that includes several charts used for both VFR (visual flight rules) and IFR (instrument flight rules) flying. These are partial versions of actual government maps, the ones used by pilots during real flights. The manual, though a complete step-by-step run-through of the simulator, is a bit difficult to use as a reference guide.

I found I had to make up my own place markers for areas I'd be referencing often.

When you first boot the disk and select the video-display type, you're given the option of entering demo mode or regular flight mode. The demo mode is a good place to start, taking you through a short flight and letting you get a feel for the features.

The video display is divided horizontally into two parts (see photo 1). The top part is the view out the "windshield" of the airplane. This high-resolution view is upgraded about three times a second, resulting in a sometimes-uncanny degree of realism. The resolution is excellent, and objects on the ground are clearly discernible for what they are, rather than just a hazy intersection of jagged lines. However, don’t expect to see intimate details of the cities and towns you're “flying” over. Because of obvious memory limitations, three-dimensional objects are outlines, without details filled in.

The lower part of the display contains the instrument cluster, including the standard airspeed indicator, artificial horizon, altimeter, turn coordinator, heading indicator, and rate-of-climb indicator found in every airplane. In addition, you'll find an Omni-Bearing Indicator with glide slope (for landings during instrument conditions), a clock, magnetic compass, and various annunciator lights that monitor lights, landing gear, carburetor heat, and outer/middle/inner markers (also used for instrument landings). There's also a full complement of instruments that monitor the engine, including a tachometer, oil temperature and pressure gauges, and, most important, dual fuel gauges for left and right tanks. A single NAV/COM (navigation/communication) radio is provided, as is a radar transponder that sends a coded signal every time a pulse from tracking radar hits the airplane.

All in all, the plane is very well outfitted. About the only things missing are an ADF (automatic direction
finder) and a second (or even third) NAV/COM radio. The many frequency changes needed during instrument flight and during a departure from or approach to a moderately busy airport can be maddening with only a single radio.

The Microsoft Flight Simulator was designed by its author, Bruce Artwick of Sublogic Corporation, to simulate a Cessna 182. This single-engine aircraft—called the Skylane—delivers relatively high performance. Because an airplane like the Skylane has enough power and controls to get you into trouble, it's not normally used for student training. The simulator acts surprisingly close to the Skylane, the major difference being that the simulator can climb a bit faster than the "real thing." Another difference between the simulator and the Skylane is that the simulator has a retractable landing gear instead of the Skylane's fixed landing gear.

Flight Controls

In an actual airplane, you control it using four major controls:

1. **Yoke.** This is the "steering wheel" of the airplane. Turning it right or left controls the ailerons on the tips of the wings and banks the aircraft right or left. Pushing it in and pulling it out controls the elevator, the large horizontal wing on the back of the airplane. Pushing it forward tilts the nose down; pulling it backward tilts the nose up.

2. **Rudder.** This is the vertical wing on the back of the airplane, which is controlled by two pedals on the floor. It controls the left to right axis of the airplane. Maneuvers such as turns actually cause the airplane to slip sideways unless the turn is coordinated with the rudder. On the ground, most airplanes have the front-wheel steering connected to the rudder pedals.

3. **Throttle.** The amount of power in an airplane controls its rate of climb and descent as well as its airspeed. In fact, proper use of the throttle is one of the most difficult aspects of flight to learn. Landing an airplane properly is a fine art of controlling descent using power and the yoke so that the airplane stalls (stops flying) several inches above the runway.

4. **Trim.** Depending on the power and airspeed, as well as conditions such as passenger and equipment load and quantity and location of fuel, the force needed on the yoke to make the airplane perform a maneuver can vary greatly. The trim is a fine adjustment that equalizes the forces on the airplane.

Obviously, there's no yoke, throttle, trim lever, or rudder pedals on the IBM PC. Therefore, these variables are controlled by the keyboard (see figure 1). The primary controls are clustered on the numeric keypad located on the right side of the IBM keyboard. The primary yoke controls are in a standard cross configuration, with 2 (↑) and 8 (↓) controlling the nose attitude (elevator) and 4 (←) and 6 (→) controlling left and right banking (ailerons). The 0 (left) and + (right) keys are your "rudder pedals" and throttle position is controlled by the even-numbered F2 through F10 function keys on the left side of the keyboard. In all cases, pressing key 5 on the keypad centers the yoke. Because you don't have that "seat of the pants" feel, indicators on the panel show you the position of your controls. You do, of course, also get visual cues, such as when the ground is rushing up on you and your airspeed is increasing dramatically. The odd-numbered function keys (F1 through F9) control the flaps, which are used to increase lift, primarily during a descent to the runway, when you're flying comparatively slowly.

Other keys on the main keyboard control functions such as turning the lights or carburetor heat on and off and setting the frequency on the radios. The most important one is P, for pause. It lets you take a break during a difficult instrument approach—something you obviously can't do in real life.
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The Editor

One of the keys to any good simulator is to make sure it doesn’t repeat itself. This is where the Microsoft Flight Simulator shines. The Editor (see photo 2) lets you set up an almost infinite variety of flight conditions, including the time of season, time of day, cloud layers, wind, turbulence, and, most important, the location. The simulator is a real-time program, and you can actually fly between Seattle and Los Angeles, although it will take several hours. The simulator has geographic detail and airport information for four areas: Seattle, Los Angeles, Chicago, and New York/Boston. Each area comprises about 10,000 square miles. For convenience sake, you’ll probably want to limit your flights to airports within these areas, which include plenty of variety. You tell the simulator the latitude and longitude of where you want to start (normally on the ground at the airport). You can also start off in the middle of a flight if you wish.

In addition to the 10 preset modes, you can set up and store up to 20 more modes.

Ten preset flight modes are included on the disk, ranging from easy flight to advanced instrument conditions in bad weather. One of the modes is British Ace (see photo 3), where you’re a World War I ace flying against Germany. When you get sick of normal flying, you can enter this mode and have machine guns and bombs at your disposal over the terrain of France and Germany. It’s a pleasant diversion that still requires a good deal of flying skill, and you won’t succeed if you haven’t spent some time using the easy flight mode.

In addition to the 10 preset modes, you can set up and store up to 20 more modes. This gives you a large variety of flights that you can make.

A Sample Flight

To give you an idea of how the simulator works, let’s take a quick flight. When you choose the easy flight mode (which is automatically entered from the first menu), you’re lined up on the active runway of Meigs Field, a small airport located next to Lake Michigan near Chicago. Because it’s an uncontrolled airport (no control tower), you’re all set to take off. You can, if you wish, “taxi” around the airfield using a unique “radar” feature (see photo 4) that you don’t find in a real airplane. Pressing Num Lock gives you a view of the airport from above,
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with your aircraft in the middle. You can taxi around the airfield using your throttle, and zoom the view in or out using the + or - keys. If only real airplanes had this. The taxiways at large airports are confusing masses of intersections and branches going off in many directions. They can be murder if you're not familiar with the airport. I well remember flying a small Piper aircraft into Logan Airport in Boston and being told by ground control to taxi "using the inner delta." Absolute gibberish!

Once you're lined up on the runway (see photo 1a), you can hear the engine sounds coming from the speaker. (It can be turned off.) After a standard pre take-off check, you apply full throttle by hitting the F2 key. The engines rev up, and you steer to keep yourself in the middle of the runway using the rudder keys. When you reach 55 knots as shown on your airspeed indicator, you raise the nose by pressing key 2 about six times. You're off (see photo 1b). In addition to the airport and the lake, the John Hancock Tower is visible. For this VFR flight, the tower is an excellent reference.

The adjustments that you must make on the flight simulator are very much what would be done in a real aircraft. After the gear is up, you gain a bit of airspeed and can slightly reduce power to get the best rate of climb. The easy flight mode is a perfect way to get used to the feel of your computerized airplane. Turns are automatically coordinated, which means you don't have to worry about the rudder controls whenever you bank the aircraft.

Landing, as in a real airplane, is the toughest part. The best thing to do before even attempting it is to fly out over the lake and try turns, ascents, descents, and flying at a constant altitude until you're absolutely sure you're comfortable with your aircraft. Experienced pilots will spend a great deal of time looking at their instruments, the best cues for what's happening. Unless you're particularly talented (or lucky), you'll probably crash more than a couple of times. As in a real aircraft, there's a strong tendency to overcorrect on your controls, making the situation worse. With all the graphics and sound, you might expect a realistic crash. Sadly, that's not the case. If you crash, all you see is "CRASH!" on the screen. If you spin into the lake, you'll see "SPLASH!" Somehow, I expected more.

You have to face the fact that unless you're specially gifted you're going to botch up landings. Although I've done hundreds of real landings, I found getting used to using the keyboard a big hurdle to overcome. As pre-
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not familiar with instrument flight, it’s an absolute essential. Instrument flying with the simulator is, if possible, even more fun than VFR. Like the real thing, it requires intense concentration. You can fly complete trips in IFR, receiving instructions from the ground and tracking your course using VOR (VHF omnidirectional range) stations along your path. You might be asked to fly a holding pattern and then make an instrument approach through heavy overcast. Breaking out lined up with the runway and making a perfect landing is truly an exhilarating experience. If you’re a real glutton for punishment, you can even program in some heavy turbulence or aircraft problems that can be surprising. Making a successful landing after one of these flights may tempt you to kiss the carpet under your computer.

The Negatives
Despite its fantastic graphics and realism, I had one large problem with the simulator, the keyboard. After many hours of use, I still had to stop and think about which keys I needed to press in order to get the airplane to do what I wanted it to. Sometimes the delay was fatal. Unlike a real aircraft simulator, it’s never possible for more than a few seconds to actually feel like you’re flying a real aircraft. Airplanes use controls, not keyboards; and whatever sense of reality existed quickly evaporated when I had to press a key. As a pilot, that reality of the keyboard was an intense bother, although I suspect someone who’s never flown an airplane won’t have that problem to the same degree that I did.

With all the features programmed in, it’s difficult to criticize the simulator for a few minor inconsistencies or problems that can be surprising. Making a successful landing after is incapable of doing that. Airplanes designed for inverted flight must have special oil and carburetion systems that work in any attitude.

Conclusions
The Microsoft Flight Simulator is a tour de force of the programmer’s art. It acts like a real airplane, and the numerous variables that must be kept track of in actual flight are required here as well. It can be an excellent introduction to how an aircraft actually operates for a budding or student pilot and can even help instrument pilots or those going for an instrument rating sharpen their skills. It is, however, no substitute for professional FAA-approved flight instruction and is not recognized by flight schools or the FAA, so don’t expect credit. The major block to its being rated essential is that you must use a keyboard. I suspect that prospective pilots who use the flight simulator first may have some problems in converting to a real control yoke and rudder pedals.

Stan Miastkowski (POB 445, Peterborough, NH 03458) is a licensed pilot and currently is the computer columnist for Esquire magazine.
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The Eagle PC

A clone with a few improvements and a few mistakes

by Tom Wadlow

The Eagle PC Reference Guide describes the Eagle PC as "a compact, modular personal or business computer system for the serious user with an eye to his budget." The Eagle is all those things, but it does have its shortcomings.

The bottom-of-the-line Eagle PC is the Eagle PC-E, which costs $1995 for 64K bytes of RAM (random-access read/write memory), one 320K-byte floppy-disk drive, a keyboard, a parallel port; and two serial ports. It comes with no display board, monitor, or software. For $3495, you can get the Eagle PC-2, which comes with 128K bytes of RAM, two 320K-byte floppy-disk drives, a monochrome monitor, MS-DOS and CP/M-86, Eaglewriter, and Eaglecalc. Photo 1 shows the Eagle PC-2.

Hardware

Physically, the Eagle PC resembles the IBM PC. A pleasant feature for those with limited desk space is the little alcove underneath the chassis. You can slip the keyboard into this alcove when the system is not in use. The cavity, shown in photo 2, extends to the rear of the machine on the right side so that the keyboard cable can be routed through it. This is far superior to IBM’s layout, in which the keyboard cable must come around the side of the machine, where it can get in the way. Unfortunately, the Eagle’s cord enters the keyboard enclosure at an angle that guarantees the keyboard will not slide easily into the alcove. You can get around this by picking the keyboard up as you place it in the cavity, but a quick, one-handed push would have been nicer.

The Eagle has carried over one of my pet gripes from the IBM. I prefer to place my monitor beside the computer rather than on top of it. Both IBM and Eagle put their video connectors and power connectors on opposite sides of the rear of the chassis, so no matter which side you put the monitor on, one of the cables will be too short. An extra six inches of cable would eliminate this problem.

The Eagle’s construction leaves something to be desired if you intend to do simple maintenance on it. There are no less than 17 small screws of three similar (but not identical) sizes that you must remove to get at the inside of the unit. As a result, changing one of the power-supply fuses (two are outside, one inside) or adding a new set of memory chips involves removing and replacing 17 soft-metal Phillips-head screws. Do it with extreme care and you won’t have a problem. But it doesn’t take much to strip the slots for the screwdriver and wind up with a jammed screw.

The Eagle does not perform a lengthy memory test on power-up, as the IBM PC does, so the machine will boot almost instantly when turned on. It can also be warmed-started in the same manner as the IBM PC, by typing Ctrl-Alt-Del as one keystroke. And like the IBM, the Eagle cannot perform this vital function (short of turning the power off) when a program bug trashes the software that listens for a Ctrl-Alt-Del.

In my opinion, the hierarchy of personal computer features should be as follows: display, keyboard, mass storage, and anything else. The quality of the display should take precedence in both design time and effort over the keyboard, and the keyboard over the mass storage, and so on. Engineering involves compromises between goals and costs, and while a properly designed computer will still have compromises, they should be deep enough inside the machine to escape notice. Compromising a display or keyboard is asking for trouble.

By this measure, the Eagle isn’t quite up to what I would like to see in a personal computer. The optional Eagle display, when no motion is taking place, is a very
close copy of the IBM monochrome display. Motion, however, is a different story entirely. The Eagle monochrome display scrolls in a visible ripple that is quite unpleasant to watch. Combining this with the long-persistence phosphor on the monitor makes the Eagle display annoying for any serious text editing. An IBM monochrome display board does work quite well, however, in place of the Eagle display. It produces both attractive text and acceptable speed. I couldn’t tell if bad interactions take place between the two printer ports when an IBM display is used. Since the expansion bus is also IBM PC compatible, most of the display boards on the market should work with the Eagle. As with all such mix-and-match components, you should check with the manufacturers to ensure compatibility.

My biggest complaint about the Eagle concerns the keyboard (see photo 3). The keyboard is the means by which you communicate with your computer. The better you can do that, the better you can use your computer. I am a touch-typist and have used dozens of keyboards, both professionally and personally, over several years. These days, I move quite easily between my home IBM keyboard (with its accursed Shift and Backspace keys) and a Lisp Machine keyboard at work (which has seven different kinds of Shift keys, any combination of which can be, and often is, used with a single character). As you can see, I am used to dealing with a variety of often quite peculiar keyboards.

The Eagle keyboard certainly qualifies as peculiar. While the alphanumeric keys are laid out more traditionally than on the IBM keyboard, they are not as widely spaced. My left hand always found the proper Home keys, but my right hand invariably went one key too far to the right. The Eagle keys have a mushy feel, with very little tactile feedback. This is fine if you just want to hit a key or two, but with extensive typing or word processing, it becomes quite bothersome.

There are some serious errors in the layout of the other keys. My particular favorite is the way the cursor-control keys are laid out. The IBM PC places cursor control on the 2-4-6-8 keys of its numeric keypad. This layout is satisfactory, unless you want to enter numbers and move the cursor at the same time, which is not uncommon. Eagle chose to remove the cursor-control keys from the numeric pad and place them between the Enter key and the numbers. So there, in a vertical column, you have Up, Right, and Down. The Backspace key does double duty as Left, but you have to type Shift-Backspace to get the proper Left code. This layout is not very intuitive, not to mention being somewhat uncomfortable, and you

Photo 1: The Eagle PC.

Photo 2: The expansion-card connector cavity. The keyboard connector is to the left of the card connectors. The dark rectangle at the top is the magnetic catch. To get at the expansion slots, you can remove the piece of metal to which the cavity door is hinged.
spend a lot of time rubbing out characters every time you want to move left.

A little experimentation produced the undocumented fact that the 2-4-6-8 keys on the number pad do produce cursor-control codes when shifted. Unfortunately, neither the Shift-Lock nor the Alpha-Lock keys affect the number keys at all, so you must always hold down a Shift key to use this feature.

Many of the function keys are labeled with functions for one or more of the Eagle applications programs. For example, hitting the function key labeled Files in Eagle-calc displays a directory of the current disk. While I have nothing against this per se, it seems to me that a general-purpose keyboard and a nice set of cardboard overlays would save us all the trouble of explaining to a novice why the Files key doesn't work with dBASE II or some other non-Eagle product.

Eagle does have one special key that I do like a great deal—the Help key. And it does exactly what you would expect it to when you use it with Eagle software.

Unlike the IBM keyboard, the Eagle keyboard has mechanically locked Shift-Lock and Alpha-Lock keys that actually give some indication of the state of the keyboard. It is just a hint, though, since a program can set these locks in software. Thus, under some all-too-frequent circumstances, the actions of the two lock keys can be reversed, so that lowercase can be achieved only by keeping the Shift-Lock down.

The keyboard has lots of other peculiarities, such as the numeric keypad with convenient Plus, Minus, and Times keys, but no Divide. Or the Enhance key, which is as big as the Enter key and takes up a space that would be a pretty good location for a correctly configured set of cursor-control keys. Enhance is used only in Eagle-writer, and I really had to dig in the manual to find out where. But the major peculiarity of this keyboard is that it exists at all. Several companies are making good money selling properly designed keyboards for the IBM PC. If Eagle had simply chosen one of those keyboards, it would be in a very enviable position compared to the IBM PC. Perhaps the “not invented here” syndrome isn’t limited to IBM. As Eagle’s keyboard exists today, the only people that will benefit by its presence are the companies that sell Eagle-compatible replacement keyboards.

The Eagle can support two double-sided double-density disk drives; the second drive is optional. They are half-height Teac drives, and the design of the enclosure precludes any possibility of converting to more than two half-height drives (as you can do with the IBM PC). I had no problem running the disks with MS-DOS 1.1 (giving each a formatted capacity of 320K bytes) or with MS-DOS 2.0 (capacity 360K bytes). Disk access is not as fast as the IBM PC; in fact, formatting a single floppy disk on the Eagle takes several times longer than formatting on the IBM. It seems to be a problem with either the disk controller or the low-level Eagle software, since both MS-DOS and CP/M-86 maintain this snail’s pace.

The Eagle has a three-slot expansion bus for the addition of special boards. One of these slots is used for the display board and one is used for the disk controller, so, in effect, you have only one slot to play with. Luckily, the major uses of the expansion slots are already taken into account on the motherboard. For instance, the Eagle has enough memory-chip sockets to handle up to 512K bytes of RAM. Eagle has also done what IBM should have: included one parallel and two serial ports on the motherboard. So most typical uses for a PC can be met with an Eagle and one board.

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At a Glance

Name
Eagle PC

Use
IBM PC-compatible desktop computer

Manufacturer
Eagle Computer Inc.
983 University Ave.
Los Gatos, CA 95030
(408) 395-5005

Components

All models: The system unit is 20.5 inches wide by 5.75 inches high by 13 inches deep. The keyboard is 19 inches wide by 1.75 inches high by 8.75 inches deep. The entire system weighs about 40 pounds. All feature a 4.77-MHz 8088 microprocessor, a 105-key separate keyboard with 24 user-definable keys, RAM expandable to 512K bytes on the main board, two built-in RS-232C ports, and one parallel port. Also, they have three expansion slots—one for the disk controller, one for the display (except PC-E), and one for additional devices.

Eagle PC-E: 64K bytes of RAM and one 320K-byte floppy-disk drive

Eagle PC-I: 128K bytes of RAM, one 320K-byte floppy-disk drive, and a 12-inch, 720- by 320-pixel monochrome monitor

Eagle PC-2: 128K bytes of RAM, two 320K-byte floppy-disk drives, and a 12-inch, 720- by 320-pixel monochrome monitor

Eagle PC-XL: 128K bytes of RAM, one 320K-byte floppy-disk drive, and a 10-megabyte hard-disk drive

Software
MS-DOS, CP/M-86, Eaglewriter, and Eaglecalc are included with the Eagle PC-I and PC-2. This software costs $5810 separately.

Options

Hardware

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Software

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Documentation

An Eagle PC Reference Guide for novice users, but no technical documentation. Eagle-supplied programs contain a great deal of on-line documentation.

Price

Eagle PC-E $1995
Eagle PC-I $2995
Eagle PC-2 $3495
Eagle PC-XL $4495

Comments
Poor keyboard, marginal display. Seems to run most IBM PC software.

to the bottom of the Eagle chassis. Thus all the boards are “upside down” compared to their orientation on an IBM PC. Even so, I found it much easier to swap boards on the Eagle than on the IBM PC. The light weight of the system unit made it very easy to disconnect the cables, flip the unit over, and pop the boards out. The connectors on the side of the board stick out into a small cavity, actually inside the body of the Eagle. On the IBM, the connectors stick out the back. To get at the board connectors, you can open a small magnetically latched door on the side of the Eagle. The keyboard connector is in the same area.

I wonder about Eagle’s decision to use a magnetic latch on a piece of equipment that is going to be in the immediate vicinity of delicate magnetic media. Surely a mechanical catch would have worked equally well and eliminated the threat to the floppy disks.

Firmware

The ROM (read-only memory) routines in the Eagle are different from the IBM PC’s firmware routines. Unfortunately, Eagle does not include any documentation on the low-level differences between its machine and the IBM. Eagle claims to have several technical manuals in the works, but as of this writing none were available.

Eagle now offers Revision C of its ROM set, which is supposed to emulate the IBM PC better and increase display performance. The revision also makes the Eagle fully compatible with IBM-style keyboards and the Epson MX-80 printer. I was not able to test these new ROMs, but they are currently available from Eagle.

Extensive installation instructions accompany the new ROM set. You’ll need to open the Eagle chassis, so be careful that you don’t strip those soft screws. Performing the ROM upgrade might be an excellent opportunity to replace the screws with better quality ones to avoid future problems.

Software

Eagle sells several application packages for the Eagle PC. Because the machine seems to run MS-DOS fairly well, many more packages should run with it. Eagle’s version of MS-DOS is labeled 1.25 rather than 1.1 or 2.0. A version of CP/M-86 is also available.

Eagle supplies a menu-driven disk utility that performs copies and formatting. It’s a good idea, but I managed to crash the program (and the machine) in the first few minutes of running the disk utility by bumping some keys on the keyboard and causing a DIVIDE OVERFLOW error. Of all utilities, a disk-copy program (the first program you should use on any new system) should be absolutely bombproof.

Eagle does not supply a BASIC interpreter with its machine. BASIC being the quasi-standard that it is, this is
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surprising. Instead, Eagle offers GW BASIC as a separate product.

Eaglewriter is a word-processing program that is tailored to the Eagle's keyboard. It can be used with other keyboards (IBM's, for instance) but is best suited to the Eagle's. Eaglewriter uses explicit end-of-line marks and a large set of commands. It is very flexible in dealing with the printer. It has several kinds of global search and replacement commands, a real must for serious editing. Most important, Eaglewriter has a macro capability. Macros are stored sequences of commands that the user can create. Eagle supplies several macro packages that do such varied and useful things as mail merges, sorting, selective printing (printing a portion of the file), multife printing, boilerplate letters, and filling in forms. Macros are usually seen only on mainframe computers or expensive professional workstations, though they are becoming more popular on personal computers. It is very encouraging to see that Eaglewriter is equipped with such a powerful tool.

I was not too impressed with Eaglewriter's human interface, but I suspect this is a matter of taste rather than bad design. One slight drawback is the cumbersome way that Eaglewriter handles files larger than 16K bytes. Since handling files is a fairly mechanical operation (there is a 12-step procedure for it in the manual), the Eagle's designers might have let the program perform the operation for you. Unfortunately, they didn't.

Eaglecalc is a typical spreadsheet program designed to be compatible with the Eagle keyboard. It has a spreadsheet size of 255 rows by 64 columns. It performs adequately and has the right features, such as variable-width columns and formatting. It can be run independently of the Eagle keyboard, but it functions at its best with the dedicated function keys. It also has a fairly extensive Help utility.

Both Eaglewriter and Eaglecalc can be called via a menu that can be invoked by placing the proper disk in drive A and rebooting. The menu is somewhat useful for a novice user but very limited in function. The menu system has no provision for switching application programs short of rebooting. Each menu has a QUIT command that prints a message telling you to turn off the power and then paralyzes the processor. None of the menus has any provision for dropping into the DOS command processor (you can do it, but you have to type Control-C at exactly the right time). Unlike some other menu systems, this one is written as a binary program file, so it cannot be extended. Eagle does offer a program, Flex Menu, that lets you design your own menus, but it wasn't included in the package I tested.

System Support

For the novice user, the Eagle documentation is pretty good. Because it has a cookbook approach, you don't need much technical background to read it. In addition, the manuals are full of examples. However, no technical documentation is provided for advanced users.

Except for BASICA, all the IBM software at my disposal ran on the Eagle. This included the Multiplan spreadsheet, dBASE II, Peachtext, Wordstar, the Finalword, and Laboratory Microsystems' FORTH. Conversely, Eaglewriter and Eaglecalc both ran on the IBM PC. MS-DOS 2.0 also ran on the Eagle with no noticeable difficulties.

Eagle isn't the easiest company to deal with for user support. A call to the company's headquarters for technical answers involves a lot of time on hold and replies such as, "That's not my department, but I'll forward you to the XXX department." But there are people deep in the bureaucracy who know the answers to technical questions; it just takes patience to reach them.

Conclusion

The Eagle is a fairly acceptable machine. The problems with the display are slightly annoying but not enough to remove the machine from serious consideration as an alternative to the IBM PC. With the latest ROM set, the Eagle display should perform acceptably.

The Eagle keyboard is a more serious problem, but if you're doing only a small amount of typing, it might not present too much of a problem. For serious word-processing, database, and spreadsheet applications, you should seriously consider a better keyboard, such as an IBM or an IBM compatible.

Tom Wallow is an engineer at the Lawrence Livermore National Laboratory. He can be reached at POB 2755, Livermore, CA 94550.
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- Our Ad
- Our Ad
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**TABLINE**

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- Tabline
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STSC APL*PLUS and IBM PC APL

Two APLs for the IBM PC

by Jacques Bensimon

When details of the much-anticipated IBM Personal Computer (PC) were made public in 1981, I sadly joined the ranks of the crystal-ball gazers whose various predictions bit the dust that summer. You see, I had convinced myself that IBM was about to share with the world what often seems to be the computer industry's best-kept secret, namely that APL is one of the most powerful, expressive, and—not undesirable in the context of a personal computer—fun-to-use programming languages ever devised.

Looking back on it now, I suppose that it was extravagant of me to expect Big Blue to embrace APL as the premiere language for its PC while the rest of the microcomputer universe remained entrenched in BASIC. It was not unreasonable to expect, however, that IBM would at least include in the PC's character set the special symbols that are the hallmark of APL; this would have paved the way for headache-free design of APL interpreters for its new machine. IBM, after all, was an important (though at times unwilling) contributor to the development of APL in the mid-60s and remains to this day one of the language's most avid users; surely that called for encouragement of APL in the PC environment.

And yet, as I stared at the Personal Computer's 256 characters, I could find no trace of most APL symbols among that dizzying collection of playing-card suits, happy faces, musical notes, and generally unusable mathematical symbols. I was not happy.

But time passes, wounds heal, life goes on, and I have forgiven IBM. I can afford to be magnanimous because the void caused by IBM's omission was quickly filled. First (in June 1982) came the University of Waterloo's microAPL, an offering intended for the educational market. Next out of the gate (in December 1982) came STSC Inc. with its ambitious APL*PLUS/PC Application Development System. STSC, a leading vendor of APL timesharing and consulting services, was already a supplier of APL-language processors for IBM mainframes, DEC VAX superminis, and, remarkably, Radio Shack TRS-80 Model III microcomputers. And most recently (in June 1983), IBM itself introduced a surprising Personal Computer APL System, the first major piece of software for the PC to come out of the halls of IBM.

It won't give away too much of the ending for me to tell you right off the bat that the news is mostly good: both STSC's APLPLUS/PC and IBM's PC APL fully implement conventional APL's language component; differences between the two packages—and there are many—arise from language extensions to handle such things as report formatting and error trapping and from the mechanisms used to provide access to disk files, video screen, printers, and communication ports. (More on all this later.)

STSC's Version of APL

For the not-insignificant sum of $595, you can buy the APLPLUS/PC Application Development System. It consists of a 5¼-inch disk in single-sided format (but recorded on both sides) that contains the APL interpreter and a collection of utility workspaces, a 24-pin ROM IC
At a Glance

**Name**
APL *PLUS*/PC Application Development System release 1. version 2.6

**Type**
APL language interpreter

**Manufacturer**
STSC Inc
2115 East Jefferson St
Rockville, MD 20852
(301) 984-5000

**Format**
5 1/4-inch single-sided floppy disk and 24-pin ROM IC

**Language**
8088 machine language

**Computer**
An IBM Personal Computer (or PC XT) running PC-DOS version 1.1 or 2.0, with a minimum of 128K bytes of RAM, at least one disk drive (single- or double-sided) and an 80-column display (monochrome or color/graphics)

**Documentation**
A 450-page programmers reference manual, 8 1/2 by 11 inches, in a 3-ring binder; a 170-page tutorial, APL Is Easy; and a 380-page textbook, APL: An Interactive Approach

**Price**
$595

(read-only memory integrated circuit) providing the APL symbols, a plasticized card showing the keyboard location of the characters, and extensive documentation including a 450-page programmer's reference manual, a tutorial introduction, APL Is Easy!, and the classic textbook, APL: An Interactive Approach by Gilman and Rose (second edition revised, Wiley, 1976). The textbook makes frequent references to a now-defunct desktop APL computer called the IBM 5100; interestingly, the Personal Computer's lesser-known name is the IBM 5150.

STSC deserves high marks for its well-designed integration of APL with the PC. The custom ROM chip replaces the character-generator ROM on either the monochrome or the color/graphics display adapters mounted inside the PC's system unit. I found the replacement instructions clear and easy to follow; the entire procedure took less than 10 minutes. With the new ROM in place, about one-quarter of the PC's original characters (mostly the novelty and mathematical characters with 8-bit values in the range 0-31 or 224-255) give way to the missing APL characters; unaffected are the ASCII characters in the range 32-127, the line-drawing graphics, and most of the international accented letters and punctuation.

Beyond this unobtrusive addition of APL symbols to the PC, STSC seems to have put great thought into the environment presented to users of its system. The keys on the cursor pad and some of the Alt/function-key combinations allow you to move quickly around the screen, move to the beginning or end of a line, edit the contents of a line, insert or delete lines and characters, make one line a continuation of another, and break continued lines into two lines.

Flexibility in managing the display and the fact that the APL interpreter will process the screen line that contains the cursor when you press the Enter key make it very easy to modify, combine, and reenter previous inputs, to simulate full-screen editing of defined functions, and to store already displayed output in a variable as an afterthought. All of this encourages the experimental approach to APL programming, in which the germ of an idea gradually evolves into a complete algorithm with the computer itself helping you make design decisions along the way.

Before I discuss IBM's package, I'd like to offer a few more preliminary observations about STSC's APL in the PC environment. You can assign sequences of characters to the 10 function keys (as well as to the Shift/function-key and Ctrl/function-key combinations) by using the programs in the utility workspace MULTIKEY. You can choose to make the assignments last only for the duration of the current session or to make them permanent for a particular copy of the APL interpreter. Typical uses include storing often-needed commands or making available single characters (such as the line-drawing graphics) that cannot otherwise be entered from the keyboard. In practice, I found this feature be of limited usefulness: what we really need is a system function that allows us to define function keys from our own workspace as the need arises.

If you install an Intel 8087 Numeric Data Processor in
your PC, APL*PLUS/PC will automatically take advantage of the coprocessor to accelerate all floating-point computations. If you choose not to use the 8087 (the chip currently costs anywhere from $200 to $260, and IBM Product Centers sell an 8087/8088 matched pair for $260), the interpreter will use software floating-point routines to provide the same range and precision at the expense of speed. The benchmark timings in table 1 may help you decide whether you can live with the difference.

IBM's Version of APL

In the other corner, weighing in at a modest $195, the pride and joy of the IBM Madrid Scientific Center: the

IBM Personal Computer APL System. It comes boxed in the obligatory (and rather pleasant) 8- by 9½-inch format and consists of a single-sided 5¼-inch disk, a set of keytop decals, and a 370-page reference manual. (The manual is good but will not teach you the language; buy *APL: An Interactive Approach*.) However, this implementation requires an 8087 chip, significantly increasing its price for most users.

IBM's integration of APL with the PC falls far short of STSC's: because no ROM character generator is provided (I hope all you add-on manufacturers out there are paying attention), APL characters can be displayed only if your system has the color/graphics adapter and

Table 1: Twenty-one benchmarks for the two versions of APL. "N/C" (no change) and "-" denote benchmark tests that were not run. Benchmark 21 solves the chess problem in the text on page 256.

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>IBM PC APL (w/ 8087)</th>
<th>IBM APL*PLUS (w/ 8087)</th>
<th>STSC APL*PLUS (w/o 8087)</th>
<th>STSC APL*PLUS (w/o 8087)</th>
<th>Advanced BASIC (8087 N/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Plus Reduction</td>
<td>90 msec.</td>
<td>102 msec.</td>
<td>157 msec.</td>
<td>1155 msec.</td>
<td></td>
</tr>
<tr>
<td>2. Logical Reduction</td>
<td>0.4</td>
<td>3</td>
<td>N/C</td>
<td>660</td>
<td></td>
</tr>
<tr>
<td>3. Maximum Reduction</td>
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<td>25</td>
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<td>1007</td>
<td></td>
</tr>
<tr>
<td>4. Exponentiation</td>
<td>390</td>
<td>282</td>
<td>2466</td>
<td>3781</td>
<td></td>
</tr>
<tr>
<td>5. Absolute Value</td>
<td>80</td>
<td>79</td>
<td>130</td>
<td>1007</td>
<td></td>
</tr>
<tr>
<td>6. Indexing</td>
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<td>14</td>
<td>N/C</td>
<td>114</td>
<td></td>
</tr>
<tr>
<td>7. Sorting</td>
<td>600</td>
<td>112</td>
<td>N/C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Take</td>
<td>9</td>
<td>24</td>
<td>N/C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Membership</td>
<td>150</td>
<td>146</td>
<td>N/C</td>
<td>105215</td>
<td></td>
</tr>
<tr>
<td>10. Transposition</td>
<td>450</td>
<td>60</td>
<td>N/C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Outer Product, Characters</td>
<td>360</td>
<td>141</td>
<td>N/C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Outer Product, Integers</td>
<td>2530</td>
<td>439</td>
<td>N/C</td>
<td>13169</td>
<td></td>
</tr>
<tr>
<td>13. Inner Product, Reals</td>
<td>210</td>
<td>341</td>
<td>546</td>
<td>2012</td>
<td></td>
</tr>
<tr>
<td>14. Matrix Division</td>
<td>70</td>
<td>1488</td>
<td>2206</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Fibonacci Series</td>
<td>2200</td>
<td>3827</td>
<td>3943</td>
<td>832</td>
<td></td>
</tr>
<tr>
<td>16. Multiplication</td>
<td>100</td>
<td>136</td>
<td>468</td>
<td>1314</td>
<td></td>
</tr>
<tr>
<td>17. Division</td>
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<td>142</td>
<td>724</td>
<td>4653</td>
<td></td>
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<td>143</td>
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<td>2394</td>
<td></td>
</tr>
<tr>
<td>19. Sine</td>
<td>411</td>
<td>438</td>
<td>12009</td>
<td>3913</td>
<td></td>
</tr>
<tr>
<td>21. Chess Problem</td>
<td>33,316 min.</td>
<td>28,345 min.</td>
<td>N/C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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The Origins of APL
The acronym APL derives from the title of the book A Programming Language (Wiley, 1962) by Dr. Kenneth Iverson, then an applied mathematician at Harvard University. Finding that standard mathematical symbolism was inadequate for communicating the results of his studies of sorting and other algorithmic processes, Iverson developed his own concise and consistent notation for the description of solution procedures.

Iverson's Notation, as APL was then known, was not originally meant to be a computer programming language; it evolved into one during the years Iverson spent refining his creation at the IBM Thomas J. Watson Research Center. It was there in 1965 that the first experimental APL interpreter was completed for use in Iverson's research. APL's interactive design was so successful that use of the interpreter quickly grew to include helping out with the day-to-day work of the research center staff. With its fame spreading by word of mouth, it wasn't long before APL had become an underground sensation throughout IBM. Dubbed APL360, a version of the interpreter was eventually released to interested outside organizations, primarily universities and timesharing companies. Two of the timesharing firms, I. P. Sharp Associates (where Iverson currently continues his research) and Scientific Time Sharing Corporation (now STSC Inc.), have since then played an important role in shifting APL from the scientific to the commercial world, primarily through the addition of an integrated file system, a powerful formatting facility, and exception-handling (error-trapping) features.

Text continued on page 254
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A Brief Look at APL

When using APL, you are essentially interacting with a very powerful programmable calculator: you enter a valid APL expression, hit the Return key, and the answer (if any) is displayed starting on the next line; for example,

\[
\begin{align*}
3 \times 4 \\
12 \\
3 \div 4 \\
0.75
\end{align*}
\]

Notice that entries are indented six spaces to distinguish them from the computer's answers and that no explicit command is required to have results displayed. The number of operations, or primitive functions, available in the language is very large; other examples include

\[
\begin{align*}
2 \times 3 \\
8 \\
5 \mid 8 \\
8 \\
5 \mid 28 \\
3 \\
3 > 5 \\
0 \text{ 'A' \times 'B'} \\
1
\end{align*}
\]

These illustrate, respectively, the exponentiation, minimum, maximum, residue (or remainder), greater than, and not equal to functions. You can see from the last two examples that the comparison functions return the numeric values 1 or 0 to represent logical true or false.

The examples so far have shown functions that operate on two objects, their so-called left and right arguments; they are known as dyadic functions. There are also monadic functions that operate on a single (right) argument. The examples

\[
\begin{align*}
\times 4 \\
0.25 \\
2.718281828 \\
5 \\
4 \\
24 \\
1
\end{align*}
\]

illustrate the reciprocal, exponential, floor (or integer part), factorial, and logical negation functions.

Because the number of primitive functions is so large and because you can define your own, functions in an APL expression are executed in the order in which they are encountered going from right to left across the line, except as modified by parentheses:

\[
\begin{align*}
9 - 2 \times 5 - 3 \\
5 \\
9 - (2 \times 5) - 3 \\
2 \\
(9 - 2) \times 5 - 3 \\
14
\end{align*}
\]

The seemingly strange choice of right-to-left execution stems from the desire to have a monadic function's argument appear on its right, where it belongs naturally, while keeping the design of the interpreter simple and efficient.

Intentionally used the vague term object when referring earlier to the right or left argument of a function. A lot of the power of APL derives from the fact that these objects need not be single numbers (numeric scalars) or single characters (character scalars) but can in fact be entire vectors, matrixes, or higher-dimensional arrangements of numbers (numeric arrays) or characters (character arrays). Unlike other languages, APL treats arrays as wholes, accepting them as arguments and returning them as results:

\[
\begin{align*}
1 & 3 & 2 & 5 & 7 & + & 2 & 4 & 6 & 8 & 4 \\
3 & 7 & 2 & 11 & 15 & . & 4
\end{align*}
\]

You can assign a name to an array without, as in other languages, having to first declare its type and shape to reserve its storage; APL manages all available memory space and allocates it dynamically. The assignment function (denoted by the left-pointing arrow) attaches the name on its left to the array on its right:

\[
\begin{align*}
S + 6.28 \div 2 \\
V + 'JOSEPH' \\
MAT + 3 & 3pVEC + 1 & -1 & 2 & 0 & 6 & 3 & -1 & 9
\end{align*}
\]

\[
\begin{align*}
S \\
3.14 \\
JOSEPH \\
VEC \\
1 & -1 & 2 & 2 & 0 & 6 & 3 & -1 & 9 \\
MAT \\
1 & -1 & 2 \\
2 & 0 & 6 \\
3 & -1 & 9
\end{align*}
\]

The following examples use the variables defined above to illustrate, without additional comment, some of the many other primitive functions that APL provides for the manipulation of arrays:
Programming in APL is the process of creating new functions. These user-defined functions are denoted by names rather than by symbols but are otherwise used just like primitive functions. They can be monadic, dyadic, or even niladic (requiring no arguments) and may or may not return a result. You indicate to APL that you wish to temporarily leave calculator mode and go into function-definition mode by typing the triangular del character followed by a function header. The function header is APL's only declarative statement; it specifies the function’s name, its syntax (the number of arguments it requires and whether or not it returns a result), and the names of any temporary local variables it uses. While you’re in function-definition mode, APL prompts you with bracketed line numbers and then records (rather than acts upon) the statements that you enter. You have already seen two of APL's three types of executable statements: the assignment, which does not display a result, and the APL expression not ending with an assignment, which does display its result (if any). The third type of statement is the branch (denoted by the right-pointing arrow), which can alter the top-to-bottom sequence of execution of a defined function's lines by directing execution to a given line.

APL work is organized around the concept of the workspace: the active workspace is that portion of the computer's memory in which all of the functions and variables you create are stored and in which all of the computations you request take place. You may, at any time during your APL session, have the current contents of the active workspace preserved in secondary storage as a named saved workspace (which usually appears as a file on your disk). Once saved, a workspace can be reactivated (loaded) at a later time, thus restoring the active workspace to its original state, or its contents (variables and functions) can be selectively copied into the current active workspace. An APL application usually consists of a saved workspace containing all of the pertinent functions and variables along with a latent expression, a special vector containing the character representation of an APL statement to be executed automatically as soon as the saved workspace is loaded. The latent expression will typically initiate execution of the application's master function.

Most APL implementations provide a battery of so-called system commands to manage the saving, loading, copying, and erasing of workspaces and to make possible examination and control of their contents. These system commands are not, strictly speaking, part of the APL language and therefore cannot be lines in defined functions. The trend in recent years has been for APL systems to provide system functions that duplicate the action of system commands and can be used under program control.

The language has two advantages that cannot be readily conveyed by a quick printed tour of its facilities. One is the ease with which you can learn the language: the simplicity of APL syntax, the absence of red tape in using arrays, and the immediate feedback of calculator mode combine to provide an environment in which you can freely experiment with language features, concentrating at first on a few functions and gradually building up your repertoire. The second advantage is the sense of programming confidence that you will experience as a user of APL. The power and versatility of the language encourage you to tackle even the most difficult tasks with the knowledge that the step between a mental solution and a computer solution is a short one. APL drastically reduces programming time because a verb-oriented oral description of an algorithm can often be immediately written down as a function-oriented APL expression. This leads to terse programs and explains the often-heard criticism that APL is unreadable. APL is in fact quite readable, but you should not expect to grasp at a glance the meaning of a line of APL any more than you would a pageful of BASIC or five pages of COBOL.
listing 3. I include it in this review for two reasons: first, because it involves the cooperation of several functions, one of which (FMATE) is recursive, it gives a thorough workout to the systems' function-calling mechanism (with the associated stacking of the execution environments and creation of local variables); second, it provides a good example of API's capability to make short work of a relatively complex programming problem. I spent more time selecting data structures than I spent actually writing code for the functions, with the entire process taking about 10 hours. With most programming languages, this recreational exercise would have been a major project.

Now, what are we to make of the results of all these benchmarks? If you consider speed to be the deciding factor in choosing between the IBM and STSC APL systems, you'll find no final pronouncement here. I'm calling it a draw. IBM showed up slightly faster in the simple arithmetic benchmarks (with the exception of exponentiation), quite a bit faster in the inner product and heavily-looping Fibonacci series benchmarks, and shockingly faster in the matrix division benchmark. STSC, on the other hand, did much better in the categories of indexing, sorting, transposition, and outer product, and put it all together to come out on top in the grueling Chess-problem marathon. If nothing else, these timings point out where the authors of the packages chose to cut corners: it is a fairly common practice in designing APL interpreters to implement some primitive functions (especially those considered infrequently used) as a combination of calls to other already-coded functions, which essentially means that those functions are written not in assembly language but rather in a subset of APL. I would guess that this was the fate of STSC's matrix division primitive and of IBM's outer product, dyadic transposition, and maybe even grading (sorting) primitives.

Without the 8087 coprocessor, STSC's APL still performed quite acceptably in the floating-point benchmarks; the difference became painful only in the case of logarithmic and trigonometric functions. The multiplication, division, and exponentiation benchmarks were slowed down by factors of about 3, 3, and 9, respectively. That's a far cry from the factors 78, 82, and 170, which represent the published relative speeds of the 8087 and the 8088 performing single instances of those same double-precision operations. This is probably due to the fact that, overall, the 8088 spends the majority of its time retrieving operands from memory and storing results back into memory. Nevertheless, if your applications tend to be numerically oriented, the coprocessor is likely to be a good investment.

As for BASIC, although it did very well in the Fibonacci series benchmark and held its own in the Sieve of Eratosthenes (both of which involve a lot of looping), it ran out of breath trying to keep up with API's easy handling of array operations in the other benchmarks. BASIC's apparent superiority over STSC's APL without the 8087 in the logarithmic and trigonometric benchmarks is a result of the fact that version 1.1 of BASIC calculates such functions to single precision only, less than half the accuracy of STSC's software emulation of the 8087.

Other Features
To be great, an APL system must provide many facilities beyond the language itself. This is especially true of an APL system running in a microcomputer environment, where users expect to have direct control of the hardware and where there's a need to support a wide array of peripheral devices. I'll discuss STSC's and IBM's efforts in this direction under several broad headings.

Workspace size: Your workspace under STSC's APL can be as large as your machine's total memory minus an interpreter and operating-system overhead of approximately 90K bytes. A parameter on the operating system command that starts up APL even allows the interpreter to use memory beyond the 544K-byte maximum recog-
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Notes on the Chess Benchmark

Given sufficient time, this set of five functions (see listing 3) will solve any chess problem that ends in checkmate, including problems that involve casting, en-passant capture, or under-promotion of a pawn to a knight. WSINIT must be run once to define some global variables.

To solve a problem, assign to variable A the attacking color and to B the defending color (White = 1, Black = -1), and then run FMATE. The left argument of FMATE is the maximum number of moves to mate, and the right argument is a 69-element numeric vector representing the position. The first element is either 0 or the square number on which an en-passant capture can take place on the next move. Squares are indicated in algebraic chess notation (e.g., c5 is 35 and f2 is 62). The next four elements are either 1 or 0 to indicate whether or not casting is still possible (in the order White queen- and king-side, then Black queen- and king-side). The remaining 64 elements are the contents of the chessboard from the top left corner to the bottom right corner as seen from White's side (0 = empty, 1 = pawn, 2 = knight, 3 = bishop, 4 = rook, 5 = queen, 6 = king, positive for White, and negative for Black).

The result of FMATE is a two-element numeric vector that contains, if a solution is found, the “from” and “to” square of the winning move (in algebraic notation, with a negative “to” square indicating pawn-to-knight promotion); or, if no solution is found, either 0 1 or 0 0 (0 0 indicates that the attacker has no legal move in the given position).

The functions should run in any APL system if statements using the diamond separator are broken up into several lines and if the sequence “[0]” is substituted for the hyphen-comma overstrike character (as in lines 5 through 9 of function MLIST). I'd be interested in timings of the benchmark problem on hardware more powerful than the PC (see note 4 in table 1 for its definition, and expect the solution 85 15). FMATE makes no attempt to examine potential moves in an intelligent order and can take a long time to execute.
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Listing 3: A complicated chess-problem solution program, FMATE, and its associated functions (subroutines). See the text box on page 256 for more details.

Listing 4: A formatted output in APL. Listing 4a shows an example of the powerful STSC APL formatting function. Listing 4b shows the less powerful IBM APL Picture Format option.

(a4)
Once upon a time there was a very diligent man, Jack. Every year the man promised his very faithful wife that he would keep accurate records to make tax time more bearable.

One sunny day, Jack traded in his family cow for a new computer. That starry night, he began to enter all of his tax records onto disk. "How easy and accurate this will be," he stated.

The months went by. Tax time approached. Confidently, Jack inserted his data file and entered "Run Taxes." "Just watch," he said to his wife. But alas. His CRT, as if it were alive, proclaimed, "I/O ERROR." "Gads," he stammered in frustration. "Oh my," said his wife.

Then entered his neighbor carrying three beans, a golden lyre and the new Discwasher® Clean Runner Interactive Drive Cleaner. The good neighbor told Jack, "Preventive maintenance will destroy dirt in the disk drive and keep it running clean."

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Not all endings are that happy. A dirty read/write head can cost not only many hours of time but also the loss of valuable data.

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Clean Runner directs the head(s) of your drive to a different track for each cleaning. Clean Runner provides a contamination-free cleaning surface.

Clean Runner effectively works on both single or double-sided drives.

Clean Runner is programmed for 20 cleaning operations.
Error trapping: When an error occurs during execution of a statement, STSC's APL suspends processing at the point of error, retrieves the current contents of the special character vector \( \text{DELX} \) (error latent expression), and executes them as a line of APL. You might have previously set up \( \text{DELX} \) to force an exit from the executing function (returning some specific result indicating that a problem was encountered) or to generate a branch to a different part of the function, where the cause of the error may be determined by examining the system-generated variable \( \text{DM} \) (diagnostic message). If the program is sufficiently sophisticated, it may then be able to take corrective action and resume execution.

IBM's tool for the automatic handling of errors is the elegant system function \( \text{EA} \) (execute alternate). It takes two character-vector arguments representing APL expressions and attempts to execute the one on its right; if it fails because of an error, it goes back and executes the left argument instead. This allows you to exercise very fine control over errors occurring in different parts of a statement: for example, the expression in listing 5 adds the inverse of matrix A (or a matrix of 0s if A is not invertible) to the inverse of matrix B (or to a matrix of 1s if B is not invertible).

One problem with \( \text{EA} \), however, is that if an error occurs in a defined function called from \( \text{EA} \)'s right argument, the execution state of that function is discarded before processing of \( \text{EA} \)'s left argument begins. This means that it becomes impossible to determine the cause of the error, to recover the values of the function's local variables, or to automatically resume execution at the point of error.

Disk file access: This topic brings up a long-standing philosophical debate between STSC and IBM on the subject of APL's control over its hardware environment (i.e., peripherals). STSC holds the view that APL should provide primitive system functions and variables that allow you to manage every aspect of your computer and has accordingly never been shy about adding such facilities to its APL interpreters. (APL*PLUS/PC boasts more than 100 system functions and variables as well as approximately 20 documented memory locations that you may modify to further control the system's behavior.) IBM, on the other hand, believes that such matters belong outside the realm of the APL language and should be handled by external programs (auxiliary processors) operating independently of the APL interpreter. You communicate your wishes to an auxiliary processor (and it in turn communicates results to you) by the clever device of sharing one or more variables in your workspace with the auxiliary processor: when you assign a value to a shared variable, the auxiliary processor can examine and modify it so that when you next look at the variable, it contains the result of your request. For example, a hypothetical clock/calendar auxiliary processor named AP24 (auxiliary processors are distinguished by number) might work as shown in listing 6.

The example demonstrates the use of the system function \( \text{SVO} \) to first "offer" to share VAR with AP24 and then to verify that the share was "accepted." If you want to program in assembly language, check out the IBM APL reference manual to find out how to create your own auxiliary processors to complement (or replace) the ones distributed with the system; this is potentially a very powerful capability.

Now, then, what about disk file access? Not surprisingly, STSC provides an abundance of excellent system functions to support two kinds of file organizations: the APL component file, a random-access arrangement of arbitrarily shaped APL arrays, and the so-called native file.
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which is simply a DOS file viewed as a long sequence of bytes that you can read or modify at will. The file functions are easy to use and extremely fast. You might especially enjoy the capability to snoop around DOS files interactively.

IBM, of course, provides a file auxiliary processor (named AP210) and a collection of APL-defined functions that use the auxiliary processor to achieve a pale imitation of STSC's file capabilities. AP210 illustrates all that goes wrong in practice with the elegant concept of auxiliary processors: it's difficult to use interactively because of the many steps involved in initiating and verifying shares, assigning data and hard-to-remember request codes to the shared variables, and retrieving data and success/failure codes from the shared variables. Also, because the auxiliary processor has no knowledge beyond the shared variables, it can't take advantage of available memory in your workspace and must use its own small buffers for disk access, which limits data transfers to 2K-byte chunks and creates unnecessary time and space overhead.

Printer and communication ports support: STSC provides a very powerful system function, called \texttt{ARBIN}, that's somewhat tedious to use. It gives you detailed control over all of the parallel and serial ports in your PC and enables you to send or receive characters in any of the following modes: typewriter-pairing and bit-pairing APL/ASCII overlays (which enable communications with timesharing APL systems and with high-quality APL printers), 8-bit ASCII, and Epson dot-graphics (which enables printing of all 256 characters using the graphics features of Epson graphics printers). In addition to \texttt{ARBIN}, STSC also supplies the system terminal mode; with the push of a function key, you can transform the PC into an excellent APL/ASCII terminal that emulates the Datamedia 1520 and enables you to switch between your APL workspace and a remote computer.

IBM provides more modest capabilities through two auxiliary processors. AP80 supports the first parallel port but will print APL characters only if your system has an IBM Graphics Printer (which, despite rumors to the contrary, is not quite compatible with Epson graphics printers); AP232 supports the first serial port and does a reasonably thorough job of it, although you would have to write a fairly sophisticated program to duplicate STSC's capability to make APL printouts with a serial printer. A set of APL functions furnished with the system uses AP232 to provide a very limited form of terminal simulation.

Full-screen I/O (input/output): STSC provides system functions that enable you to capture or modify characters and video attributes in any rectangular region of the screen. IBM's AP205 offers the same capabilities plus an excellent form-designing feature that should make it easy for you to support full-screen applications.

Machine language and memory access: In addition to vector-oriented versions of BASIC's PEEK and POKE functions, both APLs provide you with the capability to call machine-code subroutines stored in the workspace; in STSC's case, the code can be given access to APL objects and can modify them if necessary. IBM gives you the potentially powerful capability to write your own auxiliary processors.

Speaker support: A system function in STSC's APL allows you to generate a sequence of tones of specified frequency and duration. IBM offers a more sophisticated music-playing capability through auxiliary processor AP440 (similar to BASIC's PLAY statement).

Miscellaneous extensions: STSC's APL supports the diamond statement separator (which allows multiple APL

Listing 5: An example of the IBM PC "execute alternate" function, which tries to evaluate the expression on the right and, if an error occurs, evaluates the alternate expression on the left.

\[
(pA)p0 \quad \square EA \quad (pB)p1 \quad \square EA \quad (pB)
\]

Listing 6: An example of auxiliary processors (APs) in IBM APL.

\begin{verbatim}
24 \texttt{SVO} \ 'VAR+'
1 \texttt{SVO} \ 'VAR'
2 \texttt{VAR}+'TIME?' \texttt{VAR}
\texttt{THE TIME IS} \texttt{11:07:45}
\texttt{VAR}+'DATE?' \texttt{VAR}
\texttt{THE DATE IS} \texttt{12/01/83}
\end{verbatim}

Listing 7: An example of the replicate extension to the compress (/) function. Normally, the compress function uses the left argument as a logical mask through which filter selected components of the right argument (see listing 7a). If the left argument contains numbers greater than 1, the corresponding element is repeated that many times in the result.

\begin{verbatim}
(7a)
1 0 1 0 1 / 'ABCDE'
ACE
0 1 1 1 0 / 'ABCDE'
BCD
(7b)
0 0 3 0 0 / 'ABCDE'
CCC
1 0 0 2 0 / 'ABCDE'
ADD
\end{verbatim}
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statements on one line), the replicate extension to the compress (/) function (see listing 7 for some examples), and a string search primitive. It also provides system functions that can load or copy workspaces from within defined functions; this enables you to split very large applications among several workspaces in a transparent manner.

IBM’s APL allows ambivalent defined functions (i.e., functions that can be used with either one or two arguments). System commands are provided to store and retrieve workspaces in transfer form, an ASCII-like representation of APL functions and variables that lets them be moved to or from other APL systems. (I used this feature to transfer the benchmarks from STSC’s APL to IBM’s through files created by the STSC native file facility.)

Both APLs allow you to sort character arrays by using dyadic forms of the grade primitive functions.

**Planned extensions:** Release 2 of STSC’s APL*PLUS/PC (which will probably be available by the time you read this) promises to add several new features. Some of them are:

- APL keyword form, which substitutes English words for APL symbols and lets you program in APL without installing the character ROM
- on-line documentation in the form of a user-modifiable Help facility
- graphics primitive functions to support the IBM color/graphics display adapter (as well as the higher-resolution Hercules Graphics Card and possibly others)
- detached I/O, which enables input to the APL interpreter to come from a file and APL output to be redirected to a file
- the capability to execute DOS commands from within APL

As for IBM’s plans beyond version 1.00 of PC APL, your guess is as good as mine—IBM never announces its plans in advance.

**Conclusions**

After using the two packages, I feel that STSC’s APL*PLUS/PC represents the more serious effort to provide a heavy-duty APL system that does not sacrifice control over any aspect of the IBM Personal Computer. I especially like its terminal mode and other communications features, file system (particularly the native file facility), flexible printer support, and clean integration of APL characters into the PC environment.

IBM’s APL succeeds admirably in delivering the power of the raw APL language to the PC. It also makes a valiant effort to apply auxiliary processors to the task of controlling peripherals, but unfortunately it comes up short in this respect. The strengths of IBM’s approach are that it provides a language uncluttered by special features, which makes it suitable for educational purposes (especially at its $195 price), and it gives an ambitious user the capability to customize the system by writing auxiliary processors. Unfortunately, the IBM APL’s low price of $195 is offset by the major expense of installing an 8087 chip, which most people won’t already have.

Jacques Bensimon has a master’s degree in mathematics from New York University and works as a financial systems analyst for Becker Paribas Inc. in New York City. He can be reached at One Strawberry Hill, Stamford, CT 06902.
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</tr>
</tbody>
</table>

*K-MAN V1.05, dBASE II V2.3D, IBM XT, 256K RAM, heavily populated directory.

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Chalk Board's Powerpad and Leonardo's Library

A new large touch panel for the Atari 400/800, the Commodore 64, and the Apple II comes with a wide selection of software

by Elaine Holden

At last! Technology is finally beginning to incorporate educational philosophy. A new company, Chalk Board Inc., has come up with the Powerpad (hardware) and Leonardo's Library (software). The Powerpad, shown in photo 1, is a touch-sensitive pad that is used by the programs in Leonardo's Library as the primary input. The programs teach visual arts, music, mathematics, science, language arts, and social studies. However, only a fraction of the total series of educational packages is currently on the market.

The Powerpad does not involve traditional teaching approaches such as ditto sheets (those awful purple unreadables handed out by many teachers) and workbooks. Instead, there is direct interaction and immediate feedback with this teaching tool. This is referred to as the multimodal approach. In other words, if you touch it while you hear it and see it, you remember it longer.

**Powerpad**

The main component of the product is a 12-inch by 12-inch touch pad housed in a 20-inch by 17-inch hard plastic case. Mylar overlays that are part of the software package take the place of a conventional keyboard. Some areas of the pad are defined as keys, depending on the program. The flexibility of the Powerpad expands the range of potential users. Because an intricate keyboard is not involved, children and nontyping adults can learn with the computer in a much more relaxed and natural fashion.

The Powerpad connects through the game input port of your computer. It is lightweight, well constructed, and very versatile. [Editor's Note: See the text box on page 270 for technical notes on the Powerpad.]

**Leonardo's Library**

The set of learning packages is named after Leonardo da Vinci, who explored many areas of study. Similarly, Chalk Board's library tries to cover many disciplines in the Renaissance tradition. Each discipline has packages that range over five levels of sophistication and complexity. Almost any child or adult can locate a program at the appropriate educational level without becoming frustrated.

Included with each software package is a Mylar overlay sheet that fits over the active surface of the Powerpad. The overlay defines areas of the pad's surface that correspond with specific functions. The matching overlay imprinted with color-coded "buttons" serves as the menu and as special function keys.

Photo 1: The Powerpad with the Mylar overlay for Micromaestro.
For this review, I had access to three of the available packages from Leonardo’s Library—Leo’s ‘Lectric Paintbrush, Micromaestro, and Powerpad Programming Kit. The first two packages help learners discover art and music; the third allows you to use the Powerpad as an input device in your own BASIC programs.

**Leo’s ‘Lectric Paintbrush**

Briefly, this program lets you finger-paint electronically. Using Leo’s ‘Lectric Paintbrush has to be the most fun I’ve had since I dipped my fingers into a paint dish as a six-year-old in Mrs. Sparrow’s first-grade class.

Brush, paint, and crayons are often regarded as too messy for frequent use by children. Only when art class has begun or mother has the patience can a child paint. We tend to forget that a child’s timetable may be different from ours, and later we are often disappointed when children do not develop enthusiasm for art.

With this program, you don’t need paints or even paper. A stylus is provided, but I much preferred my fingers. The stylus, however, is useful for drawing fine lines. All you have to do is press the pad and the image appears on the screen.

The 36-page instruction booklet provided a very considerate walk-through of all the capabilities of the Paintbrush program, but it did not answer all my questions. It did, in fact, raise some of its own. These probing but nonthreatening questions provide directions for the learner without stifling the process of discovery. I had to experiment and explore to answer the questions.

Eight colors are provided for the palette. With the colors and my fingers, I was ready to create a masterpiece. Naturally, at first, I left small green fingerprints all over the place while trying to pinpoint where I left off. There’s no way to tell on the Powerpad where I had already painted. The images show up only on the screen. Then I discovered that, much like my Logo program, the Powerpad has a Pen-up command that lets me see where my finger is without marking on the screen. When my finger is in the right place, I press the Pen-down area to recommence drawing.

First, I attempted to draw a landscape. Traditionally, a bright yellow sun hovers over all my versions of Mt. Monadnock. I used the Fill command to color in my sun. This is when I discovered that an incomplete circle (or any other shape, for that matter) will leak color all over the landscape. Cancel stopped the process and I cleaned up.

You can also move objects. The manual suggested making clouds. They fit in the picture, so I did. To and End commands define objects. I defined a cloud and used the Move command to put a second cloud, just like the first, in another place. Failing to recall the Pen-up command, I first positioned the cloud in the treetops. Even-

Photo 2: A landscape created with Leo’s ‘Lectric Paintbrush.
tually it made its way across the sky to the right position, then I cleaned up all my little fluffy fingerprints. The result is shown in photo 2.

You can get quite carried away with this and before long discover that all the computer’s memory is used up. Economical use of computer memory is learned through trial and error at this stage but, to make it less frustrating, a Hashmark key (#) is provided on the Mylar overlay as well. When pressed, this key provides a vertical gauge of memory to the right of the picture. The artist can determine how much memory is left because, as he draws, this gauge fills with color.

Pictures can be saved; very clear directions are provided for this, with sample experiments. The experiments stimulate a learner rather than just provide him with lockstep directions. Too many programs give such precise directions that the student behaves like a robot. This is not teaching, this is programming.

Complete referencing is the form of an index is also provided. This is very useful for beginners. It is clearly organized and not complicated.

**Micromaestro**

This program is an answer to a music teacher’s prayer. Limited funds prohibit quantity purchases of pianos, so classes often only hear music, but never make it. Prior solutions have included recorders for all (an agony of sound) and cardboard keyboards (no sounds but everyone got to practice).

Structured music class, individual classroom practice, and home use are all possibilities for Micromaestro, shown in photo 1. Naturally, this program is not a substitute for the real McCoy. I have yet to be convinced that any electronic marvel will ever take the place of a real piano. But basic music theory and composition can effectively be learned through this program. Its visual display function is especially useful, because it lets you see what you are playing on your computer screen. Photo 3 shows you what I mean.

Very little music theory is directly provided in the 40-page user’s guide. I assume that this is because it is the most basic of the proposed five music packages and

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**At a Glance**

<table>
<thead>
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<td>Type</td>
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<td>Audience</td>
<td>Pre-school to adult</td>
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<tr>
<td>Computer Needed</td>
<td>Commodore 64 and VIC-20, Atari, Apple, IBM PC</td>
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**The Technical Side of Powerpad**

The Powerpad contains an x,y matrix of 120 by 120 wires. The wires are connected to several 4051 eight-channel analog multiplexer/demultiplexers. The 4051s along one axis are connected to +5 volts. A 4024 seven-stage binary counter makes the 4051s along the axes transfer the +5 volts to its matrix wires, one wire at a time. When the user presses the Powerpad matrix, the wires under the point of pressure touch each other so that the potential from one axis is carried over to the wires of the other axis. When this happens, the scanning process stops and the SENSE line to the computer goes low. This alerts the computer that the Powerpad has been touched and the coordinates of the touched area may now be read. The coordinates are stored in two 4021 8-bit shift registers that, for programming purposes, are treated as one 16-bit register. The 16-bit register always contains the values present in the two 4024 binary counters. The x-axis coordinate is stored in the least significant 7 bits of the register, and the y-axis coordinate is stored in the next 7 bits. The most significant 2 bits of the register are always 01. These are discarded by the computer.

To read the coordinates, the computer pulses the CLOCK line to the Powerpad high 16 times. At each pulse, the shift register outputs one bit of its contents to the DATA line through a 4069 inverter. When all the data has been read, the computer pulses the CLEAR line to the Powerpad high. This tells the Powerpad to place the SENSE line low and continue scanning for a touch. Note that the binary counters are not set to zero. Instead, they retain their count and continue the scan from there.

The scanning begins from the point 0, 0. The y axis is scanned from 0 to 119 while x remains at zero; then x is incremented by one, and the y axis is scanned again.

By the way, the Powerpad uses the same I/O port on the Commodore 64 that the keyboard uses. This means that you cannot use the keyboard while the Powerpad is communicating with the computer, although Chalk Board Inc. says that it will tell you how to use both if you join the Padmasters Guild, the Powerpad users group.
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also because the truly capable music student will attain a lot on his own.

The program carries the student along by suggesting various notes to play. Nothing much beyond this is suggested for songs, the remainder of the booklet being taken up with instructions on the use of various keys, symbols, and game suggestions. Hopefully, the remaining four packages in this series will teach some theory.

**Powerpad Programming Kit**

This programming kit consists of a blank overlay and a book that explains how to program the Powerpad with BASIC. This is not for the very young or the recent convert to the Computer Age. I was delighted with the program. Middle-school students who are familiar with computers and BASIC are naturals for this kit. I feel that average inquisitive elementary-age youngsters would have a problem, though, unless they are first instructed in the fundamentals of programming.

**Conclusions**

Leonardo's Library and the Powerpad are fine examples of educational tools. They follow sound educational philosophy, they stress creativity and problem solving, and they have the element of surprise. With these programs, students cannot rush through an exercise to get done, look at the back of the book for answers, or ask someone else—they must discover on their own.

The electronic wizardry of the Powerpad is impressive, and the rigid plastic housing keeps it quite safe. I would say it will last for a long time under normal use. The Mylar overlays also seem durable but, should accidents occur, they can be replaced for only $6.

In order for the student not to feel alone with his discoveries, another feature is the Padmasters Guild and the Chalk Board newsletter. The Guild membership is free to anyone owning a Programming Kit and costs $9.95 a year for everyone else. Included is a hot-line number for troubleshooting and publications on new programs for the Powerpad written by other programmers. The newsletter answers questions and publishes users' comments and ideas. These features, plus the excellent software, add up to a useful tool in education.

---

*Elaine Holden (22 Elm Street, Peterborough, NH 03458) is the supervisor of reading and language arts at the Merrimack School District in New Hampshire.*
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Simulated Computer II

by Richard Grehan

Back in my college days, the only programming languages I had under my belt were BASIC and FORTRAN. I saw the computer as a mass of equipment so hopelessly complex that assembly-language programmers were like Nobel laureates. If you find yourself viewing the prospect of having to learn assembly language with the same pessimism that I felt back then, or if you just want to get a better idea of what goes on inside a computer, then Simulated Computer II deserves your attention.

Simulated Computer II from Carousel Software Inc. takes you on a fantastic voyage inside an imaginary computer. You can watch system registers being loaded, memory locations being modified, and even see and hear information flow from one location to another. Simulated I/O (input/output) devices allow you to load programs, execute them, and display their results. Also included are a programmable sound generator and a "turtle screen," a version of the line-drawing creature used with the popular Logo programming language.

Main Display

Nearly all of Simulated Computer II's action takes place on a single screen. It displays the four major components of the simulated computer (see photo 1). In the upper left is the input device, a stylized representation of a terminal complete with screen, keyboard, and a pair of tiny hands ready to begin typing. As you enter commands, the hands actually dip down to strike keys on the imaginary keyboard (a very nice touch that enhances the reality of the simulation; I give the designers an A+ for that one).

The upper-right portion of the display holds the computer's output device, where all program output and system error messages appear. This is a printer—obviously equipped with a tractor feed, since you can see the little holes in the paper—that makes a wonderful sputtering sound as its print mechanism operates.

The lower half of the screen displays the computer's memory, a whopping 24 memory locations arranged in a 4 by 6 matrix of boxes. The address of each box is easily identified by an attached tag, so there is no confusion about where things are coming from or going to. The last four locations have special functions with regard to sound and graphics, which I will describe in detail shortly.

The central processing unit sits in a sovereign position in the upper center of the screen. Six boxes inside the central processor represent its registers. Two of them, the accumulator and the program counter, are directly accessible by user programs. The other four—the instruction register, fetch register, increment register, and execute register—are used by the processor for its internal operation. The contents of these registers are visible at all times. (This simulated computer is a base-10 machine; registers and memory locations can hold numbers in the range +/-999. Having all operations performed in decimal numbers—rather than the expected binary or hexadecimal—is actually a good idea, since people trying to learn what goes on inside a computer have enough on their hands without having to worry about number base conversion.)

Connecting everything is the system bus, the real star of the show. Information traveling from one part of the computer to another is represented by a white, glowing electron that whizzes along the bus. This is the addicting part of the simulation. You find yourself entering and running programs just to watch the light show, and, best of all, you get to see exactly what's going on.

Simulated Computer II sports a pretty lean instruction set (see table 1). All mnemonics are three characters long, usually followed by a two-digit address. I believe that the designers were trying to find the balance between a product that was too simplistic and one that was too complex.

The two primary system commands are LOAD, which allows you to enter program and numeric data into memory; and RUN, which begins execution. Instructions may be loaded directly into memory in their mnemonic representation, but when RUN is executed, Simulated Computer's first action is to scan through all memory locations, translating all mnemonics to their operation code values so that all you see in the memory boxes are numbers. The subtle lesson being taught here, something that people familiar only with high-level languages are largely unaware of, is that data and instructions are indistinguishable until they reach the central processor.

Various versions of the RUN command let you execute programs at speeds from about 5 seconds per instruction up to a half-second per instruction or even single-step, which causes the system to wait for a keypress between each event.

Sound

Simulated Computer's sound capability is accessed by
storing a number into memory location 20. The number must be greater than 0 and less than 37 (less than 92 for the Commodore 64 version). These values seem to correspond to three octaves of an even-tempered scale starting one octave below middle C. However, I found it nearly impossible to determine the relationship of value stored to pitch produced since the generated sound is just a short beep. Even running the program at top speed, time between tones is nearly 6 seconds. Add to that the racket of the electrons racing from place to place as instructions are executed, and you can hang up the hope of generating even simple melodies.

Turtle Graphics
Memory locations 21, 22, and 23 control “a memory-mapped turtle.” (For anyone not familiar with the turtle, it is the software incarnation of a small robot used to produce line graphics. You program the turtle to move along a path, and it leaves a “trail” on the screen as it carries out your commands.) Storing a number in location 21 tells the turtle which color to draw, location 22 determines the angle (in clockwise degrees) through which it will rotate before drawing, and location 23 selects the distance it will move. It is the act of storing a number in location 23 that actually sends the turtle on its way.

At a Glance

<table>
<thead>
<tr>
<th>Name</th>
<th>Simulated Computer II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Educational Simulation</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Carousel Software Inc.</td>
</tr>
<tr>
<td></td>
<td>877 Beacon St. Boston, MA 02215 (617) 437-9419</td>
</tr>
<tr>
<td>Available From</td>
<td>Apex Resources Inc. 17 St. Mary's Court Brookline, MA 02146 (617) 586-1569</td>
</tr>
<tr>
<td>Price</td>
<td>$29.95 suggested retail</td>
</tr>
<tr>
<td>Format</td>
<td>Cassette or disk</td>
</tr>
<tr>
<td>Language</td>
<td>Compiled FORTH (a FORTH interpreter is not required)</td>
</tr>
<tr>
<td>Audience</td>
<td>Anyone interested in learning the fundamentals of assembly-language programming (age range recommended by manufacturer: 12 to adult)</td>
</tr>
</tbody>
</table>

Computer
Atari series of microcomputers with 32K bytes of RAM or Commodore 64
Documentation
Approximately 35 pages

Photo 1: The Simulated Computer’s main display, showing (clockwise from upper left) the input device (a terminal), the central processing unit, the output device (a printer), and system memory.
When the turtle receives a command, the main display disappears and is replaced by the turtle screen (see photo 2). This is an aerial view of the little fellow, surrounded by a rectangular border near the edges of the screen. As a program runs, the system flips back and forth between the main and turtle screens, and you can watch the graphics commands execute step by step.

I discovered that if you command the turtle to move some distance that would send it off screen, it rams into the border with a painful crashing sound and the program halts. I really wish the little printer had sputtered out ERROR-INJURED TURTLE.

A Sample Machine Cycle
Since the beauty of this simulation is its ability to reveal the individual actions that must take place for a single machine instruction to execute, let’s take a look at what happens when we single-step through an LDA06 (load the accumulator from memory location 6). We’ll assume that our instruction is stored at location 00:

1. The number 00 appears inside the program counter and fetch register boxes in the central processor. The numbers gleam brightly for an instant when they ap-
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2. The contents of location 00 scintillate, and a buzzing electron zips out of that box and races over to the instruction register. There is another flash, and the number from address 00 appears; we've just witnessed a fetch from location 00. Meanwhile, the fetch register is cleared and the letters PC appear in the increment register. This means that the program counter is about to be incremented—an important action; most microprocessors set the program counter to point to the instruction following the one being executed.

3. The program counter flashes, and a 01 appears in it. The letters LDA pop up in the execute register. The computer has correctly decoded the contents of the instruction register.

4. The number in location 06 flares briefly, and another electron rushes out of that box, depositing the number in the accumulator. A 01 appears in the fetch register. Our load was successful, and the contents of the fetch register show that the computer is ready to execute the next instruction.

A rather drawn-out process just to get the contents of a memory location into the accumulator, I agree. The point is, that was a close approximation of what happens when a real computer executes a "load accumulator" instruction, and we were able to watch each individual step. This is what a graphic simulation is all about.

Documentation
At the time this article was being written, only a rough draft of the documentation was available. The final version should be a booklet about 35 pages long. In any case, the rough draft was extremely well written and easy to follow.

The first two chapters guide you through the process of loading Simulated Computer II on your computer, then describe the different elements of the display. This is followed by instructions for entering a number of example programs and a wonderful breakdown of central processor operations as you process a program in single-step mode (possibly the most worthwhile part of this entire simulation).

One chapter is devoted to sound generation—more than it deserves, I think—and one to turtle graphics. A lot is left to user innovation at this point. Several "program challenges" presented problems requiring programming solutions. I was pleased to find that sample solutions to these challenges were printed in the appendices.

Conclusion
Although I agree with the designers' decision to keep the instruction set simple, I feel that their omission of indexed addressing and subroutine CALL/RETURN instructions was a mistake. It's easy to see from table 1 that Simulated Computer's instruction decoding scheme limits the number of processor instructions to 10, so that any additions would require a major overhaul of the entire product. However, given the importance of address indexing and subroutines, I urge the designers to include this in the next version of the program. Subroutines could be used to introduce users to the stack, which is also missing from the current design.

My other big objection concerns the sound generator. If there were some way to turn off the noise of the electronics and run the processor at twice its current top speed, maybe you could make a little melody or even a scale. As it stands, I don't see much use for this feature at all. Tom Smith of Carousel Software explained that, limited though it was, sound was found useful in motivating children who might not be attracted by other parts of the simulation. As he put it, "Different kids respond to different things."

Despite my complaints, I remain generally enthusiastic about Simulated Computer II. Introductory computer classes from high school up to continuing education should have something like this in their software libraries. I recommend it to anyone interested in learning more about what "goes on under the hood." Certainly programmers about to take their first jump into assembly or machine language will find it a worthwhile introduction to what lies ahead. I sure could have used it when I learned assembly language a few years ago.

Richard Grehan (621 North 100W, Apt. C, Orem, UT 84057) is an educational software applications programmer for WICAT Systems.
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Bank Street Writer

A word processor simple enough for children, but powerful enough for many writers

by Mario Pagnoni

"Word processing is the best invention since the erasable pen." With that perceptive comment, my 10-year-old son, James, thanked the computer industry. James, like many of his teachers, is finding that word processing is one of the best educational uses for computers. Sure, schools are using drill and practice programs, tutorials, simulations, and other forms of "computer-assisted instruction." And they're making strides teaching programming languages like BASIC, Logo, and PILOT. But through all the hoopla about the computer "saving" education, many teachers remain skeptical.

One thing that does impress many educators, though, is the machine's ability to help children express themselves. Children use word processing for a variety of writing tasks including stories, poetry, school reports, and letters to Grandma. James and his brother, Joseph (age seven), have used word processing for about a year. Their writing has improved and they enjoy it more.

For Joseph, word processing arrived just in time. Remembering his struggles with messy, erasure-riddled papers in our pre-word-processing days, he said, "The best thing is, when you erase your mistakes, the paper doesn't scrunch up and tear." Word processing bought time for his fine motor coordination to catch up to his expressive skills. And it's even more beneficial for those "special needs" children for whom the physical process of writing is difficult or impossible.

Everyone seems to agree that processing words is great for children. As they learn to manipulate text, they begin to look into the very fabric of writing. They become acutely aware of the effect of the different arrangements of their words. Moreover, they become conscious of the logical progression of thoughts expressed in good writing. Their writing gradually becomes clear and uncluttered.

Children today take to all phases of computing with little or no instruction. "It's the parents and teachers who need the handholding," said one computer instructor. "To get children writing, all you have to do is give them a word-processing package they can handle."

The problem is just that—finding a word-processing program that children can handle. Most are difficult to learn and even more difficult to use. And if, after mastering a program, the children don't run it for a while, they forget how to use it. Powerful editors with exotic functions bewilder children. Having to spend a long time learning a program frustrates them, and they may give up before doing any actual writing. Manuals are often confusing and intimidating. According to William Zinsser, author of Writing with a Word Processor, "If any single force is destined to impede man's mastery of the computer, it will be the manual that tries to teach him to master it."

One word-processing program that solves these problems and opens the world of processing words to children is Bank Street Writer by Broderbund Software Inc. Bank Street Writer is a well-designed, inexpensive, easy-to-use word processor. It's not only simple for children to learn, it provides prompts to help them remember how to use it. Developed by the highly respected Bank Street College of Education to serve children, it is billed by Broderbund as "the home word processor." While it lacks the sophisticated features of a business word-processing package, it does everything most nonprofessional writers want. It's ideal for people with little or no computer experience.

Bank Street Writer consists of three programs—the writer itself, a tutorial (on the flip side of the disk), and the utility program (used to change how the writer communicates with your peripherals).

The Tutorial

Bank Street Writer features a logical, interactive tutorial containing five brief lessons. Working through the exercises (in less than 30 minutes) is all most children need to begin working with the writer program, and many don't need the tutorial at all. The same goes for the printed documentation. It is a concise, 28-page pocket-size manual with a useful index/glossary feature. It would be even more useful if you needed it more. The program is so simple and logical that you could misplace the manual after the first few days and never miss it.
The Writer

Because the entire program loads into memory at the start, it is easy to use with just one disk drive. Boot the program disk, then replace it with a data disk. Boot time is quick—you'll be ready to write in about 12 seconds. There are no exotic graphics, just a blinking, beckoning cursor.

The writer program has three modes—Write mode (to enter text), Edit mode (to make corrections and revisions), and Transfer mode (to “communicate” with your drive or printer). You can get from one mode to another by hitting the Esc key. If you get confused, all you need do is press Esc until you come to a familiar mode. A message in the screen’s upper-right corner always indicates which mode you are in.

Write mode gives you a 38-character screen that allows 18 lines of writing. A rectangle that resembles a sheet of paper outlines the screen; the area inside that border is for text. Outside the border, at the top of the screen, is an area devoted to prompts. This virtually eliminates the need to memorize commands. The few that you do need to know are logical: Control-I to indent 8, 16, 24, or 32 spaces; Control-C to center text; and Control-S to determine how much space is left in your file.

Bank Street Writer accommodates files of 1300 words if you have a 48K-byte machine—3200 words if you have an additional 16K-byte RAM (random-access read/write memory) card. To overcome these file-length limits you can create short files and then link them before printing. When text memory is almost filled, an additional prompt appears—“NOTE: ROOM FOR 50 WORDS REMAINING” (it counts every six characters as a word).

Bank Street Writer displays uppercase and lowercase letters on the Apple II without additional hardware. Hit Shift-N and the following letter will be capitalized. Hit Shift-N a second time for caps lock and once more to unlock the caps. If your machine has the Shift-key modification for capitalization, you can “notify” the Bank Street Writer through the Utility mode (this is unnecessary with the Apple IIe).

The program features word wrap so that carriage returns are necessary only to start a new paragraph. After 18 lines of text, the screen automatically scrolls up eight lines to allow for more typing. Characters can be erased in either direction with the left and right arrow keys.

In the Edit mode the cursor-movement keys (the four arrow keys on the Apple IIe, and I,J,K, and M on the Apple II Plus) are displayed in the prompt area. You’ll have to “memorize” that B gets you to the beginning of your document; E to the end; U takes you up 12 lines, and D down 12 lines. To edit text, enter the Edit mode and use the cursor-control keys to locate your error. Then press Esc to get back to Write mode and type the correction.

Bank Street Writer “knows” whether it is booting on an Apple II Plus or Ile and loads the appropriate version. The Ile uses the open and closed apple keys to select a function and the II Plus uses the left and right arrow keys. In either case you access the function by highlighting your choice and pressing Return. Edit mode functions include Erase, Unerase, Move, Moveback, Find, Replace, and Transfer.

You can erase up to 15 lines of text at a time. To do this, select Erase from the prompt menu. Follow the step-by-step directions that tell you to place the cursor at the beginning of the text you want to erase—then hit Return. Place the cursor at the end of the text that you want erased—hit Return. The appropriate text will be highlighted and you will be asked, “Are you sure you want to erase highlighted text (Y/N)?” (Bank Street Writer always double-checks your command before executing it.) If, after erasing text, you decide that the erased portion should have stayed, you can Unerase (now there’s a term children can understand). It could be the first example of “computerese” that demystifies. If you have to learn to Access and Interface and Paginate, you may as well learn to Unerase.

The Move function is similar to Erase. You highlight the section of text you want to move (again, up to 15 lines) and indicate its destination. You are then asked, “Are you sure?” All of this is well prompted and, of course, you can Moveback if you change your mind. The Unerase and Moveback functions only allow you to undo
your last move immediately after that move. Thus, if you
Erase a passage and then enter some new text, you will
not be able to Unerase your original passage.

There are also powerful Find and Replace functions.
Select Find on the edit menu. Type in the word or words
(up to 29 characters) that you want to find. The first ap­
pearance of the word will be highlighted. Answer "Y"(es)
to the prompts to find subsequent occurrences of the
word(s). Replace operates in a similar way, replacing the
word you searched for with the replacement of your
choice.

Transfer mode (which you enter from Edit mode) is
for disk and printer operations. It allows you to initialize
disks, Save and Retrieve files, Rename or Delete files,
Clear memory, Print-draft, Print-final, or Quit the writer
program. If you attempt to Quit Bank Street Writer with­
out saving your document, you will be reminded that
"You did not save this text. Are you sure you want to
quit now (Y/N)?"

The Print-draft function prints your text exactly as you
see it on the screen (38 characters per line). This is useful
for proofreading and leaves generous margins for
teachers' comments. It also makes it easy for students
to go back to the computer and find their mistakes on
the screen. Some students "paste up" two print-drafts
(side by side) to create a two-column effect for their
school newspaper.

Print-final prompts you with options about how you
want the printed document to look. You can select page
numbering and double or triple spacing, for example.
You can print copy that is 40 to 126 characters per line.
Another useful feature allows you to see and adjust page
breaks before printing. All of this formatting goes quick­
ly, especially if you accept the default values by press­
ing Return after each question.

The Utility Program

You access the utility program by pressing Esc while
Bank Street Writer is booting. It is used to list the names
and passwords (used to lock files) of each file on your
data disk, and to convert Bank Street Writer files (binary)
to standard text files and vice versa. Conversions are
slow. It took 15 minutes to convert this review (about
2600 words). You can also change default values like
width of margins and page length through the utility
program. In addition, the cursor can be changed from
a blinking line to a white square, and you can engage
a typing keyclick sound. The keyclick option is helpful
to experienced typists who don't need to look at the key­
board or screen. Those barely audible clicks reassure
them if they feel that they may have missed a key. I ap­
preciated the keyclick option for a different reason. It
reminded me that, although the program was designed
for children, it is powerful enough for most adults.

Drawbacks

Bank Street Writer does not support right justification,
tABBing, or embedding commands for things like under­
lining or boldface, though Broderbund does plan en­
hancements. Nor does it support split-screen operation,
scripts, or superscripts. These criticisms are almost
invalid when you consider that the program was not de­
signed for professional writers. This software isn't for
formats; it's for writers and would-be writers of all ages.
My only complaints are that it's slow going from the
Write mode to the Edit mode as text memory gets filled,
and that there is no storage buffer that saves deleted text
and lets you reinsert it elsewhere. Bank Street Writer
supports all parallel and serial printers that are Apple
compatible.

Conclusion

Bank Street Writer is great for school and the home,
too. If you're planning to write the great American novel
or do technical writing involving superscripts and in­
dexes, look elsewhere. If, however, you want a program
that your family can actually use the first day—a pro­
gram that helps you recover from mistakes—then I
recommend Bank Street Writer without reservation.

Mario Pagnoni (76 Emsley Terrace, Methuen, MA 01844) is
a teacher/freelance writer who spent last year teaching his children at home. He is work­
ing on a "how-to" book for home schoolers that emphasizes the use of microcom­
puters in education.

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Circle 181 on inquiry card.
SPOC
The Chess Master

by Emil Flock and Jonathan Silverman, Computer Hand Holding

Photo 1: Screen generated by SPOC. The board is shown after move 8...QxP? in table 2.
At a Glance

Name: SPOC The Chess Master, version 2.0
Type: Chess-playing program
Programmer: Jacques F. Middlecoff
Manufacturer: Cypress Software
1450 Koll Circle, Suite 108
San Jose, CA 95112
(800) 321-3900
(408) 995-5185
Price: $39.95
Format: 5¼-inch floppy disk for IBM PC-DOS
Language: FORTRAN and assembly
Computer: IBM PC or XT; 128K bytes of RAM
Documentation: 12 pages (5½ by 8 inches)
Audience: Chess players at all levels

The pleasure of playing chess on a microcomputer comes, in part, from the heartfelt appreciation of losing to a good opponent. You can replay the game from the printout, changing an occasional move and learning how to avoid specific problems. In addition, the computer never coughs while you’re deep in thought and never blows smoke in your face, glares at you, or tries to confuse you.

If you like to recreate Bobby Fischer’s prize-winning games, computer chess may not be for you. But if you want to practice with an opponent that puts up with untold verbal abuse and never gets tired, a chess program is the answer.

Few computers, and certainly no microcomputers, can seriously compete with a human chess master; however, computer chess programs can force the average person to play better chess. Lazy players who make blunders and initiate half-baked attacks usually lose badly to a program.

Computers—mainframes, minis, and micros—tend to play ugly, inelegant chess. They are impatient, which almost always leads to defeat against a master player. Robert Byrne, one of the best chess players in the United States, wrote that “computers lack positional judgment and do not know what to do in tranquil situations. However, tactically they are freer from error than the average human player.”

Chess involves subtleties that are beyond everyday imagination. It is, indeed, an art form. You can lose a game completely and irretrievably by making a small error. A seemingly tiny positional disadvantage in the opening can lead to a devastating defeat by the middle of the game. “Endgame” study is an art form all its own. It’s easy to lose early in the game to a world-class human chess player.

Mainframe and minicomputer chess programs are beginning to play well by any standards. A program called Belle achieved a master rating at 1983’s United States Open against some top-notch human players (see Table 1).

Computer Chess Theory

In 1949 Claude Shannon showed that a typical chess game contains some $10^{120}$ possible continuations. Today’s “supercomputers” do 80,000,000 operations per second. Even a supercomputer would take $10^{40}$ seconds to run the entire chess tree. (Our universe is only $10^{47}$ seconds old.) The human player escapes this massive and impossible task by considering only a fraction of the moves available following any given move—and the machine must also. While the computer examines a vast number of continuations compared to the human player, that number is tiny compared to the total possible.

In chess the branching factor—the average number of possible moves from a given position—is 35. Therefore, a complete list of legal moves for a depth of three moves from any given position could contain 1.8 billion entries. To help prune this enormous tree, Belle uses an alpha-beta algorithm that throws away any move not better than the one already under consideration. Belle also remembers repeated positions.

Table 1: Chess rankings for the United States Chess Federation (USCF) and Fédération Internationale pour le Développement des jeux d’Échecs (FIDE).

<table>
<thead>
<tr>
<th>Mean rating of USCF members (December 1983)</th>
<th>1537</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>0–1199</td>
</tr>
<tr>
<td>D</td>
<td>1200–1399</td>
</tr>
<tr>
<td>C</td>
<td>1400–1599</td>
</tr>
<tr>
<td>B</td>
<td>1600–1799</td>
</tr>
<tr>
<td>A</td>
<td>1800–1999</td>
</tr>
<tr>
<td>Expert</td>
<td>2000–2199</td>
</tr>
<tr>
<td>Master</td>
<td>2200–2399</td>
</tr>
<tr>
<td>Senior Master</td>
<td>above 2400</td>
</tr>
<tr>
<td>Highest active rating (Anatoly Karpov)</td>
<td>2710 (FIDE)</td>
</tr>
<tr>
<td>Highest rating ever (Bobby Fischer)</td>
<td>2760 (FIDE)</td>
</tr>
<tr>
<td>Belle's rating (approximate)</td>
<td>2203</td>
</tr>
<tr>
<td>SPOC’s estimated rating</td>
<td>1700</td>
</tr>
</tbody>
</table>

Microcomputer Chess

The state-of-the-art chess programs for the IBM Personal Computer include two main contenders: SPOC (Selected Pruning Optimization Chess) and Bluebush (Bluebush Inc., 3379 St. Mary’s Place, Santa Clara, CA 95051). These programs are new and haven’t been thoroughly tested under tournament conditions. In this review we will concentrate on SPOC.
games to test its skill as an opponent, we've chosen SPOC's best effort to give you an idea of its quality of play (see the text box "Modern Benoni Defense" on this page).

For the average tournament chess player (who rates around 1500 on the United States Chess Federation's scale), SPOC is a worthy opponent. It plays at an average rating of about 1700 points, or as a "B" player (sometimes better, sometimes worse). SPOC has nine levels of play. When you give it three minutes to move (level 6), it plays like a strong amateur. We didn't try its "postal chess" mode (level 9, 60 minutes per move) because of the time involved to finish even one game. It played a number of fairly decent blitz games (level 2, 10 seconds per move).

**Playing Against SPOC**

You load SPOC by typing its name in at the PC DOS prompt. SPOC then asks you (1) to select the level of play (1-9), (2) if you want to print the moves, (3) if you have a color display, and (4) if you want to resume a previous game saved on disk. If you press FlO during the startup questions, it starts over and asks each question again, ignoring invalid answers.

You may choose to play either black or white. When you have chosen your color, the chessboard and playing pieces appear on the screen. If SPOC has white, it starts its own clock and begins "thinking" about its move. If SPOC has black, it starts your clock and waits for your move. At tournament level, the clocks accumulate time for a 40-move sequence, similar to a real tournament. For other levels, the clocks reset themselves after showing the accumulated time for each single move. (You will find you have a compelling desire to disconnect the loud beep that occurs each time SPOC makes a move.)

You move the chess pieces with the cursor keys. Position the cursor over the piece you want to move and press the carriage return. Next, position the cursor where you want to put the piece and enter another carriage return. SPOC doesn't follow the "if you touch it, you move it" rule. Until you press Return at a new square, you can retract your move.

SPOC checks the legality of all your attempted moves and growsl at you if you try to castle out of check or move your King as if it were a Knight. (Castling is accomplished by moving your King two squares in the direction you wish to castle.) SPOC also handles "en passant" captures properly. [Editor's note: This is not always the case. I tested one version of SPOC and it did not execute an "en passant" capture correctly.]

Function keys let you change the level of play (F2) and save the game to disk (F1). To abandon the game and return to PC-DOS, press the Escape key (Esc). The SPOC version we tested lets you set up game positions with a stand-alone program on a separate disk. Just load the desired game position into SPOC and play.

**How a Computer Plays Chess**

How does a computer play chess? First, it generates a list of all its legal moves (the first ply) and all the legal responses to each of these (the second ply) as depicted in figure 1. This tree is extended, branch by branch (ply by ply), until the computer begins running out of time. Belle builds a tree of some 30 million positions, allowing a "look-ahead" of four moves (eight plies). SPOC

<table>
<thead>
<tr>
<th>Modern Benoni Defense</th>
</tr>
</thead>
<tbody>
<tr>
<td>White: SPOC The Chess Master, tournament level 6</td>
</tr>
<tr>
<td>Black: Jonathan Silverman, USCF Expert</td>
</tr>
<tr>
<td>San Francisco</td>
</tr>
<tr>
<td>October 2, 1983</td>
</tr>
</tbody>
</table>

SPOC's notation

| 1. d2-d4 | 1. P-Q4, N-KB3 |
| 2. g8-f6 | 2. P-QB4, P-K3 |
| 3. c2-c4 | 3. N-KB3, P-B4 |
| 4. e7-e6 | 4. P-Q5, P×P |
| 5. g1-f3 | 5. P×P, P-Q3 |
| 6. c7-c5 | 6. b6×d5 |
| 7. d4-d5 | 7. c4×d5 |
| 8. e6×d5 | 8. c5×d5 |
| 9. c4×d5 | 9. d6-d7 |
| 10. d7-d6 | 11. c1-f4 |
| 11. e6-e5 | 12. a7-a6 |
| 12. e7-e6 | 13. d7-d6 |
| 13. b6-b5 | 14. a6-a5 |
| 14. b7-b5 | 15. a5-a4 |
| 15. e6-e5 | 16. c3-e4 |
| 16. a4-a3 | 17. f6-g7 |
| 17. e5-e4 | 18. g7-g6 |
| 18. f2-f3 | 19. e4-e5 |
| 19. c2-c3 | 20. b2-b3 |
| 20. b7-b6 | 21. c2-c4 |
| 21. e2-e3 | 22. f1-c1 |
| 22. b1-b2 | 23. e3-e2 |
| 23. b2-b3 | 24. a3-e7 |
| 24. a7-a6 | 25. d2-c4 |
| 25. e1-e2 | 26. c7-c6 |
| 26. c6-c5 | 27. f7-f6 |
| 27. c5-c7 | 28. a6-a5 |
| 28. f6-f5 | 29. c7-c5 |
| 29. b3-e2 | 30. d4-d5 |
| 30. d5-d6 | 31. c8-a6 |
| 31. e1-e2 | 32. c5-c6 |
| 32. a3-a2 | 33. b1-b2 |
| 33. b2-b3 | 34. c5-c4 |
| 34. d2-d4 | 35. e2-e3 |
| 35. e7-e7 | 36. f2-f3 |
| 36. f3-f2 | 37. d1-d2 |
| 37. c7-e7 | 38. e1-e2 |
| 38. b2-b3 | 39. c6-c7 |
| 39. e4-e5 | 40. f6-f5 |
| 40. c3-c5 | 41. g5-d2 |
| 41. d4-d5 | 42. f5-d5 |
| 42. d5-d6 | 43. b5-b6 |
| 43. b1-b2 | 44. c4-c5 |
| 44. a5-a4 | 45. g2-g3 |
In this game, SPOC holds its own at the beginning, then it makes the subtle mistake of developing a Bishop before a Knight, followed by an incorrect Queen posting. SPOC does come up with one move currently in vogue in master play—half move 8—a testament to its quality of play.

A few annotations on specific moves are in order here:

4. Out of its own book openings, SPOC begins to “think” for itself and continues to make book moves (see reference 1).

In short, SPOC has played the opening logically, but not typically looks at 500 positions (level 6) and looks ahead at least three plies (a move and a half). It goes further on those branches containing captures and checks.

The heart of the program is a scoring function. Each board position in the tree is scored by material, positional, strategic, and other criteria that are inserted as coefficients in this equation. Finally, the computer applies a “mini-max” selection technique to choose its own best (maximum) score and its opponent’s best (the computer’s minimum).

This whole scoring and mini-maxing process begins after the computer jumps out of its “book” (a predefined
list of the program's favorite openings). The computer “memorizes” many openings in order to get past the critical first 8-12 moves, much as tournament players do. Belle's book contains 350,000 opening moves; SPOC's has about 3000. This means SPOC is forced out of book much earlier in a game than Belle.

Because SPOC only looks three plies deep, it relies on an extensive scoring function written in FORTRAN. A random-number generator prevents it from playing the same openings again and again. As it progresses to higher playing levels, SPOC restricts itself to its best openings. You can begin play at level 1 to get the widest choice of openings and then change to higher levels (F2) after a few moves. A handy move-immediate feature (F3) forces SPOC to make obvious moves like Queen captures.

SPOC jumps into a separate endgame routine when it determines that there is not much power left on the board. In an endgame with no Queens, the King becomes a powerful piece. Before the endgame, SPOC's scoring function discourages King moves after casting. (You can't coax SPOC's King out from behind its protective wall of pawns.) Once the program decides that the endgame has started, however, it lets its King roam.

How to Beat SPOC

By examining the actual moves a computer makes, you can understand something about its scoring function. For example, if it makes useless checks, you can assume that the scoring coefficient for checking moves is too large. If it is slow to recognize sacrifices, perhaps the material coefficient is overriding the danger coefficients. It is difficult to work an instinct for the kill into the scoring function.

There are a number of ways to beat SPOC depending on your chess experience.
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1. Exploit its materialistic nature. Maintaining the balance of pieces is essential for SPOC; it’s not likely to sacrifice material for positional advantage.

2. Take it out of its book early. If you don’t, the middle game is sure to be a real fight. However, if you can play an opening SPOC doesn’t “know,” it starts its positional slide sooner.

3. Exploit its early Queen moves. This kind of mistake is a “natural” result of SPOC wanting to bring its heavy artillery to the front line. Chess “rules of thumb,” such as “develop Knights before Bishops and minor pieces before major pieces,” are hard to translate into a scoring equation.

4. Offer it “poisoned” pawns. Even the big machines have trouble here. Computer chess programs are “willing to give up too much for a pawn,” says Belle’s author, Ken Thompson.

5. Give it useless checks to make. SPOC will waste moves putting you in check because that’s the first step to checkmate. These possibilities get good grades from the scoring function.

6. When all else fails—try speculative attacks on SPOC’s King. Throw a few pieces at it. It never expects you to sacrifice.

The opening in table 2, ending in photo 1, shows how to use the strategies above to defeat SPOC. An early stroll of its Queen leads to the capture of a poisoned pawn and then to the exchange of a pawn for a Knight.

**Conclusion**

While a Senior Master would be able to exploit SPOC’s weaknesses, 90 percent of the estimated 40 million American players who “know” the moves would not. Even many tournament players would have trouble beating SPOC (the average ranking of the United States Chess Federation’s 30,000 chess players is 1537).

Some informed people expect the programs to start beating the best of human chess masters. Professor Monroe Newborn of McGill University, who wrote Ostrich, predicts that a program good enough to be the world chess champion will be developed within two or three years.

David Levy, author of *All About Chess and Computers*, isn’t so sure: “…the best chess programs see 10,000-50,000 times more (than humans) but do not understand what they see. . . . (This) produces a kind of monkey/typewriter situation. . . . (The computer) appears to play moderately well, whereas it actually playing very weak chess so much of the time that its best results resemble the moves of strong players. Some programmers . . . argue that as the search becomes deeper, strategy and tactics merge into one. But in my opinion this view is erroneous.”

David Slate, author of Northwestern University’s Nuchess, has said that a chess program is “…like sharks swimming around, it’s not very bright, but once it gets a taste of blood, it’s right there and goes munch, munch, crunch.”

---

**Table 2:** Chess moves used to defeat SPOC.

<table>
<thead>
<tr>
<th>Sicilian Defense</th>
<th>Descriptive notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. e2-e4</td>
<td>1. P-K4, P-QB4</td>
</tr>
<tr>
<td>2. c7-c5</td>
<td>2. N-QB3, N-QB3</td>
</tr>
<tr>
<td>3. b1-c3</td>
<td>3. P-KN3, P-KN3</td>
</tr>
<tr>
<td>4. b9-c8</td>
<td>4. B-N2, B-N2</td>
</tr>
<tr>
<td>5. g7-g6</td>
<td>5. P-Q3, P-Q3</td>
</tr>
<tr>
<td>6. f1-g2</td>
<td>6. KN-K2, P-K3</td>
</tr>
<tr>
<td>7. d2-d3</td>
<td>7. B-K3, O-N3?</td>
</tr>
<tr>
<td>8. d7-d6</td>
<td>8. castles, QxP?</td>
</tr>
<tr>
<td>9. e1-g1</td>
<td>9. R-N1, Q-R3</td>
</tr>
<tr>
<td>10. f8-g7</td>
<td>10. N-N5, Q-R4</td>
</tr>
<tr>
<td>11. b1-b5</td>
<td>11. NxBP, K-K2</td>
</tr>
<tr>
<td>12. f2-f4</td>
<td>12. R-N5, QxP</td>
</tr>
<tr>
<td>13. e7-e5</td>
<td>13. BxP, B-Q2</td>
</tr>
<tr>
<td>14. b5x6</td>
<td>14. P-B4, P-N3</td>
</tr>
<tr>
<td>15. c3-b5</td>
<td>15. N-B5ch, K-B3?</td>
</tr>
<tr>
<td>16. e8-e7</td>
<td>16. P-K5ch, NxB</td>
</tr>
<tr>
<td>17. a1-b1</td>
<td>17. PxNch, . . .</td>
</tr>
</tbody>
</table>

Whether you’re a “patzer” (a Yiddish word used in chess lingo for “wood pushers” or inexpert players) or an expert, SPOC’s utilitarian, methodical play can wear you out. We’ve had a great deal of fun with it, however; it has improved our play and our appreciation for the game. SPOC’s ability to start a game from any board position and present it on the screen is a nice added feature. But the important thing is the level of play and that level is surprisingly high.

---

**References**

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Beneath its clever packaging lies a fascinating economic simulation
by Gene Smarte

Whoa, mule, whoa!
Whoa, mule, I say!
I ain’t got time to kiss you now,
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— “Buckin’ Mule,” traditional folk song

The fun-to-use economic strategy game M.U.L.E. (multiple-use labor element) lets you plot the economic development of a new territory on a planet called Irata. With your grubstake of money and goods and your knowledge of capitalism, you and three other “planeteers” are ferried to an undeveloped area of the planet. Once there, using the limited supplies of the general store, the planet’s only structure, you must decide how to make the best use of your resources. Your supply ship won’t be back for at least six months.

Before the game begins, the program introduction takes you through a demonstration in which you (and the computer, when there are fewer than four players) select a color and the type of creature—there are eight kinds—you wish to be. A brief description of each and its advantages and disadvantages is included. The computer always picks the mechanical Mechtron—but so can you. You also select the game level: beginner, standard, or tournament.

As the game begins, you have just landed on Irata and are watching your only link with help, your supply ship, cruise off into space. A status report lists the resources of each planeteer and the general store. (In the tournament-level game, the planeteers have but one round to become self-sufficient because their supplies are good for only one month.)
While “mule” might conjure up images of bearded prospectors and four-legged flop-eared beasts of burden, this M.U.L.E. is actually an intelligent (though sometimes unpredictable—it can run away) machine designed to resemble a real mule. You purchase it at the general store. Each M.U.L.E. must be outfitted for the task you choose: farming, energy production, or mining. Those are the main tasks of this game.

As in real societies, or “life in the rest of the galaxy,” as mentioned in the player’s guide, a balance must be struck between various needs and wants. In the case of Irata, you must have food, so farming is a requirement; you must have energy for the creation of all products, so energy production is necessary; and you must mine Smithore, the stuff from which a M.U.L.E. is made (except at the beginner’s level), to ensure availability of the M.U.L.E. as the scope of Irata’s development increases.

After the resource status report, the display shows an aerial view of the area of Irata to be developed. The landscape includes a fertile river valley ideal for farming, prairies for open-space energy production, and mountains for mining. A cursor scans the territory, and each planeteer chooses a plot of land by pressing a joystick push button. The color-coded plots correspond to the colors the planeteers select earlier in the game.

After the first round of plot selection, each planeteer has a limited time to enter the general store, decide which type of production best suits the plot just selected, outfit a M.U.L.E. accordingly, lead, via the joystick, the M.U.L.E. out to the plot, and install him (a M.U.L.E. is referred to in the masculine). Should you have some time left over, you can return to the pub in the general store and do a little gambling or go Wampus hunting. Gambling is an automatic way to win, but it ends your turn. The Wampus, as explained in the Player’s Guide, lives in mountain caves, and when he opens his door a light flashes that signals his whereabouts. You must move quickly if you expect to capture him. He’s difficult to catch, but he’ll pay you to let him go.

When each planeteer has installed a M.U.L.E., production begins automatically. But, just as in real life, random events can help or (more likely) hinder your production. Planetquakes, meteor showers, and an imaginative array of pest attacks can wipe out a turn’s production. These random events are particularly clever in concept and execution and had me looking forward to the next one.

After production, planeteer and store resources are displayed and an auction for each commodity begins. Here, a dog-eat-dog capitalist mentality can help. But you must remember that if, for example, all the planeteers try to corner the Smithore market and no one does any farming, you all have a good chance of perishing on Irata (shudder). I liked this touch of realism.

If you have the cash, you can buy what you want, and you can sell any surpluses, providing someone is interested. Both buying and selling prices are set by the planeteers with some limits in the beginner’s level. The program sets the store’s rate of exchange. With the conclusion of the auctions, an updated status report prepares you for the next round of plot selections as your first month of development ends. The game continues for 6 turns (beginner) or 12 turns (standard and tournament levels). At the conclusion, the player who has accumulated the highest net worth is the winner.

It’s impossible to adequately describe all the interaction and economically realistic subtleties of M.U.L.E. The standard level increases the complexity of the beginner level with land auctions and selling, development-
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At a Glance

Name
M.U.L.E.

Type
Economic strategy game

Manufacturer
Electronic Arts
2755 Campus Dr.
San Mateo, CA 94403
(415) 571-7171

Price
$40

Authors
Dan Bunten, Alan Watson, Jim Rushing, and Bill Bunten

Format
One 5¼-inch floppy disk

Language
Assembly language

Computers
Atari 400, 800 with 48K-byte RAM, Commodore 64

Documentation
6-page disk jacket, 20-page M.U.L.E. Player’s Guide

Audience
Capitalists, entrepreneurs, and pioneers

strategy nuances, and gyrating resource prices. You can also sell below a “critical level” if you think that you can make it up later. The tournament level adds Crystite mining and Collusion (private trading between friends). Tournament play requires some fast thinking and razor-sharp business savvy because the time allowed for decisions is significantly shorter.

M.U.L.E.’s packaging and documentation make entertaining reading. In addition to providing an interesting description of the game’s flow, the authors unveil their personal strategies. And the 20-page M.U.L.E. Player’s Guide is peppered with playing tips along with the economic realities of pricing, economies of scale, the learning-curve theory of production, and the law of diminishing returns. This is definitely not a simplistic, learn it/be bored with it, kill-the-galactic-villains time-waster.

Conclusion

M.U.L.E. is an intriguing way to illustrate some of the triumphs and perils of free enterprise. While it falls in the broad category of games, it also offers an excellent means to test your business mettle. It’s realistic, too, because just when you think you’ve done everything right, an unforeseen disaster can happen, like having your M.U.L.E. run away.

Gene Smarte is a BYTE technical editor. He can be reached at POB 372, Hancock, NH 03449.

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Somebody was nuts. I was nuts. Everybody was nuts. None of it fitted together worth a nickel. . . . I was in bad with the police, I had spent ten dollars of my twenty expense money, and I didn’t have enough leverage anywhere to lift a dime off a cigar counter.

—Philip Marlowe, speaking in Trouble Is My Business by Raymond Chandler

I can understand Marlowe’s lament now that I’ve played The Witness, the second prose murder-mystery game from Infocom. I logged a considerable number of hours trying to crack this programmed puzzler, but the case remains unsolved, wide open, no good leads, no evidence that sticks. This is one mystery-game review you can read without worrying about the solution being revealed.

Stu Galley, the author of The Witness, has styled his prose after that of Chandler, Ross Macdonald, and other captains of the hard-boiled mystery. Galley, a programmer at Infocom, has apparently read enough of the genre to emulate the style without mocking it. The descriptions are well done—quick but thorough and evocative. The narrative is detailed enough so that the player can imagine the surroundings but not have his mental picture cluttered with knickknacks. Because they provoke use of the imagination, the all-prose games are like the radio dramas of pretelevision days.

The story of The Witness begins: “Somewhere near Los Angeles. A cold Friday evening in February 1938.” The player is the detective, dispatched by police chief Klutz to assist a nervous Mr. Linder, who says his life is being threatened by a somewhat sleazy Mr. Stiles. Linder’s wife has recently killed herself. Stiles has allegedly been sending nasty notes.

A taxi drops you off at the Linder joint. The questions and decisions begin before you enter the house. Do you go to the front door? (Nah, too obvious.) Do you check out the garage? Do you stalk around the backyard? Remember, you have only 12 hours (720 moves) to solve the mystery, and every move kills a minute.

If you take the right steps, you can meet the main characters before they get away from the house. There’s Freeman Linder, who’s made millions in the Orient trade. There’s his daughter Monica, a tough dame who acts “as though you were a masher who just gave her a whistle.” There’s Phong, the mysterious butler. And there’s Stiles, who apparently was on very good terms with the late Mrs. Linder and allegedly wants Mr. Linder to join her in that Big Sleep.

The best detectives operate in a mode that balances logic and instinct. The Witness gives you plenty of opportunity to exercise both. You can minimize dead ends by keeping a list of questions asked and responses received. I sketched each room as it was described. Because the Linder house is big, I had to make lots of maps. However, the maps I drew were not much help. Despite an effort to diagram the layout of the place and to chart my steps, I frequently ran into walls and windows. This can be a problem when you’re trying to shadow someone. At one point, I gave up mapping and relied on instinct, luck, and the handy LOOK AROUND command, which flashes a description of the surroundings on the screen. I have yet to determine if the trouble is due to a bug in the program or in the player.

Infocom’s parser, the program’s language analyzer, is obviously a remarkable improvement on the simple two-word verb-noun commands of earlier adventure games. A player can interact with The Witness on a more articulate basis, which makes for a greater sense of realism. Despite this remarkable addition of adjectives, prepositions, indirect objects, and compound verbs, I still felt considerably limited in the vocabulary I could use. The rule book points out that the parser uses far more words than it understands, but when you’re onto a hot lead, with clues and questions running through your mind, it’s hard to remember that you’re talking to a computer.

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program. Generally, the linguistic limitations cause only a minor inconvenience; you may have to rephrase a question until the parser understands. But in a few cases the restrictions impede the detective work. Here's a perfect example.

I asked one character to please tell me about Monica and her father. The program informed me that I couldn't use multiple indirect objects with the word "tell." This is an unfortunate snag. A detective dealing with several characters, particularly characters who are suspect, would want to know about the relationships between them. It's a line of questioning that can help reveal motives, and unearthing motives is what investigation is all about. Certain grammatical constructions are important to the detective of a programmed mystery.

The game's designers have provided some very helpful commands. The ones I used most frequently, besides the usual legwork commands (e.g., WALK WEST), were EXAMINE, which lets you look closely at something; ANALYZE, which includes checking for specific substances and fingerprinting; and SEARCH (something or someone), to which some characters do not react favorably. And as Holmes had his Watson, you have Sgt. Duffy, who can be called in for assistance. Duffy can handle analysis, booking, questioning, and other tasks—if you can find him. Failing that, you can still shout obscenities and even shoot at characters. (Galley anticipated certain input statements and apparently expected some players to get very frustrated.)

The Witness, in the Infocom tradition, is attractively packaged. The *National Detective Gazette*, the main piece of documentation, is cleverly and clearly written and features some nice illustrations. The graphic artists involved in this project deserve a round of applause. The reference card is straightforward and explains booting and playing procedures in terms simple enough to be followed by the village idiot. This is commendable.

Playing time varies greatly. Infocom games have reportedly taken from 20 to 60 hours (real time). You can play The Witness for five minutes if you like, store your game position, and resume the investigation later. If you arrest a character judged innocent by the grand jury (it takes a lot of evidence to convince the jurors), the session is ended for you. Wrong moves can be counted against you. Think before you act; think again before you enlist the steel.

Frustration is a part of this game. Questions multiply, answers are scarce. Hours after suspending play, you might find yourself evaluating a move you made or pondering that response a suspect made. How often have you played Monopoly and then wondered hours later why you didn't buy Baltic Avenue?

Remarkably, The Witness gives you an idea of the sort of situations an investigator is up against. Dropped into a situation in which a crime has been committed, you have to decide what questions to ask and whom to ask. You have to determine who's lying and who's got something to hide. You have to make assumptions about people you've only recently met. And your approach is based on scant clues: a note, a matchbook, a trace of gunpowder, a conflicting statement. Kojak never had it so rough. Of course, there is one big difference between being a detective and playing an adventure game. Real-life detectives sometimes must look down the barrel of a gun; the game player only has to look down the tube of a video display.

No law-abiding gumshoe likes a dead end, a lying suspect, or a stiff. But these are the elements of a good mystery and a good mystery game. Galley and the Infocom staff have succeeded in designing what Sherlock Holmes would call "a three-pipe problem."

### At a Glance

- **Name**: The Witness
- **Type**: Prose murder-mystery game
- **Manufacturer**: Infocom Inc.
  55 Wheeler St.
  Cambridge, MA 02138
  (617) 492-1031
- **Author**: Stu Galley
- **Price**: $49.95; $59.95 for DEC RT-II, NEC APC, and CP/M versions
- **Format**: 5½- or 8-inch floppy disk
- **Computer**: Any of the following with 48K bytes of RAM, one disk drive, and a black-and-white or color monitor: Atari 400 or 800, Apple II, Commodore 64, DEC Rainbow or RT-II, IBM PC, NEC APC or PC-8000, Osborne, TRS-80 Models I or III, TI Professional, CP/M-based computers
- **Documentation**: A computer reference card, *National Detective Gazette*, and assorted props (including a suicide note, a telegram, and a matchbook)
- **Audience**: Game players

---

**A Tip**

If you begin to feel as if the district attorney is breathing down your neck, everyone's lying to you, and the Scotch is starting to taste sour, you probably need some help. An *Invisiclues* booklet contains some hints that might assist your investigation. It costs $7.95 and comes with a special pen that lets you reveal clues one at a time. To order, telephone (800) 262-6868; in New Jersey, (800) 238-2200. Above all, keep cool. And remember: it's Chinatown, Jake.

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Dennis Barker is a copy editor at BYTE. He can be reached at POB 372, Hancock, NH 03449.
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You somehow knew that Radio Shack was eventually going to come out with an IBM PC-compatible computer, but the actual announcement was surprising nonetheless. Also surprising was the fact that Radio Shack chose not just to copy the IBM Personal Computer, but to design a much more powerful machine.

The Tandy TRS-80 Model 2000 has a number of notable features: a true 16-bit Intel 80186 microprocessor with a high clock speed, high-capacity floppy-disk drives, optional high-resolution color graphics, MS-DOS version 2.0, modest compatibility with the IBM PC, and a low price. To be sure, other machines boast such features, but this is the first to combine these features with a marketing structure as formidable as that of Radio Shack.

Physical Appearance
The 2000 departs radically from the traditional look of TRS-80 computers. The color scheme is the ubiquitous off-white. The keyboard is thin and light and has a very ergonomic look, and the monochrome monitor is small and stylish. Both are detached from the system unit, which resembles that of many other 16-bit computers.

Closely examined, the new model...
has a number of interesting features. Most notable is the system unit's ability to rest horizontally on a desk or, like the DEC and Wang machines, vertically on the floor. And the computer's nameplate can be rotated 90 degrees to suit either orientation.

The nameplate itself is unusual: it reads "Tandy TRS-80 Model 2000." No Radio. No Shack. Apparently Radio Shack encountered some resistance to the word "Shack" on its high-end computers. The implication here is that, in the future, any new computer over $2000 will carry the Tandy label. Although Radio Shack denies the possibility, I wouldn't be surprised to find the Radio Shack Computer Centers renamed Tandy Computer Centers.

Immediately below the nameplate (or beside it, as the case may be) are two minor but important details: an easy-to-find power switch and a Reset button. For the benefit of those who abhor Reset buttons, the Control-Alternate-Delete key trio used by the IBM PC will also usually reset the machine.

The Displays

Radio Shack offers a choice of two displays: a small green monochrome monitor for $250 and a large color RGB (red-green-blue) monitor for $799. A two-color graphics option is available for both monitors at an additional $449. Extra memory chips for eight-color graphics on the color monitor sell for $199. In addition, a small pedestal base is available for the monochrome monitor for $90.

The monochrome monitor has a 25-MHz bandwidth without interlacing. The characters are sharp and steady: the character font is simple and readable, although not as ornate as the IBM PC's monochrome monitor. If you desire, you can replace the entire 256-character set with your own character set. Characters can also be displayed in either double-width or double-height sizes.

The color monitor uses the same character generator as the monochrome monitor. The characters are well formed and readable in most colors.

The graphics resolution of both monitors is an impressive 640 by 400 pixels (picture elements). When the eight-color graphics option is installed, eight out of a possible sixteen colors can be displayed at once. (These colors are the standard white, black, red, green, blue, magenta, cyan, and yellow, with each color available in both high and low intensity.) Color-mapping hardware allows you to change colors quickly on the screen.

Seeing a display of color graphics on a Radio Shack business computer is somewhat unusual. More unusual, however, is the speed with which the graphic images are drawn. Thanks to a faster microprocessor, the Model 2000 can draw charts and graphs in what seems to be less than half the time required by the IBM PC.

The Model 2000 reportedly has smooth-scrolling capability (i.e., it can scroll pixel by pixel rather than line by line), but I did not see this demonstrated. The scrolling I did see was very fast.

The Keyboard

The keyboard on the 2000 has a very nice touch and is one of the finer keyboards available. It lacks the peculiarities that have plagued other computers and previous Radio Shack designs. The typewriter keys appear in a standard IBM Selectric typewriter configuration. Cursor keys are in an inverted T, just to the right of the typewriter keys, and a numeric keypad is placed to the right of the cursor keys. A row of twelve function keys is arranged in groups of four and runs along the top of the keyboard. This logical arrangement makes it easy to find a particular function key.

The Insides

Tandy has decided to use Intel's powerful but infamous 80186 microprocessor chip, which is similar to Intel's 8086 chip except that it incorporates several necessary support functions directly into the central processing unit (CPU). These functions include a clock-pulse generator and two high-speed direct-memory-access (DMA) controllers. The true 16-bit processing power of the 80186 gives it about a 40 percent speed advantage over the 8088, and the 8-MHz clock speed of Tandy's 80186 chip
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By The Fancy Font System

Letter Quality
Say goodbye to correspondence quality and hello to Fancy Font's high-resolution, proportionally spaced letter quality. Fancy Font provides fonts in sizes from 8 to 40 points; styles include Roman, Bold, Italic, Script, Old English, and more. All this on low-cost Epson (MX, RX, FX) and Gemini 10X printers. Fancy Font is an easy-to-use software package for CP/M and IBM PC compatible systems; no special hardware or installation is required.

Create Your Own Characters
You can use over 30 font sets in the Fancy Font package and furthermore, can create any new characters or logos you like, up to 1 inch by 1 inch. A database of over 1500 characters is included that makes it possible to print foreign languages and mathematical notations.

Font Style Samples
small medium large
Bold Italic
Sans Serif Script Old English
\[ A = \int_{a}^{b} \sqrt{a^2 - x^2} \, dx \]

Numerous Applications
Fancy Font customers, numbering in the thousands, are constantly discovering new applications:
- Business and personal letters
- Custom forms, invoices, labels, signs
- Foreign Languages
- Mathematical Notation, Greek
- Super- and Sub-scripts
- View Graphs
- Custom Letterheads
- Resumés
- Articles for publication
- Newsletters, brochures
- Complete manuals
- Advertisements
- Invitations, place cards
- Custom forms, invoices, labels, signs

Disk Storage
One of the problems with a faster microprocessor is that floppy disks tend to fill up faster. Radio Shack has more than compensated for this less-than-major difficulty. The Model 2000 comes with a minimum of 128K bytes. An additional 128K bytes can be placed on the motherboard, but beyond that you will have to add expansion boards populated with either 128K or 256K bytes. The upper memory limit is 768K bytes.

Interfaces
The Model 2000 comes with both a Centronics parallel printer port and an RS-232C serial port. An optional
With Sharp's PC-5000 you can take your entire office with you, wherever you go. Do word processing on the train, order entry from a customer's office or spreadsheet analysis in your hotel room. It goes anywhere.

It's small.
It weighs under 10 lbs. and fits in a standard briefcase.
It prints quietly, with an optional correspondence-quality printer.
It comes with software. Word processing and communications. Also available are spreadsheet, executive planning and scheduling.
It remembers over 80 (128K) typewritten pages.
And can be expanded to handle over 500 (896K).
It's compatible with a wide array of 16-bit IBM software.
It communicates with other computers and databases.
It's AC/DC with rechargeable 8-hour batteries.
It all means travel time and commuter time no longer have to be downtimes.

For more information call toll-free now at 800-447-4700 or send in the coupon.
Expansion Capabilities

The Model 2000 has four horizontal expansion slots accessible from the rear panel. Expansion boards are slipped in like trays. Each board has a nonstandard connector that consists of three rows of about 30 pins (see table 1 for a list of expansion boards available for the Model 2000).

The Model 2000 can also be purchased with a 10-megabyte hard-disk drive instead of one of the floppy drives. This configuration costs $4250 without a monitor. Since the hard-disk drive sits to the left of the floppy-disk-drive enclosure, a second floppy-disk drive can still be added. Radio Shack has not yet made this second drive option available.

Software

Of course, the most important part of any new machine is its software. Radio Shack's last 16-bit computer, the 68000-based Model 16, was hampered for a while by the lack of 16-bit software. The Model 2000, with its popular MS-DOS operating system, should have a much easier time.

The standard system comes complete with MS-DOS version 2.0 and Microsoft's GW-BASIC interpreter. In addition, Radio Shack offers many software package options (see table 2). More packages should be available in the future, but don't expect your local Radio Shack store to carry a huge assortment of MS-DOS software—these stores already stock a wide assortment for the other TRS-80 machines, and Radio Shack says that it does not want to overburden its dealers.

As you can see from table 2, Radio Shack offers at least one example from each of the main categories of applications software. You can be fairly sure that all major MS-DOS software houses will supply configurator programs that allow you to configure their software for the Model 2000.

A notable feature of the Model
512Kbyte
SemiDisk™ I $1095

Time was, you thought you couldn't afford a SemiDisk. Now, you can't afford to be without one.

- 256K  512K  1Mbyte
  SemiDisk I, S-100  $895  $1095  $1795
  IBM PC  $1095  $1795
  TRS-80 Model II  $1095  $1795
  SemiDisk II, S-100  $1395  $2095
  Battery Backup Unit  $150

Time was, you had to wait for your disk drives. The SemiDisk changed all that, giving you large, extremely fast disk emulators specifically designed for your computer. Much faster than floppies or hard disks, SemiDisk squeezes the last drop of performance out of your computer.

Time was, disk emulators were afraid of the dark. When your computer was turned off, or a power outage occurred, all your valuable data was lost. But the SemiDisk changed all that. Now, the optional Battery Backup Unit helps take the worry out of power interruptions. It keeps the SemiDisk powered for up to 5 hours during a power failure.

Time was, you had to wait until your printer finished printing to use your computer. That's changed, too. Now, the SemiSpool print buffer in our Version 5.0 software, running under CP/M 2.2, frees your computer for other tasks while your data is printing. With a capacity up to the size of the SemiDisk itself, you could implement an 8 Mbyte spooler!

But one thing hasn't changed. That's our continuing commitment to supply the fastest, highest density, easiest to use, most compatible, and most cost-effective disk emulators in the world.

SemiDisk.
It's the disk the others are trying to copy.
### Expansion Boards

<table>
<thead>
<tr>
<th>Expansion Boards</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monochrome graphics adapter</td>
<td>$449</td>
</tr>
<tr>
<td>Eight-color graphics adapter (Monochrome adapter + extra memory)</td>
<td>$698</td>
</tr>
<tr>
<td>TV/Joystick adapter</td>
<td>$250</td>
</tr>
<tr>
<td>Mouse/Clock adapter (Includes MS Windows)</td>
<td>$120</td>
</tr>
<tr>
<td>128K-byte memory board</td>
<td>$499</td>
</tr>
<tr>
<td>256K-byte memory board</td>
<td>$798</td>
</tr>
</tbody>
</table>

### Other options

<table>
<thead>
<tr>
<th>Other options</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monochrome monitor</td>
<td>$249</td>
</tr>
<tr>
<td>Color monitor</td>
<td>$799</td>
</tr>
<tr>
<td>Second 128K-bytes memory</td>
<td>$299</td>
</tr>
<tr>
<td>Digi-Mouse</td>
<td>$100</td>
</tr>
<tr>
<td>Floor stand</td>
<td>$145</td>
</tr>
<tr>
<td>Monochrome display pedestal</td>
<td>$90</td>
</tr>
</tbody>
</table>

#### Table 1: Expansion boards and options for the Model 2000.

### Software

<table>
<thead>
<tr>
<th>Software</th>
<th>Type</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planetfall</td>
<td>Game</td>
<td>$50</td>
</tr>
<tr>
<td>Videotex Plus</td>
<td>Communications</td>
<td>$50</td>
</tr>
<tr>
<td>Witness</td>
<td>Game</td>
<td>$50</td>
</tr>
<tr>
<td>MS-Assembler</td>
<td>Macro assembler</td>
<td>$100</td>
</tr>
<tr>
<td>Home Account Plus</td>
<td>Personal finance</td>
<td>$125</td>
</tr>
<tr>
<td>PFS:Report</td>
<td>Report generator</td>
<td>$125</td>
</tr>
<tr>
<td>PFS:Write</td>
<td>Word processing</td>
<td>$140</td>
</tr>
<tr>
<td>PFS:File</td>
<td>Database</td>
<td>$140</td>
</tr>
<tr>
<td>PFS:Graph</td>
<td>Business graphics</td>
<td>$140</td>
</tr>
<tr>
<td>Multiplan</td>
<td>Spreadsheet</td>
<td>$249</td>
</tr>
<tr>
<td>Multimate</td>
<td>Word processing</td>
<td>$250</td>
</tr>
<tr>
<td>GW-BASIC compiler</td>
<td>BASIC compiler</td>
<td>$300</td>
</tr>
<tr>
<td>MS-Pascal compiler</td>
<td>Pascal compiler</td>
<td>$300</td>
</tr>
<tr>
<td>MS-FORTRAN</td>
<td>FORTRAN compiler</td>
<td>$350</td>
</tr>
<tr>
<td>MAIL/Basic Four</td>
<td>Purchase orders</td>
<td>$395</td>
</tr>
<tr>
<td>Accounts payable</td>
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<td></td>
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<tr>
<td>Accounts receivable</td>
<td>$495</td>
<td></td>
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<tr>
<td>General ledger</td>
<td>$495</td>
<td></td>
</tr>
<tr>
<td>Inventory control</td>
<td>$495</td>
<td></td>
</tr>
<tr>
<td>Payroll</td>
<td>$495</td>
<td></td>
</tr>
<tr>
<td>COBOL</td>
<td>RM-COBOL compiler</td>
<td>$595</td>
</tr>
<tr>
<td>dBASE II</td>
<td>Database</td>
<td>$595</td>
</tr>
</tbody>
</table>

#### Table 2: Software offered by Radio Shack for the Model 2000.

2000's BASIC interpreter is its graphics capabilities. Because of the Model 2000's fast processor, its version of BASIC runs rings around that of the IBM PC. To see the FILL routine in action is especially impressive.

Watch for one particular software package for this machine, Ovation, which should be available during the second quarter of 1984, lets you go from spreadsheet to word processor to database manager very easily without having to cut and paste to transfer data. Demonstrations of Ovation at COMDEX in November left no doubt that applications software has advanced to a new level.

As for that other operating system, CP/M-86, Radio Shack has expressed no interest in making a second operating system available for the Model 2000.

#### Compatibility

Radio Shack stresses that its machine is an MS-DOS machine, not an IBM PC clone. Yet in its advertising, Radio Shack repeatedly makes direct comparisons with the machine from Boca Raton. And obviously, compatibility with the IBM PC is important because of IBM's ever-growing library of software. To its credit, Radio Shack makes it quite

SEE HOW THEY WORK

You can imagine how precise the components have to be to convert tones over a phone line into 120 characters every second. Precision equates to cost. With the advent of the mass market in personal computers the economies of scale drove the costs of manufacture down, but did not effect the precision required. The technology used is called "analog filtering". It is the process of sending (modulating) and receiving (demodulating) tones with perfect pitch. A lot of adjusting, noise suppression, and a little magic is required. Real expensive. Some use lots of chips and filters (known as discrete components). The latest rage is LSI (Large Scale Integration) technology. Which is the same old analog stuff condensed onto fewer chips.

ADVANTAGE #1

Digital Signal processing

A NEW IDEA

We took a different approach. Through the use of four microprocessors the tones are chopped up digitally and measured millions of times per second, eliminating the need for analog circuitry. Two microprocessors do the modulating, two the demodulating. The chips are programmed to emulate the 103 (30 characters per second) or 212 (120 characters per second) standards and determine the correct speed automatically. It's a proven technology that provides outstanding performance. Best of all, it's inexpensive and reliable.
A GENUINE BREAKTHROUGH

NO CORNERS CUT
We included every feature you would want in a modem card. It's FCC registered for direct connection to your modular phone jack with the cord which is included. There is a separate modular jack for your telephone or you can listen through the onboard speaker. The autodialer works on rotary lines, tone lines, or a combination of both, and will pause for use with Sprint or MCI. It will work in originate or auto-answer modes. A separate microprocessor, a 28, controls all the functions.

ADVANTAGE #2
Optional external serial port connector

AN ASYNCHRONOUS ADVANTAGE
The modem board is addressed in the software as COM1 or COM2 and we have a handy little option you ought to consider. If you would like to use the asynchronous communications port when your modem is not in use, we will add a connector and the necessary circuitry for just $20. This saves you the hundred bucks or so you would spend for another async card and saves a valuable slot. It can be configured as COM1 or COM2 and works just like IBM's does.

THIN IS IN
It plugs into your IBM PC or XT and occupies any one slot since it is just 1/2 of an inch thick. This is made possible by using a special speaker which is just 1/8" tall. Competing brands either use a conventional cone type speaker, or they just skip the speaker altogether. Some modems also have large transformers which allow rob valuable space.

ADVANTAGE #3
Just one slot in PC or XT

LET'S TALK SOFTWARE
Our modem is 100% compatible with the Hayes software commands so you can use any of the popular communications packages like IBM's Asynchronous Communications Support, CrossTalk, Transend, or PC Modem. We go one better than the competition. We include PC-TALK III. PC WORLD magazine referred to it as "the benchmark that other PC communications packages are measured against." It stores phone numbers, handles setting the modem's characteristics, saves to disk files, transmits from disk files, even binary files. You can program up to forty keys to have things like passwords and log-on information be entered when you hit them. And to make sure data is sent and received accurately, the XMODEM protocol detects errors caused by poor line quality and automatically retransmits the data.

WHY BUY FROM US
Because besides having the best product on the market, we stand behind it and you. You get factory direct technical support after the sale. If at any time during the one year warranty period your modem should require service, we will fix or replace it within 48 hours. Notice also there are no hidden charges in our price. Nothing extra for credit cards or COD charges. We even pay UPS shipping. If you still are not convinced, and are ready to buy another brand of modem, ask them if they will take our acid test.

THE ACID TEST
Qubie' gives you a 30 day satisfaction guarantee on your modem. If you are not completely satisfied we will refund the entire amount of your purchase including the postage to return it. If you can, get anyone selling one of our competitor's products to give you the same guarantee. Buy any modem you like and return the one you don't like. We know which one you will keep.

ORDER TODAY
It's easy to order by mail or by phone.

BY PHONE: Call us and one of our sales staff can answer any questions you have and take your order. Have your Visa or Mastercard number handy when you call.
(805) 987-9741

BY MAIL: We need your name and street address, daytime phone number, how many modems you want, and whether your computer has single or double sided drives.

$299 includes: PC 212A/1200 auto-dial modem card, PC-TALK III software, cord to connect to modular phone jack, and manual. 1 year limited warranty.

Optional: Connector and circuitry to use serial port for another serial device $25.

SHIPMENT
We pay UPS surface charges. UPS 2 day air service add $5 extra. Credit card or bank check orders shipped next day. (Personal checks take 18 days to clear)

QUBIE'
4809 Calle Alto Camarillo, CA 93010
Circle 283 on inquiry card.

ACCESS TOMORROW'S COMPUTER SOLUTIONS TODAY!

We've broken the disk access bottleneck using advanced 3M™-patented technology never before available for the IBM PC. Now, for the first time, this advanced storage technology is made available exclusively to the small-to-mid-sized business user by People & Technology.

INTRODUCING...

ELECTRONIC File Cabinet SERIES 100

20 Mb Disk Drive

- IBM™ compatible
- Plug-compatible w/ most PC/DOS and MS/DOS (version 1.1 and 2.0)
- Mainframe data access time & reliability for your PC... only 65 ms!
- All installation software, cabling, and comprehensive operations/ information manual included
- Look-alike IBM packaging
- Bank financing available
- Only $2,350 . . . more storage for less money!

For product and ordering information, call our 24 hour toll free order line at 800-443-0100 Ext. 428

People & Technology
Access tomorrow’s computer solutions today.

People & Technology

20 Mb Disk Drive

<table>
<thead>
<tr>
<th>Software</th>
<th>Publisher</th>
<th>Runs on Model 2000?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2-3</td>
<td>Lotus Development</td>
<td>No</td>
</tr>
<tr>
<td>Accounting</td>
<td>IUS</td>
<td>Yes</td>
</tr>
<tr>
<td>Accounting</td>
<td>Open Systems</td>
<td>Yes</td>
</tr>
<tr>
<td>Bottom Line Strategist</td>
<td>Ashton-Tate</td>
<td>Yes</td>
</tr>
<tr>
<td>DJ Market Analyzer</td>
<td>Dow Jones</td>
<td>No</td>
</tr>
<tr>
<td>Easywriter</td>
<td>IUS</td>
<td>No</td>
</tr>
<tr>
<td>PeacText</td>
<td>IBM</td>
<td>No</td>
</tr>
<tr>
<td>Plannet</td>
<td>Business Software</td>
<td>Yes</td>
</tr>
<tr>
<td>Quickcode</td>
<td>Fox &amp; Geller</td>
<td>Yes</td>
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<tr>
<td>Random House Dictionary</td>
<td>Aspen/Wang</td>
<td>Yes</td>
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<td>Smartcom</td>
<td>Hayes</td>
<td>No</td>
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<tr>
<td>Spellguard</td>
<td>Sorcim</td>
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<td>SuperCalc2</td>
<td>Sorcim</td>
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<td>Tax Preparer</td>
<td>Howardsoft</td>
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<tr>
<td>The Word Plus</td>
<td>Oasis</td>
<td>Yes</td>
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<tr>
<td>Visicalc</td>
<td>Viscorp</td>
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<tr>
<td>Volkswriter</td>
<td>Lifetree</td>
<td>No</td>
</tr>
<tr>
<td>Wordplus/The Boss</td>
<td>Professional Software</td>
<td>No</td>
</tr>
<tr>
<td>Wordstar</td>
<td>Micropro</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 3: Partial list, compiled by Radio Shack, of popular MS-DOS software, indicating which packages will run on the Model 2000. For more information, check your local Radio Shack dealer.

clear that several IBM PC programs will not run on the 2000.

In brief, any IBM PC program that, for the sake of speed, bypasses MS-DOS routines and directly accesses the IBM's memory is unlikely to run on the 2000. Similarly, any program that makes use of certain unique keys on the IBM keyboard or the unique graphics features is also unlikely to run (see table 3 for a list provided by Radio Shack of those programs that will or will not run).

In some cases, the obstacle to running a particular program is trivial. For example, Radio Shack mentioned a program that accesses a certain memory location in the IBM PC to ascertain whether a monochrome or color monitor is being used. To make this program run on the 2000, you simply change two bytes in the program so that it accesses the equivalent memory address on the 2000.

Obviously, some programs are more difficult than others to "port" to the 2000. Note that the best-selling 1-2-3 package from Lotus Development is not among those offered by Radio Shack. This may reflect Tandy's preference for Ovation as much as the difficulty of porting 1-2-3.

Two additional levels of compatibility with the IBM PC require mention. The first is disk compatibility and the second is hardware compatibility.

Radio Shack makes it quite clear that several IBM PC programs will not run on the 2000.

With regard to disks, the 2000, because it uses a quad-density disk format, has sacrificed complete compatibility with the IBM. The 2000 can read an IBM disk but it cannot write to one, and, while this situation is better than nothing, I'm sure that the limitation will be more than a little frustrating. (I should note that the 2000 did have trouble reading one of my IBM PC disks.)

As for hardware compatibility with the IBM PC, there is almost none. The expansion slots are completely different. The monitors are said to be specially designed for the 2000. The only common points seem to be the related CPU chips and the serial and parallel ports.

Several manufacturers, such as Tecmar, AST, and Quadram, have developed expansion boards for the IBM.
Introducing the world’s first complete, self-contained, 16-bit portable computer system.

The Panasonic Sr. Partner with a built-in printer.

The Panasonic Sr. Partner is one of the most flexible and versatile portable computers on the market today. So there are many reasons to buy one.

**Runs IBM PC Compatible Programs.**

To begin with, the Sr. Partner runs IBM PC compatible programs. So you can pick from hundreds of popular programs from an existing software library. Including Lotus 1-2-3®, Multiplan® and even Flight Simulator®.

In addition, included with the Sr. Partner are five of the most respected business-related programs including VisiCalc®, WordStar®, PFS® Graph, File and Report plus G.W. BASIC®. All at no extra charge.

This “bundle” allows you to go to work immediately doing word processing, electronic spreadsheets, file management, graph development and your own programming.

And because it also accepts IBM PC compatible hardware, the Sr. Partner’s technical capabilities can be expanded even further.

**Built-in Printer.**

The Sr. Partner is the only portable in its class with a built-in printer. It has graphics capability and can provide you or your customers with printouts of statistics, budget figures, conference notes, graphs and much, much more.

The printer is also extremely quiet and offers an 80-character line and the 132-character line that’s perfect for spreadsheets and other accounting programs. And its bi-directional logic design delivers fast printing.

**A Complete System.**

The Sr. Partner is an integrated system that doesn’t require costly add-ons to be called complete.

It has 128K internal memory (RAM), expandable to 512K. A nine-inch, high-resolution CRT with monochrome screen. An 8088 microprocessor with a MS-DOS® 2.0 operating system. An 8087 co-processor socket. A built-in, double-sided, double density, 360K, 5¼-inch disc drive and the capability of handling another one just like it. Built-in color and graphics at no extra cost. An option slot for IBM hardware. An RGB monitor output. A centronics parallel interface I/O port that accepts optional peripherals. And an RS-232 serial interface I/O port. All for a price that’s surprisingly affordable.

The Sr. Partner is also backed up by a 12-month limited warranty. Most of the competition offers only 90 days.

And if the Sr. Partner should ever need servicing, we have a national network of authorized service dealers.

**Over 60 Years of Dependability.**

We’re not one of those “here today, gone tomorrow” companies.

Our parent, Matsushita Electric Industrial Co., has been in business since 1918 and is one of the world’s largest consumer electronics manufacturers. Matsushita’s recent contributions and innovations to computer and office technology include: a data entry system that directly connects facsimile data to a computer, an online optical character reader, a “pocket terminal” telephone data entry system, and a 64K static memory chip.

For more information about the Sr. Partner, write to: Computer Department, Panasonic Industrial Company, Division of Matsushita Electric Company of America, One Panasonic Way, Secaucus, N.J. 07094. Or call: (201) 392-4261.

The Panasonic Sr. Partner. It’s everything you’ve always needed in a portable computer but never had before.

Panasonic just slightly ahead of our time.
You don’t need a computer to talk to another computer.

DISPLAY (VP3012D). High performance, 12" diagonal, non-glare, green phosphor screen.

RESIDENT MENUS. User-friendly terminal set-up and phone directory maintenance.

DIRECT CONNECT MODEM. Built-in, 300 baud, originate/answer/auto answer.

AUTO DIAL. Tone or pulse dialing of up to 26 stored phone numbers, voice or data base calls.

AUTO-LOG-ON. Enters information automatically after auto dialing.

VIDEO OUTPUT. Selectable 80 or 40 characters x 24 lines on standard monitor.

TV OUTPUT. Displays 40 characters x 24 lines on Ch. 3/Ch. 4 of standard TV set.

MEMORY BACKUP. Minimum 48-hour storage of directory, log-on and other parameters without plug-in power. No batteries required.

FUNCTION KEYS. User programmable or downloadable from host computer.

The new RCA APT (All Purpose Terminal) expands your data communications capabilities for a lot less money.

For business, professional and personal data communications, you'll find more user-friendly features and greater communications capabilities in the RCA APT than in other terminals selling for up to three times the price.

The new APT terminals are ideally suited to multi-data base time sharing and dedicated, direct computer-connected applications. They feature menu-controlled operation and a programmable "personality" to match specific communications requirements for your data bases.

A single keypress can dial a stored number, send the log-on sequence to the host computer, and return terminal control to the user. Password protection prevents unauthorized access to designated numbers. APT can also be used as an auto-dialer for voice communications.

Quite simply, matching features with price, there is no other professional quality terminal available today that can do as much at such low cost.

APT terminals list for $399, in your choice of full stroke or membrane keyboard versions. Either style is also available with a display monitor for $598 list. The data display monitor alone, VP3012D, $199 list.


OTHER FEATURES
RS232C port for direct computer connections at data rates to 9600 baud, or for connecting high speed modems and other accessories. Parallel printer port for hard copy. Numeric keypad, can dial phone numbers not in terminal directory. Built-in speaker with adjustable volume control for audio monitoring of phone line. Smooth scroll display. Automatic screen blanking to reduce possibility of burn. Briefcase size: 17" x 7" x 2". Weight: under 4 lbs.

APT VP3801. Flexible membrane keyboard version designed for travel and hostile environments.
PC. If these manufacturers will support the Tandy 2000 in the same way, the new machine's owners and Tandy itself will benefit greatly.

Apart from the IBM PC, the second area of compatibility is with other Radio Shack computers. Quite probably, the new 2000 will find its way into offices that already have a Model III or 4. Unfortunately, although they share the same disk size, they cannot read each other's disks. It would, of course, be too much to expect that these two different machines would run each other's programs. But it might sometimes be useful to be able to transfer a text file from the Model 4 to the 2000. Until someone writes a routine, you'll have to resort to using a serial cable.

Currently, the only visible compatibility with Models III and 4 is that the default disk drive is the lower one.

**Conclusion**

The designers at Radio Shack have corrected many of the faults present in the IBM PC, and, in some respects, have completely surpassed it. Most importantly, they have accomplished this at a very reasonable price.

Anyone who does serious number crunching should consider the 200C (particularly if the 80187 chip appears). A significant amount of MS-DOS software will probably become available for this machine. But users who require a particular software package should first check if that software is compatible.

This new machine should be a very effective competitor for the IBM PC—it will allow Radio Shack to enter markets it has hitherto had difficulty penetrating. And, because of Radio Shack's formidable marketing, this strong product could spell trouble for some of the other MS-DOS machines on the market.

---

*Rich Mallov is BYTE's product-review editor.*

**In a future issue we hope to present a detailed System Review of this product that will include results of several benchmark programs and compatibility tests... R.M.
**PEACHTREE CORNER**

- PeachPak (GL, AP, AR) ........ $ 215
- General Ledger / Accounts Payable / Accounts Receivable / Sales Invoicing / Inventory Control / PeachPay Payroll .......... Each ........ $ 389
- PeachYear ................. 160
- PeachText / Random House Thesaurus .......... $ 195
- Spelling Proofreader .... 95
- PeachCalc ................. 90
- PeachFormat .............. 389
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- Spelling Proofreader .... 95
- PeachCalc ................. 90
- PeachFormat .............. 389
- Job Cost System ........... 389
- Client Posting & Accounting .......... $ 389
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  - Copy II PC ............... $ 34

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  - *PC Calculator* ........ $ 29
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  - Concurrent CP/M 86 ........ $ 225
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  - *Super Chartman II* ........ $ 299
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BYE March 1984 319

Circle 276 on inquiry card.
A Closer Look at the IBM PCjr

Comparing the PCjr to the PC and evaluating its performance and expandability

by G. Michael Vose and Richard S. Shuford

IBM finally starts shipping PCjrs to customers this month. As IBM dealers try to cope with an avalanche of initial orders, many questions remain about the machine’s design, its operation, and its future in the volatile microcomputer market.

BYTE recently took a closer look at the PCjr. Our examination focused on the new machine’s performance as compared to the IBM Personal Computer (PC); we also examined its expandability, compatibility with its big brother, and graphics capabilities. Our report reveals a few surprises (see the accompanying text box, "Benchmarking the PCjr," on page 324.)

The debut of IBM’s home computer on November 1, 1983, provoked a cool media reception and a simultaneous outpouring of enthusiastic praise from personal computer market researchers. The microcomputer man on the street was glad to see the cat-and-mouse game between the media and Big Blue come to an end, quelling the hysteria to be the first to get the story, which is a distinction few people recognize. Besides, it had become clear that nobody would get the story until IBM wanted it released.

The media’s reaction to the low-key presentation of the product, made at IBM’s Gallery of Art and Science in New York, was lukewarm in part because the scribes viewed the PCjr, based on Intel’s 8088 microprocessor, as being woefully short on state-of-the-art technology. What many of the press pundits failed to appreciate was that the PCjr, as the following pages demonstrate, is a product designed to do for the home market what the PC did for the business market—provide a solid, well-conceived, and well-designed machine backed by the world’s largest computer company.

The press also seemed predisposed to criticize the PCjr in order to vent
the frustration built up during the months before the announcement by Big Blue's careful manipulation of information-gatherers to keep everyone off the track.

The market-research crowd crowed about the new machine, seeing it as the proverbial goose of golden-egg fame. The industry-watchers' only questions were, "Why are there no shipments before Christmas?" and "When will all of Big Blue's competitors file for Chapter 11?"

In the midst of this post-announcement media blitz, BYTE visited IBM's public relations office in Delray Beach, Florida, to get to know the PCjr.

A Description of the PCjr

The PCjr, billed by IBM as "the company's most affordable personal computer," is a repackaged, slightly redesigned IBM PC. (See "IBM Announces the PCjr," by Rich Malloy, December 1983 BYTE, page 358.) It comes in two versions, one with 64K bytes of memory and one double-density, double-sided disk drive with a capacity of 360K bytes. Major options include a thermal printer, joysticks, and a plug-in modem card. Table 1 shows the software products created especially for the PCjr, and table 2 lists a variety of IBM PC packages and their compatibility with the PCjr.

The PCjr comes in three separate pieces: keyboard, system unit, and power transformer. The transformer connects to a rear-mounted jack on the system unit and to a standard 110-volt, 60-Hz electrical outlet. The transformer drives a 33-watt, three-voltage-level, two-stage power supply.

The motherboard contains an Intel 8088 microprocessor running at 4.77 MHz. A power-on self-test routine, cassette BASIC interpreter and operating system, I/O (input/output) drivers, and a disk bootstrap loader are provided by 64K bytes of ROM (read-only memory). RAM (random-access read/write memory) consists of eight dynamic 64K by 1-bit chips with a 150-nanosecond access time.

An expansion slot accepts a board providing an additional 64K bytes of RAM. The PCjr uses the Motorola MC6845 graphics display controller (see the section on graphics and display, page 326) and the Texas Instruments SN776486N three-voice sound chip (there is no internal speaker for this chip, but its output can be sent to an external speaker or to a TV speaker).

The machine includes a single serial port and interfaces for a joystick and a cassette recorder, along with dedicated expansion slots for an internal 300-bps modem and the disk controller. An optional parallel printer attachment connects to the right side of the system unit with four screws.

The only innovative technology employed in the PCjr is an infrared (IR) optical transmission link between the machine's keyboard and the system unit. (For additional information on IR technology, see "Use Infrared Communication for Remote Control," by Steve Ciarcia, April 1982 BYTE, page 40.) The IR link lets the keyboard be moved up to 20 feet from the system unit, as long as the keyboard remains in front of it. This optical-link technology is new to microcomputers but has been used for years in remote controllers for television sets.

IBM adopted this technology because it perceives that a home computer, used primarily in settings that do not include a desk, needs a keyboard unencumbered by an umbilical link to the rest of the machine. The company apparently feels that a home environment demands a more mobile keyboard and that the trade-off of an occasional lost character won't matter much in this application. A keyboard cord is available for people who don't feel comfortable with the infrared link and for applications, such as a classroom, where multiple PCjrs are in use. Connection of this cord disables the IR link.

The keyboard contains a CMOS (complementary metal-oxide semiconductor) version of the Intel 8048 microprocessor to handle the interpretation of keystrokes and serial encoding of keystroke data for transmission by two infrared-emitting diodes. The system unit contains an infrared receiver and circuitry to demodulate the 40-kHz carrier signal from the keyboard and send it on to the central processing unit.

The keyboard, when used without

<table>
<thead>
<tr>
<th>Software Product</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monster Math</td>
<td>$30</td>
</tr>
<tr>
<td>Animation Creation</td>
<td>$40</td>
</tr>
<tr>
<td>Mouser</td>
<td>$35</td>
</tr>
<tr>
<td>Scubaventure</td>
<td>$75</td>
</tr>
<tr>
<td>Crossfire</td>
<td>$35</td>
</tr>
<tr>
<td>Mine Shaft</td>
<td>$35</td>
</tr>
<tr>
<td>Bumble Games*</td>
<td>$40</td>
</tr>
<tr>
<td>Juggles' Butterfly*</td>
<td>$40</td>
</tr>
<tr>
<td>Bumble Plot*</td>
<td>$100</td>
</tr>
<tr>
<td>Personal Communications Manager</td>
<td>$75</td>
</tr>
<tr>
<td>IBM PCjr BASIC (cartridge)</td>
<td></td>
</tr>
<tr>
<td>Turtle Power</td>
<td>$50</td>
</tr>
<tr>
<td>Fixed Disk Organizer</td>
<td>$50</td>
</tr>
<tr>
<td>Adventures in Math</td>
<td>$35</td>
</tr>
<tr>
<td>DOS 2.x</td>
<td>$65</td>
</tr>
<tr>
<td>Home Budget, jr</td>
<td>$45</td>
</tr>
<tr>
<td>Casino Games 1.05</td>
<td>$35</td>
</tr>
<tr>
<td>Strategy Games 1.05</td>
<td>$30</td>
</tr>
<tr>
<td>Easywriter 1.15*</td>
<td>$175</td>
</tr>
<tr>
<td>pfs:FILE 1.05*</td>
<td>$140</td>
</tr>
<tr>
<td>pfs:REPORT 1.05*</td>
<td>$125</td>
</tr>
<tr>
<td>Time Manager 1.05*</td>
<td>$100</td>
</tr>
<tr>
<td>BASIC Program Development System 1.05</td>
<td>$130</td>
</tr>
</tbody>
</table>

*Prices will vary at authorized IBM Personal Computer dealers.

Table 1: Software packages for the PCjr.
<table>
<thead>
<tr>
<th>Program Name/Version</th>
<th>Operates on IBM PCjr</th>
<th>Requires DOS 2.10</th>
<th>Requires BASIC Cartridge</th>
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<tr>
<td>Adventure/1.00</td>
<td>yes</td>
<td>no</td>
<td>no</td>
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<td>Adventure in Serenia/1.00</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Adventures in Math/1.00</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Animation Creator/1.00</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>APL (A Programming Language)/1.00</td>
<td>no</td>
<td>n.a.</td>
<td>n.a.</td>
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<td>Arithmetic Games (Set 1)/1.00</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
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<tr>
<td>Arithmetic Games (Set 2)/1.00</td>
<td>yes</td>
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<td>yes</td>
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<td>Asynchronous Communications Support/2.00</td>
<td>no</td>
<td>n.a.</td>
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<td>BASIC Compiler/1.00</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>BASIC Primer/1.00</td>
<td>no</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>BASIC Programming Development System/1.05</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Binary Synchronous 3270 Emulation/1.00</td>
<td>no</td>
<td>n.a.</td>
<td>n.a.</td>
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<tr>
<td>BPI Accounting Software (all)</td>
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<td>n.a.</td>
<td>n.a.</td>
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<td>Bumble Games/1.00</td>
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<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Bumble Plot/1.00</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Casino Games/1.05</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
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<td>COBOL Compiler/1.00</td>
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<td>Decathlon/1.00</td>
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<td>Diskette Librarian/1.00</td>
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<td>yes</td>
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<tr>
<td>Dow Jones Reporter/1.00</td>
<td>yes</td>
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<td>yes</td>
</tr>
<tr>
<td>Easywriter/1.15</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Fact Track/1.00</td>
<td>no</td>
<td>n.a.</td>
<td>n.a.</td>
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<tr>
<td>Filecommand/1.00</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
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<tr>
<td>Fixed Disk Organizer/1.00</td>
<td>no</td>
<td>n.a.</td>
<td>n.a.</td>
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<tr>
<td>FORTRAN Compiler/1.00</td>
<td>no</td>
<td>n.a.</td>
<td>n.a.</td>
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<tr>
<td>Home Budget jr/1.00</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
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<td>Homeword/1.00</td>
<td>yes</td>
<td>yes</td>
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<td>Juggles' Butterfly/1.00</td>
<td>yes</td>
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<tr>
<td>Learning DOS 2.00/1.00</td>
<td>no</td>
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<tr>
<td>Learning To Program in BASIC/1.00</td>
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<td>Logo/1.00</td>
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<tr>
<td>Macro Assembler/1.00</td>
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<td>no</td>
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<tr>
<td>Mailing List Manager/1.00</td>
<td>no</td>
<td>n.a.</td>
<td>n.a.</td>
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<td>Monster Math/1.00</td>
<td>yes</td>
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<td>Multiplex/1.10</td>
<td>yes</td>
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<td>no</td>
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<td>Multiplication Tables/1.00</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
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<tr>
<td>One-Hundred-and-One</td>
<td>no</td>
<td>n.a.</td>
<td>n.a.</td>
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<td>Monochrome Mazes/1.00</td>
<td>n.a.</td>
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<td>Pascal Compiler/1.00</td>
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<td>Peachtext/1.00</td>
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<td>no</td>
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<tr>
<td>Peachtree Accounting Software (all)</td>
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<tr>
<td>pfs:REPORT/1.05</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
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<td>no</td>
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<td>Professional Editor/1.00</td>
<td>yes</td>
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<td>no</td>
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<td>SNA 3270 Emulation/RJE</td>
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<td>Support/1.00</td>
<td>no</td>
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<td>Strategy Games/1.05</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
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<td>3101 Emulation/1.00</td>
<td>no</td>
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<td>Time Manager/1.05</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
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<tr>
<td>Turtle Power/1.00</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Typing Tutor/1.00</td>
<td>no</td>
<td>n.a.</td>
<td>n.a.</td>
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<td>UCSD p-System (all products)</td>
<td>no</td>
<td>n.a.</td>
<td>n.a.</td>
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<td>Visicalc/1.20</td>
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<tr>
<td>Word Proof/1.00</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

Table 2: IBM PCjr software compatibility chart.
More micro software is written for Hayes than for any other modems!

Because Hayes, the telecomputing leader, continues to lead the way! With popular-selling modems that make telecomputing a breeze for beginners or professionals. And with sophisticated engineering that appeals to software developers.

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Circle 416 on inquiry card.
the optional cord, is powered by four AA batteries. The keyboard is in a perpetual standby state until a key is pressed. Only then do the 80C48 processor and the IR transmitter draw power. As soon as the character data has been transmitted, the keyboard reenters the standby, power-down mode.

The 62 unmarked, carbon-contact/rubber-dome keybuttons return scan codes rather than ASCII (American National Standard Code for Information Interchange) codes. (See “Compatibility” on page 328.) These keys will stymie the efforts of a touch-typist but will feel comfortable to children and novice computerists. We discovered a key-rollover problem when typing BASIC programs in. When three keys were pressed simultaneously, as is common with fast touch-typists, releasing the first two keys caused the machine to display the first and third characters; the second letter was lost.

The IR transmission link is susceptible to interference from very bright light, including sunlight, and high-voltage sources, including some television sets. The system unit issues loud beeps when there is interference affecting the unit; during our tests of the PCjr in IBM's office building in Delray Beach, these beeps were frequent enough to be annoying.

The absence of markings on the keybuttons requires a keyboard overlay for key labeling. The standard, attached overlay is color-coded and attractive but forces you to tilt the keyboard slightly forward to see the legends. An alternative would be to hunch forward to look down on the keyboard from a position above and perpendicular to it. Virtually everything about the keyboard, from the square, rubber-topped keybuttons to the overlay, and even the IR link, guarantees a vigorous after-market in keyboard replacements for the PCjr.

The System Software

The base model of the PCjr comes with cassette BASIC in ROM. An enhanced version of BASIC, called Cartridge BASIC, is available for $75. This version of BASIC is comparable to the familiar IBM Advanced BASIC (BASICA), with some additional enhancements for graphics and sound and support for light pens and joystick. The Cartridge BASIC is required to obtain disk BASIC file I/O functions.

PCjrs equipped with a disk drive use the $65 IBM PC-DOS 2.1 operating system, an upgrade of the earlier PC-DOS series. (BYTE will assess the modifications to this operating sys-

### Listing 1: A benchmark program by Richard Willis

```basic
10 '       ********
20 ' WRITE-TO-SCREEN
30 ' (FIXED # OF DIGITS)
40 '       ********
50 WIDTH 80
60 SCREEN 0
70 DEFINT I,J
80 J=12345
90 TO-TIMER
100 FOR I=1 TO 1000
110 PRINT J
120 NEXT I
130 T1=TIMER
140 TDIF=T1-T0
150 LPRINT USING "###.### SECONDS";TDIF
160 RETURN
170 ' BENCHMARK ROUTINE
180
190 ' WRITE-TO-SCREEN
200 ' (VARIABLE # OF DIGITS)
210
220 ' BENCHMARK ROUTINE
230
240 ' BENCHMARK ROUTINE
250
260 ' BENCHMARK ROUTINE
270
280 ' BENCHMARK ROUTINE
290
300 ' BENCHMARK ROUTINE
310
320 ' BENCHMARK ROUTINE
330
340 ' BENCHMARK ROUTINE
350
360 ' SCREEN 1 GRAPHICS
370
380 CLS
390 SCREEN 1
400 DEFINT I,J
410 TO-TIMER
420 FOR I=0 TO 319
430 LINE (0,I)-1639,199-I) ,I MOD 2
440 NEXT I
450 NEXT I
460 TDIF=T1-TO
470 RETURN
480 ' BENCHMARK ROUTINE
490 TDIF=T1-T0
500 LPRINT USING "###.### SECONDS";TDIF
510 RETURN
520 ' BENCHMARK ROUTINE
530
540 ' SCREEN 2 GRAPHICS
550
560 CLS
570 SCREEN 2
580 DEFINT 1,J
590 TO-TIMER
600 FOR I=0 TO 639
610 LINE (I,0)-(339,199-I),I MOD 2
620 NEXT I
630 NEXT I
640 TDIF=T1-TO
650 RETURN
660 ' BENCHMARK ROUTINE
670 TDIF=T1-T0
680 LPRINT USING "###.### SECONDS";TDIF
690 RETURN
700 ' BENCHMARK ROUTINE
```

### The Results

The PCjr executes BASIC programs from 24 percent to 32 percent slower than the PC. Because the BASIC interpreter in the two machines is fundamentally the same, this speed degradation is due to the screen update lag created by the PCjr's use of RAM for video buffering. Using main memory rather than a separate 16K bytes of RAM on the monochrome or color adapter display boards, as is the case with the PC, places the microprocessor in a wait state as often as two out of every three clock cycles while the screen updates. (See the section on graphics and display in the main text, page 326.)

The disk read/write operations in BASIC, not involving any significant

### Benchmarking the PCjr

To evaluate the PCjr's performance, we ran a set of standard BYTE benchmark programs. These benchmarks were developed over the past two years and were used to evaluate the IBM PC (see "A Closer Look at the IBM PC," by Gregg Williams, January 1982 BYTE, page 36), the Victor 9000 (see "Victor Victorious: The Victor 9000 Computer," by Phil Lemmons, November 1982 BYTE, page 216) and numerous other popular microcomputers. The PCjr we benchmarked contained the full 128K bytes of RAM and the color display adapter. The monitor used was the IBM Color Monitor. The test machine was "fully loaded" with optional peripherals.

Listing 1 shows BASIC benchmark programs developed by Richard Willis; the results are summarized in table c on the next page. The listings for the benchmarks summarized in table c can be found in the articles cited above. The Visicalc and Wordstar benchmarks consisted of: (1) a recalculation of a small spreadsheet containing two columns of numbers, six digits in one, seven in the other; (2) reading a large text file into memory, moving a page forward and back, and rewriting the file after making an editing change.

The three tables (a, b, and c) on the next page summarize the results of these benchmarks.
(a)

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>IBM PC Time</th>
<th>PCjr Time</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>empty loop</td>
<td>6.43</td>
<td>8.51</td>
<td>1.32</td>
</tr>
<tr>
<td>division</td>
<td>23.8</td>
<td>30.2</td>
<td>1.27</td>
</tr>
<tr>
<td>subroutine</td>
<td>12.4</td>
<td>16.0</td>
<td>1.30</td>
</tr>
<tr>
<td>MDS search</td>
<td>23.0</td>
<td>29.6</td>
<td>1.29</td>
</tr>
<tr>
<td>sieve</td>
<td>190.0</td>
<td>236.0</td>
<td>1.24</td>
</tr>
<tr>
<td>disk (read)</td>
<td>31.9</td>
<td>28.7*</td>
<td>1.24</td>
</tr>
<tr>
<td>disk (write)</td>
<td>28.5</td>
<td>296.0</td>
<td>1.23</td>
</tr>
</tbody>
</table>

Benchmarks for the PCjr against the PC and an 8-bit microcomputer: a 4-MHz Z80 running MBASIC 4.51. The ratio compares PCjr and PC performance. All times (in seconds) and ratios are valid to three significant digits.

(b)

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>IBM PC Time</th>
<th>PCjr Time</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visicalc</td>
<td>1.59</td>
<td>3.68</td>
<td>2.31</td>
</tr>
<tr>
<td>Wordstar 3.24</td>
<td>3.24 (read)</td>
<td>11.9</td>
<td>3.82</td>
</tr>
<tr>
<td></td>
<td>(write)</td>
<td>30.2</td>
<td>9.63</td>
</tr>
<tr>
<td>page forward</td>
<td>2.18</td>
<td>4.42</td>
<td>2.04</td>
</tr>
<tr>
<td>page back</td>
<td>2.24</td>
<td>4.46</td>
<td>2.04</td>
</tr>
</tbody>
</table>

Benchmarks comparing execution times for a Visicalc spreadsheet recalculation, Wordstar read/write operations, and page forward/back maneuvers in Wordstar using double-spaced text.

(c)

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>IBM PC Time</th>
<th>PCjr Time</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>write screen (fixed)</td>
<td>50.2</td>
<td>41.8</td>
<td>1.20</td>
</tr>
<tr>
<td>write screen (variable)</td>
<td>48.9</td>
<td>37.8</td>
<td>1.29</td>
</tr>
<tr>
<td>medium-resolution graphics</td>
<td>23.7</td>
<td>31.8</td>
<td>1.34</td>
</tr>
<tr>
<td>high-resolution graphics</td>
<td>54.5</td>
<td>73.7</td>
<td>1.35</td>
</tr>
<tr>
<td>bubble sort</td>
<td>25.0</td>
<td>32.4</td>
<td>1.29</td>
</tr>
<tr>
<td>text manipulation</td>
<td>32.7</td>
<td>40.3</td>
<td>1.23</td>
</tr>
</tbody>
</table>

Benchmarks of a variety of tasks, as shown in listing 1.

operations. The PCjr's performance in the absence of DMA is a testament to the efficiency of the disk routines in PC-DOS 2.1 and the hardware design of the slim-line drives.

This operating system is designed for the entire IBM PC family of computers (referred to at the fall COMDEX technical presentations as consisting of the PC, PC XT, and PCjr only). PC-DOS 2.1 consumes 24,688 bytes of memory, compared to 24,576 for version 2.0. Although the PC and the PC XT will run PC-DOS version 2.1 as well as versions 1.0, 1.1, and 2.0, the PCjr requires version 2.1. This requirement derives from new disk-interface routines dictated by the disk-drive hardware used in the PCjr. PC-DOS versions other than 2.1 may boot and run in the PCjr, according to IBM
The PCjr uses a 40-column display as a default because it is designed to be used with television sets, but the display format can be altered to display 80 columns with the DOS (disk operating system) command MODE 80.

The big difference from the PC's video architecture is that part of the main system memory must be used to contain the video-display data, thus the 8088 processor must share memory space and memory-access time. At least 16K bytes of memory must always be reserved for the display buffer, though only 2K bytes are used for a 40-column alphanumeric display, and the two high-bandwidth graphics modes require a 32K-byte buffer.

The designers of the PCjr did provide a measure of compatibility in display addressing; in early reports on the PCjr, this point was sometimes lost. In the big PC, the color/grayscale display buffer, although separate from the main memory, is mapped into the 8088 processor's address space beginning at location hexadecimal B8000. The PCjr contains special address-mapping circuitry that traps memory references made by the 8088 to addresses in that region and redirects them into the low-range addresses of main memory where the PCjr's display data is kept, using a processor page register as an index. Consequently, some programs that bypass the operating-system display routines will run unmodified on the PCjr.

Because the main memory is shared, the processor and video-display circuitry must access it at different times. The 8088 can read or write memory during only one of every three memory clock cycles. Display refreshing takes place during the other two cycles. In the unexpanded PCjr, the first refresh cycle fetches a byte that contains the ASCII value of the character to be displayed via an 8-bit data path; the second refresh cycle fetches the display attribute of the character. But when the 64K-byte Memory and Display Expansion board is plugged into the PCjr, the memory addressing is reconfigured so that even-addressed bytes reside on the motherboard and odd bytes on the expansion card. During both refresh cycles, 16 bits of character and attribute data are fetched via a 16-bit data path, doubling the bandwidth of the display. The denser graphics modes and the 80-column alphanumeric mode require the greater bandwidth. In either case, the 8088 can get to memory every third memory cycle, or approximately every 1.1 microseconds.

All of this gives rise to a limitation of the PCjr: the unexpanded 64K-byte system cannot use several of the video modes; in fact, text display is restricted to 40 columns in the minimal unit.

The PCjr does not contain any circuitry to emulate the functions of the PC's monochrome display adapter, so the IBM Monochrome Display cannot be used with the PCjr. The IBM Color Display with its RGBI (red, green, blue, intensity) inputs works fine, but at $680 it's rather expensive for use with a computer that has a base price of $669. A radio-frequency modulator for using the

<table>
<thead>
<tr>
<th>Mode</th>
<th>Number of Colors</th>
<th>Compatible with Color/Graphics Adapter</th>
<th>Requires 64k-byte Memory and Display Expansion Board</th>
<th>Buffer Size (Bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-column alphanumeric</td>
<td>16</td>
<td>yes</td>
<td>no</td>
<td>2k</td>
</tr>
<tr>
<td>80-column alphanumeric</td>
<td>16</td>
<td>yes</td>
<td>yes</td>
<td>32k</td>
</tr>
<tr>
<td>640 by 200</td>
<td>2</td>
<td>yes</td>
<td>no</td>
<td>16k</td>
</tr>
<tr>
<td>320 by 200</td>
<td>4</td>
<td>no</td>
<td>yes</td>
<td>4k</td>
</tr>
</tbody>
</table>

Table 3: PCjr video modes.
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computer with a TV is built in, but the cable to connect it costs $30. (And you wouldn't want to try viewing 80-column text on a TV.) You can also use a composite-video monitor. Like most of the PCjr's connections to external equipment, the cables plug into Berg-type pin connectors.

Compatibility

One of IBM's design goals for the PCjr was a certain amount of compatibility with its bigger siblings, the PC and the PC XT. As we have seen with the redirection of video-display addresses, the engineers took some effort to achieve this. Yet the PCjr is not 100-percent compatible with the other PCs. The contents of the ROM are certainly different, and there are certain hardware differences.

The incompatibilities between the members of the IBM PC family can be isolated into three categories: timing dependencies, unequal configurations, and actual hardware differences. Sources of incompatibility include the PCjr's smaller amount of memory, the lack of DMA (direct memory access) data transfers in the PCjr, different hardware addresses for the disk controller, and out-of-sync timing from the slower execution speed.

Even if there are no known sources of incompatibility, you can't be sure that a given program will run unless you try it. While visiting in Delray Beach, we tried to run a few pieces of IBM PC software we happened to have on hand.

Word processing proved to be a trove of success. Three popular programs—Sorcim's Superwriter (version 1.01), Mark of the Unicorn's Finalword (version 1.1), and Micropro's Wordstar (version 3.24)—seemed to run fine, although we didn't have time to exhaustively test every function. (We didn't have a copy of version 3.3 of Wordstar with us, so we don't know if the new program's direct screen accesses are compatible or not.) Jim Button's popular Freeware data-storage program, PCFile (version 8.6), also ran just fine, even though it had been compiled from BASIC under PC-DOS 1.1. But our string of successes ended when we tried Orion Software's J-Bird arcade game. Somehow the graphics display was hopelessly scrambled.

As IBM's technical staff emphasized during a seminar at COMDEX, the safest route for software compatibility is through use of the disk operating system. If relied upon for all services, the latest version of PC-DOS, 2.1, can shield application programs from the hardware differences. It remains to be seen if IBM's DOS software will provide support for all the functions that programmers need to write state-of-the-art code—support like that provided by Microsoft's Windows environment.

The PCjr keyboard is a good example of how the DOS shields programs from hardware differences. The keyboard has only 62 keys, as opposed to the 83 keys on the keyboards of the bigger machines, and the 62-key unit sends a different set of scan codes to the computer. But the DOS BIOS (basic input/output system) contains a routine to translate the scan codes to the same ones.

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<th>Ultra diskettes</th>
<th>3M diskettes</th>
<th>Memorex diskettes</th>
<th>Burroughs diskettes</th>
<th>Dysan diskettes</th>
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<td>$1.94 each</td>
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<td>80S-530110 Compact 3 1/2 in. 120 track</td>
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<td>$1.39 each</td>
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<td>$1.94 each</td>
<td>$2.09 each</td>
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<td>80S-530120 Compact 3 1/2 in. 720 track</td>
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<td>80S-530210 Compact 3 1/2 in. 4.5 track</td>
<td>$1.29 each</td>
<td>$1.39 each</td>
<td>$1.94 each</td>
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<td>$1.94 each</td>
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<tr>
<td>80S-530220 Compact 3 1/2 in. 2.25 track</td>
<td>$1.29 each</td>
<td>$1.39 each</td>
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<td>80S-530230 Compact 3 1/2 in. 1.125 track</td>
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<td>80S-530240 Compact 3 1/2 in. 0.5625 track</td>
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<td>$1.94 each</td>
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<td>$1.39 each</td>
<td>$1.94 each</td>
<td>$1.94 each</td>
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<td>$1.94 each</td>
<td>$1.94 each</td>
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<td>$1.94 each</td>
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</tr>
</tbody>
</table>

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used by the 83-key setup. In this way, you can emulate any keystroke combination from the big PC on the PCjr's keyboard. (You can even emulate the Num Lock key, which produces a less-than-useful working condition on a keyboard without a numeric keypad, as one of us found by accident during our examination of the PCjr.)

**Expandability**

IBM states publicly that there are no architectural limits to memory or disk-storage expansion of the PCjr. The IBM PCjr Technical Reference Manual confirms that a 512K-byte block of 8088 address space is reserved for future user RAM (see figure 1).

Additional electrical power will be needed, however, for any expansion of RAM or disk storage. No room exists within the system-unit chassis for memory above 128K bytes, nor for another disk drive; therefore, expansion requires the use of the 60-pin I/O expansion bus. The power available at the connector for the expansion bus is limited to 400 mA of +5V DC. Because disk drives require +12V DC, no power is available at the connector for floppy expansion unless an additional power supply is provided. Similarly, 400 mA of +5V DC could marginally power 64K bytes of additional RAM, but expansion beyond this limit also requires additional power.

It seems likely that significant expansion will dictate a separate box containing power supply, additional RAM up to a maximum of 512K bytes, and one or more floppy drives and/or a hard disk. Because the electronics and housing for this kind of expansion unit could cost from $800 to $2500, expanding the PCjr is costly.

Expanding the basic PCjr unit with IBM peripherals could drive the cost to $2,073 for a system with 128K-byte RAM, disk drive, keyboard cord, thermal printer, joysticks, and carrying case. Other than cassette BASIC, there is no software bundled with the machine.

**Conclusions**

One surprise beneficiary of limitations in the PCjr's design will be the older generation of microcomputer-software vendors. Their products, largely derived from programs written for 8-bit computers, naturally work at their full capabilities in a relatively small memory space and with few system resources. It's the newer software houses—especially the ones whose products are "integrated" and therefore memory-hungry—that will gnash their teeth trying to figure out how to sell programs to owners of PCjrs.

Their molars may get relief, however, if the memory cavity enjoyed by the ROM cartridges can be filled. As much as 192K bytes of ROM could be addressed (with some ingenuity), enough perhaps to accommodate slimmed-down versions of some of the larger IBM PC packages. There are two other advantages to putting application programs in ROM: they execute faster (read-only memory needs no delays for refreshing), and the single floppy-disk drive is freed from program-loading duties; it can be dedicated to holding the application's data files. But it will take time for ROM-cartridge versions of popular programs to be produced.

The PCjr may turn out to be "the hobbyist's IBM." Unstymied by features left out of the design and attracted by the low (for IBM) cost, hobbyists and experimenters could soon be happily running a "poor man's clone" with wire-wrapped accessories hanging off on every side: an interface for a better keyboard, outboard memory expansion, and a DMA-based controller for a second floppy-disk drive connected by clip-leads to a Navy-surplus power sup-

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### Memory Map

**Figure 1:** The IBM PCjr memory map.
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home computer, you can be sure that IBM will try to sell it to schools and colleges, where students will be more tolerant than business users of the keyboard and the limited memory and storage. IBM is making the Logo language available for the PCjr, a strong hint of its desire to sell to the education market. Furthermore, IBM's dialect of BASIC is superior to that available on the Apple II and Commodore computers used by many schools (although the Extended BASIC for the TRS-80 Color Computer is almost as good).

The PCjr will be costly to expand for additional memory or disk storage. The new, low-cost bubble memory or EEPROM (electrically erasable programmable ROM) chips might be an alternative to a second disk drive.

The PCjr performs well compared with low-cost machines like the Commodore VIC-20 and 64, but it is slower than the PC. It cannot be compared in cost with most of the competing home computers.

The software and hardware aftermarkets for the PCjr will be vigorous.

Vendors have already announced keyboard replacements, and several are planning to make memory-expansion boards to compete with the IBM board, which sells for $140.

There is still some question as to the magazine address space of the PCjr. Several publications have already been announced, and one, PCjr, published by Ziff-Davis, will have prepared three issues before customers begin receiving machines. Should the PCjr fail to attract a market, a lot of folks will be crushed by the resulting fall.

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The Japan Shows
An Update on the Japanese Computing Scene

NEC introduces an impressive 16-bit computer, and Canon previews a remarkable, inexpensive laser printer

by Richard Willis

Business applications of microcomputers were the overriding emphasis at the 1983 Japan Data Show, held in Tokyo October 18-21, 1983. Individual personal computers took a back seat as computer makers put forward a wide range of networking and office-automation systems promising to transform the Japanese workplace into a futuristic information-intensive environment. But the home computer was also given its due. After a long, exhilarating day interfacing with the office workstation, tomorrow's Japanese workers will apparently look forward to spending the evening in front of their own ultra-high fidelity, satellite downlink videotex banking and home-management terminals and laser-disk-driven arcades. At least that's the scene painted by some of the same manufacturers at the Japan Electronics Show, held the week before in Osaka. You have to wonder whether, at some point, people will start to overdose on all this technoculture.

Restraint is clearly not the operative term for describing the Japanese love affair with the latest electronic gadgetry—nor for describing the means by which such innovations are promoted. The Data Show and Electronics Show are cases in point. Big Japanese trade shows like these are an organized assault on all the bodily senses, at least an order of magnitude more intense than one experiences at NCC or COMDEX. Multimedia theaters at many of the larger firms' booths extol the exhibitor's technical wizardry, often with only minimal reference to specific products. Legions of young women sporting brightly colored blazers and overamplified microphones keep the halls brimming with decibels. Most of all, there are the crowds, a continuous human crush in the aisles and the booths that can only be compared to rush hour on the subway (see photo 1). A week-long NCC or COMDEX show in the U.S. may draw 100,000 to 150,000 visitors. The Japan Data Show, four days long on about the same amount of real estate, attracts close to 400,000.

Fewer Machines, Better Systems

The shows clearly revealed some new and significant movements within the Japanese microcomputer industry. Microcomputers are beginning to have a real impact on the Japanese workplace. Because even the simplest of business applications requires the computer to deal with kanji characters, microcomputers did not really begin to penetrate the business world until the introduction of 16-bit microprocessors. Even when the 16-bit machines first appeared, they left a lot to be desired in terms of software support, for their makers lacked the three or four years of hard-won business-market experience that benefited Western systems designers. Now, however, at least a few Japanese manufacturers seem to have realized the necessity of providing total systems packages, including a full range of applications software, for each new machine they introduce. And all the makers are working hard to improve their support of existing models by enhancing both hardware and software.

Almost every major firm at the Data Show was touting its new data-networking capabilities. But most of these systems were large-scale proprietary networks, specifically tailored to the needs and conditions in the Japanese office or factory and in many cases tied to one or more of the company's mainframe computers. There did not appear to be any standardized, compact network system emerging that might eventually have an impact on the American office-automation market.

And while software is receiving tremendous, much-needed emphasis in Japan, there is little or no consensus among computer makers as to which operating system (OS) to adopt. Microsoft got a jump on the market
by developing a Japanese-language version of MS-DOS, currently the most widely used OS among garden-variety 16-bit machines. But some manufacturers had already started to develop their own proprietary operating systems for their high-end hardware. Others are abandoning standard operating systems in favor of building custom OS modules into each individual task-environment program, claiming that this strategy can improve performance substantially. Some machines provide a combination of stand-alone program modules (usually for word-processing and similar text-intensive tasks) and OS-dependent programs. And while some manufacturers have stuck with MS-DOS, others are moving to CP/M-86. There is considerable behind-the-scenes interest in Unix, but very few of the major manufacturers have introduced Unix packages for their machines, and its acceptance will probably remain in doubt until the next generation of processors arrives.

The effect of this fractious environment is, not surprisingly, to discourage independent software development, the force that has driven the American microcomputer industry ahead so vigorously. Most third-party software development is carried out under contract with a single large manufacturer for a specific machine. There are very few Japanese-written standard software packages (such as Visicalc or Wordstar), and it's doubtful that a healthy, inventive, independent software industry will emerge in Japan any time soon.

Recent BYTE reports from the Japanese computer shows (“New Japanese Microcomputers,” April 1983, page 110, and “Update on Personal Computing in Japan,” September 1983, page 250) have given fairly detailed summaries of the models produced by each of the major Japanese manufacturers, and most of these product lines have undergone incremental upgrading rather than total overhaul. Relatively few of the machines exhibited this year were new introductions. I will focus on those new systems that demonstrate significant technical advances or that typify major trends in the Japanese market, especially those that may soon affect us in the U.S.

**Good News for Mouse Fans**

Published surveys give Nippon Electric Corporation (NEC) over a third of the personal and desktop computer market in Japan, and the company shows no sign of
slacking off. In what was perhaps the most significant system introduction of the show, NEC unveiled its new PC-100, an 8086-based personal computer (see photo 2). This reasonably compact system is built around a very high-resolution display, a mouse, and a bundled software package. The 8086 processor runs at 7 MHz, and there is provision for an optional 8087 numeric coprocessor. The standard memory complement is 128K bytes of RAM (random-access read/write memory) expandable to 640K bytes, plus video RAM of 128K bytes for monochrome display or 512K bytes for color. The unit can be configured with one or two built-in 320K-byte 5¼-inch floppy-disk drives.

The video RAM is organized as a 1024 by 1024 bit map, of either one plane for monochrome or four planes for color. The 14-inch CRT (cathode-ray tube) display units offered with the system, both the monochrome (soft white) and the color, will display any 720- by 512-pixel window of the bit map, with smooth scrolling that can be controlled by either the mouse or a keystroke command. The color unit can display 16 colors from a palette of 512.

The real kicker is that the display can be turned vertically or horizontally to suit the application. In this characteristic, the system is similar to the Corvus Concept ("What a Concept," May 1983 BYTE, page 134). The user has a choice of four different kana or alphanumeric character formats (up to 64 lines of 120 characters) and two kanji character formats when the display is set horizontally, and three kana and one kanji format when the display is in its vertical orientation. A new type of display controller is used in this system; instead of employing its μPD7220 controller chip, NEC has designed an analog-output controller circuit, which may indicate that NEC plans to integrate the system with other video media in the future. Both the color and monochrome displays produce beautifully crisp visuals. All in all, the PC-100 sets a new high standard for personal computer graphics capability.

The two-button mouse that comes with the PC-100 is identical to the Microsoft mouse; Alps Electric, a major Japanese maker of electromechanical devices, developed it under contract from Microsoft and now sells or licenses it to NEC. The mouse's tail (cord) plugs handily into the right edge of the detached keyboard unit. The keyboard itself is extremely simple in layout, with the Japanese Industrial Standard (JIS) kana pattern and 10-key pad, five numbered function keys, and a bare minimum of special-purpose keys, all in a lightweight, low-profile enclosure.

The most revolutionary aspect of the PC-100 is that it is one of the first Japanese computers to come complete with a well-chosen package of software. The key element of the package is a Japanese-language word-processing program called JS-Word that employs a screen-icon-and-mouse control structure similar to the Apple Lisa or the new Microsoft Windows system. Up to eight overlapping windows, each carrying its own appropriate icons, can be opened on the screen at one time. Japanese textual material may be entered either in kana or in Roman-character equivalent form and then converted to kanji. Jean Yates, writing in a recent issue of The Yates Perspective (a newsletter covering software trends, with an emphasis on Unix) after a hands-on demo of JS-Word, describes it as one of the best word-processing programs she has seen, surpassing even Microsoft's Word (a fascinating irony because JS-Word was developed by ASCII-Microsoft, Microsoft's Japanese partner/subsidiary).

Also provided in the package are a Japanese-language version of Multiplan, a BASIC interpreter (whose program files, incidentally, can be edited by JS-Word), and some utilities, including software support for the standard RS-232C interface. The operating system is a Japanese-language version of MS-DOS dubbed version 2.01.

NEC clearly has designed a winner in the PC-100, a machine with a nearly perfect mix of capabilities at an impressive price: $2200 (in Japan) for a two-disk monochrome system with monitor, $3200 for color. A full kanji-capable, 18-magnet dot-matrix printer plus interface is available for another $1100. While the system does not have the total integration of different task environments offered by systems like the Lisa (you must load the various function programs separately and pass data via disk files), it goes a long way toward providing simple, accessible computing power and will undoubtedly appeal to many Japanese business and personal users. The question is whether this machine will be imported into the U.S.; the NEC spokesperson I talked to was noncommittal on this point. However, last May an NEC executive said that the PC-9801 (NEC's other new high-end computer) would not be exported but, rather, that NEC was developing a new machine with high-resolution graphics for introduction in America. So there is a very high probability that we will see the PC-100 here. It is also a good bet that it will feature a software package composed of Microsoft's Tools running under that company's Windows operating environment. If and when the PC-100 does show up in the U.S., it will certainly pose some stiff competition for Epson's QX-10 Valdors system and perhaps also for Apple's mouse-and-icon-based Macintosh system.

The introduction of the PC-100 gives NEC a third 16-bit personal computer; the other two are the N5200 (sold in the U.S. as the APC; see October 1983 BYTE, page 280) and the PC-9801. Each of these machines now will be steered toward specific segments of the Japanese microcomputer market.

Daring Sordplay

While almost all Japanese companies are intensely competitive and ambitious, this year's prize for Most Audacious Agenda by a Start-Up Company must go to Sord Computer. Founded by a small group of very young engineers and programmers in the early seventies, Sord has been gaining steadily on its giant competitors in the microcomputer industry and now holds about 7 percent of the overall market (about 13 percent if the focus is narrowed to

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business microcomputers). One might expect a small company such as this to adopt a relatively cautious product strategy, choosing to address only a few markets that offered the best chance of success. Sord, however, has never shown the least sign of faint-heartedness as it charged ahead, achieving (according to a recent study) the highest five-year sales-growth rate of any company in Japan. Sord's current line of microcomputer products, together with several new products to be introduced in the coming months, will put the company into virtually every microcomputer category, from video-game-oriented home computers, to portables, to business machines, to mainframe-challenging supermicrocomputers. All in all, Sord seems to be in an excellent position to continue its so-far spectacular growth.

Indicative of Sord's capabilities is its latest high-end machine, the M68, one of the first Japanese desktop computers to be built around the Motorola MC68000 16/32-bit microprocessor (see photo 3). The M68 runs its 68000 at 10 MHz and comes standard with 256K bytes of parity-checked RAM, expandable to 1 megabyte. It also includes an auxiliary Z80A on line with 128K bytes of additional video RAM. The Z80 can function as an I/O and display controller for the 16-bit system or it can be used to run existing 8-bit software under CP/M-80. It is augmented by an Am9511 (Advanced Micro Devices) arithmetic processor that performs 16- and 32-bit fixed-point and 32-bit floating-point arithmetic operations.

The M68's monochrome and color displays have a resolution of 640 by 400 pixels; 16 displayable colors can be chosen from a palette of almost 5000. This is excellent resolution for any sort of business graphics but a little coarse for CAD (computer-aided design) work, one of the more obvious applications for a system with such computing power. Sord is planning to offer a higher-resolution display with the M68 at some future date.

The M68 comes standard with a pair of 1.2-megabyte 5¼-inch floppy-disk drives and two RS-232C ports, one Centronics and one IEEE-488 interface port. A hard-disk controller is built in, but the drives (either a 7.5-megabyte 5-inch or a 20-megabyte 8-inch) must be added externally. A pair of expansion slots can be fitted with specialized interface modules, including a network-communication controller, analog- or digital-signal interfaces, and a module that interfaces the M68 to an S-100 expansion chassis.

Sord is now exporting the M68 system to the U.S. at a very attractive price: a 256K-byte system with dual floppy-disk drives and a monochrome monitor lists for $4890. But the real bargain will arrive in the spring of '84, when Sord starts shipping M68s with Fujitsu 256K-bit dynamic RAMs installed. The base system will then have 1 megabyte of main memory and will sell for $5690 with a monochrome monitor or $5990 with color. Additional 1-mega-byte memory modules—up to a total of 4 megabytes—can be added for $2390 each.

In the matter of software for the M68, Sord seems to have expansive plans, especially at the OS level. The company literature lists six operating systems that can be run, including CP/M-86, RDOs, the UCSD p-System, and a version of CP/M-80. With an optional 8088 module installed, the machine will run MS-DOS. And Sord is planning to release a Unix system for the M68 sometime in 1984.

At the same time that Sord is trying to be all things to all programmers, it is also continuing to promote its own proprietary software philosophy, as embodied in the package called PIPS (Pan-Information Processing System). PIPS is the pride and joy of Sord and probably is the best-known standard software package of Japanese origin. As Sord products start arriving in the U.S., PIPS will no doubt follow, heavily promoted.

The PIPS framework, designed by a banker, reflects a banker's way of looking at data (mainly numbers) in that all data in the system is thought to be organized in tables. At the heart of PIPS is a database manager; information is entered into the system in the same manner as to any relational database, though it is not clear whether the internal data structures of PIPS are true relational records or classical data tables. Once the database is established, it can be operated upon in various ways. The best analogy I can invoke here is that of a tool chest. The PIPS tool chest has several drawers, each containing a certain category of tools—Sorting and Searching, Arithmetic, Graphing, and so on. In general, only one drawer of the tool chest can be open at a time, but when you change drawers, you don't have to pick up all the data, put it away, and then pull it out again; the data of the table you're working on is always actively at hand. You call up the specific tools,
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or operations, to act upon the tabulated data by typing short mnemonic commands, as in Wordstar. Once you start a given process, the system will automatically request any additional parameters needed to define the operation. Unlike spreadsheet programs such as Visicalc, which are organized by cells, PIPS is column-oriented, so when you perform any operation that creates new data from existing data, you create a new column in the table. After the table has been stretched and scrambled and otherwise massaged to produce the desired results, various output formats, both tabular and graphic, can be specified for reporting the data. “Programs” in PIPS thus consist of sequences of table-manipulation commands.

First released in 1980, PIPS was the first real integrated package of software tools for microprocessors. In 1980, Software Arts (now Visicorp) was just starting to work on the file protocols that would allow Visicalc data to be passed to other Visitools, and Lotus's 1-2-3 was just science fiction. On the other hand, many aspects of PIPS—such as its confinement to columnar data structures—look rather primitive nowadays. However, the most sophisticated structures aren't always the most useful, and many people who work with financial data find the PIPS format intuitive and powerful. At any rate, Sord is constantly upgrading the package, so PIPS may someday attract some interest over here.

**Mr. T Meets the Computer**

Another of the major contenders in the Japanese microcomputer arena is Fujitsu, one of Japan's high-tech powerhouses, and the country's largest computer maker. Unlike many other firms now selling computers, Fujitsu did not start out making TVs, rice cookers, or cameras. Fujitsu's focus always has been on the industrial applications of electronics. Personal computers are Fujitsu's first venture over the rocky shoals of consumer marketing, but the company is apparently determined that it will not be out-hyped by anyone.

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Data Show exemplifies the trend toward building better systems around existing hardware. None of the microcomputers shown by Fujitsu this time were new (although some of the microprocessor-based workstations for the company's larger office computers were). The main attractions here were Fujitsu's proprietary fiber-optic "data highway," which tied a number of different machines on the floor into a large-scale mainframe at a company facility 10 miles away; a digital voice mail system capable of storing spoken messages and delivering them to integrated phone/data terminals; and a multichannel mobile data-communications system designed to support portable data terminals installed in automobiles (for salesmen, law-enforcement officers, and irrepressible hackers).

As far as personal computers were concerned, Fujitsu was standing firm on a fairly strong product line, the popular FM-7 8-bit and FM-11 16-bit machines. Also prominently featured was a 16-bit personal workstation computer, the 9450-II, which is now about a year old. This machine is the Ferrari of Fujitsu's personal computer line, but unlike the NEC PC-9801, with which it directly competes, I didn't see any huge stacks of 9450s bulging from the doorways of shops in Akihabara, Japan's mammoth retail electronic district. It seems that Fujitsu is conducting a more focused marketing program for the 9450, aiming to establish its credentials as a business machine rather than a mass-market toy.

Far from a toy, the 9450 employs a pair of MN1613s, a proprietary Fujitsu 16-bit microprocessor. The standard RAM complement is 256K bytes to 384K bytes. The unit can be configured with two 1-megabyte floppy disks, either 5¼-inch or 8-inch, or one floppy disk and one 10-megabyte hard disk. Display resolution is 640 by 480 pixels in both color and monochrome. The color display produced by this machine is as sharp and brilliant as any I have seen. Even though its kanji font is only 16 by 15 pixels, the characters are highly readable. An optional 8086 board is planned, although, surprisingly, the company says it intends to support CP/M-86 rather than MS-DOS.

The 9450 runs a proprietary multitasking operating system called APCS-III and offers an integrated package of business software—word processing, spreadsheet, graphics, and accounting—called the EPOC series.

One other Fujitsu product deserves special mention here, both for its technological achievement and its cultural overtones: the MyOASYS-2 personal word-processing system (see photo 4). This compact unit, about the size of the Otrona Attaché portable, has some rather powerful features for its size and price. For about $2200 you get a complete word-processing system, including a built-in video screen capable of displaying 14 lines of 40 kana or kanji characters or up to 80 alphanumeric characters, a 5¼-inch disk drive, and a printer, either thermal-transfer or wire-dot-matrix. Both the display and printer use a 16- by 16-pixel representation for kanji characters, with over 7200 character fonts stored in ROM. The system can perform semiautomatic kana-to-kanji conversion at the word level, with reference to a dictionary of about 40,000 words standard, plus up to 10,000 user-chosen readings. Additional disk-based software enables the MyOASYS-2 to perform simple graphics and calculations as well.

Every bit as interesting as the machine itself is the way in which the MyOASYS-2 is being promoted in Japan. Fujitsu has chosen Takamiyama, past winner of the Emperor's Cup (the grand championship of sumo wrestling) and one of Japan's best-known sports personalities, as the media representative for its MyOASYS series of word processors. You see Takamiyama's clowning visage plastered everywhere in Japan—in subway cars, on train platforms, and in full-size cardboard mannequins in front of computer

Photo 4: Sumo wrestler Takamiyama demonstrates the portability of the Fujitsu MyOASYS-2 word processor. If asked, he could probably demonstrate the portability of a Subaru.
stores—but the sight of this 6-foot 3-inch 440-pound mountain of a man prancing (yes, prancing) across the TV screen, word processor in hand and three leotard-clad nymphets in tow, can only be compared to a certain scene from Fantasia!

**See Sharp or Be Flat**

If Fujitsu has worked its way down the scale from mainframes to microcomputers, Sharp has climbed upward, from pocket calculators. Sharp is number two in total PC sales in Japan but holds a much smaller share of the business computer market (about 6 percent), and the company is clearly aiming to improve that situation with its latest round of product introductions. Most significant of these is the OA-8100 (see photo 5), the only other 68000-based office computer besides the Sord M68 (and the OEM version of the M68 sold by Fuji-Xerox). What's more, Sharp has taken the plunge and is offering Unix System III with the 8100, even though a full kanji version of this operating system has yet to be developed. (This does not mean that applications packages running under Unix cannot use kanji, only that the system commands must be entered in English, if you can call “chmod,” “mkdir,” and “nroff” English.)

The 8100 comes in three configurations, numbered 8130, 8140, and 8150, the main difference being the disk complement. Memory capacity is 512K bytes to 4 megabytes. Various combinations of floppy- and hard-disk drives (10, 20, 40, 74, and 135 megabytes) can be ordered. The display has exceptionally high resolution—1152 by 750 pixels in monochrome and 768 by 550 pixels in color, with 16 colors displayable on the latter. The data sheet lists support for RS-232C and Ethernet interfaces, plus a circuit-switching/packet-switching communications controller.

The most popular of Sharp's serious personal computers, the cleverly packaged PC-5000, is now being sold in the U.S. This integrated unit, with a proprietary CMOS (complementary metal-oxide semiconductor) 8088-type microprocessor, 128K bytes of RAM, and an 80-character by 8-line LCD (liquid-crystal display) is priced at $1995, with an optional built-in thermal-transfer printer for an additional $395 and external dual floppy-disk drives for $995. This portable has several interesting systems features: its MS-DOS operating system is contained in one of three 64K-byte CMOS ROMs, the others being a system ROM and a BASIC interpreter ROM; in Japan, an additional kanji ROM module is added. The unit can accept 128K-byte nonvolatile magnetic bubble-memory cartridges. And dot-addressable graphics can be performed within its 640- by 80-pixel LCD. Weighing this machine's features—choice of microprocessor, memory capacity, display size, quality of keyboard, integrated printer, standard operating system, battery power—against its competition, the PC-5000 stacks up as one of the best values in the portable market.

In its new assault on the business market, Sharp has not abandoned the home-entertainment scene. The company is continuing to push the integration of the home computer with other electronic entertainment media. At this year's Electronics Show, Sharp added to its line the C1, a video game and graphics system...
Photo 6: Matsushita ("National" in Japan, "Panasonic" in the U.S.) showed its new portable voice-recognition module, the JH-600. The unit can be used by itself to recall short memos related to spoken inputs or can be connected to other systems as a controller or data-entry device.

completely integrated into the cabinet of either a 14-inch or a 19-inch color TV. This system has nowhere near the capabilities of the Sharp X1 introduced last year ("New Japanese Computers," April 1983 BYTE, page 118) but seems instead to be intended for families with very young children. While the X1 can display 25 lines of 80 characters on its high-resolution color monitor, the Cl’s screen is organized (in the two interactive program modes) as 20 lines of 28 “blocks” each.

The Cl does not include a keyboard; instead, all interaction with the system is accomplished through a small controller box on a cord. This box has four cursor-control buttons, a Select button for stepping through a menu, a Start button, a Cursor Mode button to choose shape, color, or position modes, and a Pickup button. The Pickup button is the key element in the Cl’s elegantly simple human-interface scheme. In character mode, you simply move the cursor down into a chart of available characters (alphabetic, kana, and just a few kanji for days of the week), position the cursor over the desired character, and press the Pickup button. Then when you move the cursor, it carries a copy of that character to anywhere in the array of blocks you wish to deposit it. In graphics mode, the pickup process is the same, except that the character chart is replaced by a palette of about 60 different shapes and five colors that can be used to create a display as any six-year-old is likely to conceive (see photo 5b).

While this human-interface system will never make the keyboard obsolete, it is certainly an excellent entry method for very young children. If Sharp were to implement a turtle-graphics capability into the system as well, it could be an unbeatable product. The Cl does have sufficient underlying graphic resolution for such an application because it also supports a number of video games in the form of cartridges that are plugged into the front of the console; a second controller box can be added for competitive games, and a game sound synthesizer is built into the system. Once a memo or graphic has been created, it can be saved to any audiocassette recorder. Unlike the X1, the Cl does not allow computer-generated graphics to be superimposed on regular television images. The 19-inch version of the Cl sells for about $640 in Japan.

Its Master’s Voice

Like many American companies, the Japanese are experimenting with voice-entry systems. One or two firms at the show were demonstrating voice-recognition modules for their workstations. But the most remarkable voice-entry product I saw was a little portable machine from Matsushita (which uses the brand name National in Japan and Panasonic in the U.S.), the JH-600 Voice Recognition Computer (see photo 6). This unit is very similar in appearance to the company’s JR-800 portable, except that the latter’s 8-line by 36-character LCD has been replaced with a single-line 20-character display and a loudspeaker. Voice pickup is via external microphone. The JH-600 is capable of recognizing as many as 62 different phrases up to 1.2 seconds in length, from either of two human speakers. Recognition is accomplished by pattern matching (using Walsh and Hadamard transforms) with phrases stored in the unit’s memory. The total length of all stored phrases cannot exceed 42 seconds. To program the voice-recognition function, you first select a memo number, 1 to 62, and then type in a short memo that will be associated with the corresponding spoken input. For example, you can store the spoken names of several people but put their phone numbers in the corresponding memo. After each memo is entered, you switch to voice-entry mode, press a button identifying yourself as either speaker A or B, and speak the desired word or phrase into the microphone. A light flashes to show that the entry has been accepted, and you then proceed to the next memo/phrase entry. Once all the desired phrases have been stored, you can
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In addition to displaying a memo for each phrase recognized, the JH-600 will transmit the memo number over three interfaces: an RS-232C port, a special interface for the company’s JR-800 portable, and a 6-bit parallel control output. Thus the unit could be used to enter a predefined set of commands or other information into a larger personal computer. One application suggested by the manufacturer is the vocal entry of BASIC phrases; the 62 possible commands, a handful of names, and numbers 0 through 9. Just put the program editor in autonumber mode and start talking.

The JH-600 can function as a multi-step programmable calculator and report its numerical results in synthesized (Japanese) speech. It can also act as a straight RS-232C terminal.

The unit employs a complex VLSI (very-large-scale integration) speech processor integrated circuit, and, at the time of the shows, Matsushita was still adjusting its process line to mass-produce the chips. Volume production of the JH-600 was due to start in early 1984, but no decision has been made on whether the unit will be exported to the U.S.

Matsushita was also displaying its new MSX-standard computer, the CF-2000. MSX is a combination hardware/software standard developed by Microsoft that theoretically allows home computers developed by various manufacturers to use each other’s software. On the hardware side, MSX specifies a Z80 processor and a TI 9918 video controller and also defines other details such as I/O ports, joystick interfaces, etc. The standard software for MSX machines is a form of Microsoft BASIC. MSX has been accepted (in some instances grudgingly) by 18 companies at last report, including most of the major manufacturers of Japanese home computers.

The CF-2000 comes with 16K bytes of program RAM and another 16K bytes of video RAM. Up to two additional 16K-byte RAM modules can be plugged into the two cartridge slots, which also accept 48K-byte ROM cartridges containing such game hits as Boogie Woogie Jungle. The unit will generate a video display of 24 lines of either 32 or 40 characters; the character set includes alphanumeric, kana, 19 simple kanji, and some graphic symbols. The CF-2000 sells for about $230 in Japan.

**It’s a Sony**

Sony introduced a couple of new home computers this time around, establishing a new HITBIT product line (HITBIT being an English play on the Japanese word hitobito, or “people”). One was an MSX-standard home computer, the HB-55, which will list for $230. This unit looked very similar to the Matsushita CF-2000—in fact, there were a half-dozen or more of these “cookie
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Circle 418 on inquiry card.
is copiers. Although Canon plans to sell only the mechanism (8b), a prototype of a complete printer was on display at the Data Show.

Photo 8: Canon's new low-cost laser printer is shown in 8a. The unit has many similarities to the company's line of personal cartridge copiers. Although Canon plans to sell only the mechanism (8b), a prototype of a complete printer was on display at the Data Show.

cutter" home computers at the shows; with little to recommend one over another. That's the down side of standards.

Sony's other release was much more interesting—a $650 home computer called the SMC-777 (see photo 7) with one of Sony's 3½-inch, 280K-byte microfloppy drives built in. This Z80-based machine comes with 64K bytes of program RAM and 38K bytes of video RAM and will generate a full 25-line by 80-character display on an RGB (red-green-blue) monitor or 25 lines of 40 characters on a TV (with external modulator). Graphics resolution is 640 by 200 pixels, 4-color, or 320 by 200 pixels, 16-color. Character and graphic displays can be superimposed. Also included is a TI 76489 sound-generator chip. Optional plug-in boards can be added to create a 4096-color palette, to provide kanji display capability, or to interface with the company's SMC-70 desktop computer. A second 3½-inch drive can be added externally. The SMC-777 does not conform to MSX, since that standard makes no provision for disks. A Sony spokesman in this country said the company had not decided whether to bring the SMC-777 to the U.S. For one thing, Sony isn't sure which of its marketing divisions should handle it.

International Marketing Agreements

While Apple did not have a booth in Tokyo, it was announced shortly before the show that the company had signed a nonexclusive distributor agreement with Canon Sales Ltd. under which Canon would take on the promotion and sales of Apple products in Japan. This should help Apple's position considerably; at last count, it had less than 1 percent of the Japanese market.

A number of marketing agreements are working in the other direction. For example, Mitsubishi has an extensive line of personal and office computers in Japan, hardly any of which are ever seen in the U.S. But the company is now producing an IBM-compatible PC clone that is being sold here by Sperry (under the Sperry trademark) and also by Leading Edge Products.

Canon's Peripheral Vision

Far and away the most significant development in peripherals was Canon's new laser-printer mechanism, a device that could make high-end daisy-wheel printers obsolete. Canon has combined the cartridge copy system of its PC-10/PC-20 line of personal copiers with a laser-diode writing system to come up with the world's smallest, and least expensive, laser printer (see photo 8).

While the company says it has no current plans to sell complete printers directly to consumers, its OEM (original equipment manufacturer) prices for the print mechanism are remarkable—about $2000 for sample quantities, dropping to near $1000 in production quantities. For this price, the unit (called the LBP-CS) includes the entire printing system up to a serial video interface. From there, the end-product manufacturer would add font generation logic, timing and control electronics, and whichever form of data interface is desired.

This means that a straightforward office printer using the Canon mechanism could be brought to market in the $2500 to $3000 price range, landing squarely in the territory now occupied by high-speed daisy-wheel and dense-pattern dot-matrix printers. And the Canon system has the potential to far outperform these competing technologies. Its print speed is eight letter-size pages per minute, which for a character printer would correspond to more than 500 characters per second. The unit can generate images with a resolution of up to 300 dots per inch, about twice that of the best multipass dot-matrix printers. This will allow many different high-quality fonts to be produced, including, of course, kanji characters. And with appropriate interface electronics, all manner of graphic images can be created as well. Like the company's PC-10 and PC-20, the entire copy process—photosensitive drum, toner, etc.—is contained in a replaceable cartridge that's good for a few thousand copies. However, the cartridge used by the LBP-CS is different from that used by the copiers. For one thing, the drum has the opposite optical "polarity," i.e., it picks up toner in those areas that have been exposed by the laser radiation rather than where the dark printing of an original has been imaged.

All told, the Canon printer is a significant advance in hard-copy technology, especially in view of the fact that existing laser printers whose print specifications are not much better still cost 5 to 15 times as much. While the Canon is not designed for the sort of high-volume applications now being handled by laser printers, such as cranking out 10,000 invoices every day, it is perfectly suited for the small- to medium-size office environ-
Images from the new color printers shown in Tokyo. The resource map in 9a is from Sharp's scanned-head ink-jet printer. The baboon head (9b) was created by a sequential thermal-transfer printer driven by a video-frame-capture device.

A number of other developments in print technology were on display at the Data Show, most involving ink-jet and thermal-transfer printing. Both methods are now able to produce remarkably vivid full-color images. Two such images are shown in photo 9.

**Storage Trends**

The Japanese seem to be paying remarkably little attention to hard-disk storage, certainly nothing like the venture frenzy now being witnessed in this country. A couple of the majors were starting to show expanded-capacity 5¼-inch Winchester disks—up to 40 megabytes—but with business use of microcomputers just now picking up, it seems that most Japanese customers have yet to discover that they need more on-line storage than they can get with 8-inch floppy disks. Floppy-disk drives are moving forward, however, with the new preoccupation being thinness. Single drives are now available from a couple of manufacturers in a 28.5-mm (1.12-inch) height, and dual drives sharing the same motor are only 40 mm (1.57 inches) high. This would allow you to put eight floppy disks in an IBM PC if it had the power to run them.

Richard Willis (POB 6, Goleta, CA 93116) heads a small consulting firm specializing in electronic systems for production test and control applications. He received his master's degree in electrical engineering from Caltech in 1973 and has been studying Japanese at the University of California, Santa Barbara. He is a member of the Computer and Automated Systems Association of the Society of Manufacturing Engineers.
The User Goes to COMDEX,
1983

by Jerry Pournelle

I think it stands for COMputer Dealers EXposition. There's more than one COMDEX now, but the fall meeting, just after Thanksgiving in Las Vegas, is always the biggest, and traditionally it's where the most important new technologies are announced.

Fair warning. This year more than 80,000 attended to see something like 1500 exhibits (see photo 1). Clearly, I didn't look at them all. If I'd spent five minutes at each exhibit, it would have taken me two weeks to cover a five-day show. Thus, I can report only what I saw, and although I tried to find the most significant exhibits, I may have missed something important.

Second warning. Unlike my columns, in which I report on very little that I haven't tested myself, in show reports I talk about stuff I've seen but not tried. I presume what I saw will work when you get it home, but I can't guarantee it.

The Big Hits

Picking the "best of show" out of a zoo like COMDEX isn't easy; but I've singled out three items worth special attention. Each will be discussed in detail. They are Xerox Americare service, Ovation's wonderful new software, and Helix Labs' PC Bubble Disk.

Getting There Isn't Half the Fun

COMDEX is no place for users. It's too crowded. It's also nearly impossible to get there. My son Alex and I went up on Sunday, the day before the show officially opened. Weeks before, Rick Foss, our crack travel agent, had gotten our tickets. It didn't matter. The PSA flight was oversold. We were squeezed aboard the plane as the last two let on.

Two days before COMDEX we received an Eagle Spirit XL, which is a portable version of the IBM PC XT,

Photo 1: The user's panoramic view of COMDEX.
1500 booths, 80,000 attendees, and, surprisingly, some nifty stuff

complete with a 10-megabyte hard disk. Eagle rushed the Spirit—we’ve named it Denny Colt—so we could take it to COMDEX.

I was also carrying Adeline, my Otrona. It’s not that we didn’t trust the Spirit, but I’d never traveled with it before, and I’d really hate being without a machine for a week. If Alex hadn’t been with me I’d not have carried both; but it seemed the intelligent thing to do as we left the house.

Hah. It didn’t seem so smart when we got on the airplane. Every seat was filled. So was every overhead rack. It turns out that the Apple people couldn’t get flights from Silicon Valley to Las Vegas, so they went by way of Burbank—and they had lots of equipment. We gulped hard and prepared to stuff the machines under the seats and ride with our knees up to our chins; but that was not to be.

“That won’t fit,” one harried flight attendant said. “We had one just like it a few minutes ago, and it won’t fit.”

Now I’d have been much surprised if she’d ever seen an Eagle Spirit before, but there was no point in telling her. She’d made up her mind. We would have to check those computers.

By this time I’d lost most of my composure and a good part of my gruntle as well. My disposition wasn’t helped by a mental picture of Adeline and Denny Colt tumbling down a baggage conveyor belt. I explained to the crew that tossing computers about wasn’t a particularly desirable thing and sadly watched as they took both machines out . . .

It all came out well. Ms. Carol Franklin, the chief flight attendant, arranged to have a station agent meet the plane and hand-carry our machines. When we reached the hotel both worked flawlessly.

Incidentally, the Spirit will fit under both aisle and center seats, as we found when we returned from Las Vegas. You won’t be very comfortable if you’ve legs as long as mine, but it can be done. It will also fit in overhead storage, provided the airplane has overhead racks; the one we returned on didn’t.

A Maturing Industry

Sunday evening we registered and cruised through the exhibition hall to establish some landmarks. Monday morning was a press breakfast.

The big announcement was that a full year of Xerox Americare service will now be bundled with each Compupro business system sold. Xerox’s Joe Cleary, Americare’s honcho, had a few words about parts and service; Xerox has stockpiled a lot of spare parts for the machines it services. Those include Osborne computers, incidentally. Americare is completely separate from Xerox Computer. It doesn’t sell anything but service.

You can buy different packages of services, with options for Americare to come to you, or vice versa, and so forth. The contracts aren’t particularly cheap, but you wouldn’t expect them to be. The important thing is that you can get service for a wide range of
The new and disdained keyboard arrangement from DEC.

machines. (I wish I could list them, but my notes seem to be indecipherable. I'm usually not coherent in the early hours.)

At first thought Xerox Americare didn't seem like big news, but on reflection I think that in its quiet way this was the most important announcement of the show because it's a sign that the mini industry is mature enough to attract not just hobbyists and micro nuts, but small businesses. The availability of skilled outside service means we don't have to stay exclusively with the big companies. It also means the micro customer base is expanding, which means that prices will continue to fall.

It's good news for us all.

PC Compatible

The Las Vegas Convention Center is enormous. In addition, exhibits were also housed in the Sahara and Riviera Hotels, miles from the Convention Center. Not only were all the exhibition halls filled; a dozen smaller halls were also used. Every one of them, as well as the wider corridors, was filled with exhibits.

Half the exhibits were IBM PC look-alikes. I know, that's got to be an exaggeration; there aren't 750 computer companies in the world. Still, a lot of new computers were on display, and just about every one was billed as IBM PC compatible. "Look!" they exclaimed. "We look just like IBM, only we're not IBM. Isn't that amazing?"

I'm not so certain I'd want to be known as an imitator, but most of these companies want that very badly. We can call this "The Compatibility COMDEX." Even the beer and coffee were IBM PC compatible.

Of the PC work-alikes, the Eagle line remains my favorite, partly because I'm most familiar with them—I've both the Eagle 1600 and the Spirit XL—and partly because they go beyond "being just like" the IBM machines. The Eagles are faster and, in my judgment, better engineered.

Of the "just like IBM" machines, the one that most impressed me was the Panasonic. The company claims it's 100 percent compatible with the PC, and one of its salesmen told me he no longer carries software when he goes to demonstrate the Panasonic to dealers; he has them take PC software off their own shelves. He has, he says, yet to find PC software that won't run.

The Panasonic is portable, which is to say it has a handle and can be carried if you don't mind getting muscular biceps. It's very competitively priced and should be a real challenge to the Compaq and other "me-too" machines.

How Are the Mighty Fallen

Digital Equipment Corporation, aka DEC, had a large booth, but I didn't see many people at it. I don't know how many Rainbow computers DEC has sold, but I'd be very much surprised if the number approached Zenith's Z-100 sales.

DEC has come out with yet another lousy keyboard with a big key just to the left of the space bar that transmits a complex escape sequence, the > < key between the Z and the left Shift, bad keys to interfere with hitting Return, and other such insults to touch-typists (see photo 2). DEC claims this keyboard will be standard on all its new offerings, including the new VT-200 replacements for the VT-100 terminal.

DEC is primarily a minicomputer company, of course. Part of the mini tradition is to isolate your customers from anyone else. Use a proprietary operating system, make people run software written just for your machine and useless for any other machine; that way you keep your customers away from the competition.

DEC made it, what with disk formats that no one else can read or write to and its own operating system. True, the Rainbow can run both 8- and 16-bit software, which is a big plus, but on the other hand, little outside software is currently available. DEC wanted to keep its people from using software written for the IBM PC. It succeeded beyond its wildest dreams.

I didn't notice one single exhibit advertise itself as "DEC compatible."

For the Most Important Person in My Life....

Last year we saw laser printers that could also double as your office copier. I had thought they'd be available at reasonable prices by summer, but I never saw any. John Carr, our long-suffering editorial associate, was getting fed up with not having a copier, so we went out and bought one of those Canon machines that you see Jack Klugman advertising.

We love it. It has never failed to work. We never have to mess with
## SOFTWARE

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toner or other copier supplies because the Canon uses a cartridge system that's good for about 3000 copies. When it's used up, you put in a new one. The cartridges cost about $60 (that's about 2 cents a copy).

We got the model that has a paper-feed system. You can override that by inserting a sheet of paper, which means that you can make it print on both sides of the paper if you like.

We've been very pleased with it.

At COMDEX, Canon announced a laser printer built much like our Canon office copier. It uses the same paper-feed system, including the override feature, so you can hand-feed special paper (or print on both sides). It uses the same cartridge system. I couldn't tell whether the cartridges were identical to those in our copier. I'd be surprised if they were.

The model on display at COMDEX was really nice. It isn't any larger than our daisy-wheel printers, and it's much faster (about 12 pages a minute). The character set is very nice, and it's certainly a letter-quality printer. There's provision for full fonts: upper and lowercase, italics, small capitals, etc., as well as for special graphics, or for that matter, for downloading your own design. It doesn't have a tractor, but it does have a single-sheet feeder.

We've used our Canon office copier long enough to have considerable confidence in the cartridge system and sheet feeder being used.

I liked the Canon enough that I wanted one, but the company isn't selling them yet. All Canon would say is that you should be able to get one by the fall of 1984 and the end-user price will be less than $4000. Canon doesn't intend to sell direct to end users at all; it will sell the units and sheet feeder being used.

We're getting a Helix PC Bubble Disk board, so there'll be a full report.

Big Bubbles

There was a lot of new hardware, including machines based on the Intel iAPX186 chip; but what impressed me most was Helix Laboratories' Helix PC Bubble Disk for the IBM PC. (Helix also makes them for Apple II and Ile machines.)

The Helix PC Bubble Disk is a board containing half a megabyte of bubble memory. You drop it into the PC, and the machine thinks this is a fast hard disk. It has its own ROM (read-only memory) aboard to read in the programs required to access it.

Because it's bubble memory, it's nonvolatile. You could even use it to transfer programs from one machine to another. It also has a write-protect switch (accessible from the back of the PC cabinet) and power-failure protection circuitry. Helix wants $1500 for the 500K-byte board, but when Intel lowers the price of the bubble chips, it expects to cut that by a hundred dollars or so.
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in an upcoming column. Meanwhile, I saw it running at COMDEX, and this is my choice for the most exciting new hardware at the show.

Mass Storage

Last year I speculated that if the industry could get together on the size and format of disk drives of 3½ inches, these drives plus memory drives and cartridge hard-disk drives would take over, leaving little place in the market for conventional 8-inch and 5¼-inch floppy disks.

That doesn’t seem to be happening. Instead, even someone as conservative as I am now must admit that 5¼-inch technology is reliable and here to stay. That’s not optimum, because when they designed 5¼-inch disks they didn’t put in communication lines that let the machine know whether there’s a disk in the drive. With 8-inch disks there’s a hardware method of telling whether the drive is ready; thus, a “drive not ready” error can be compensated for. It’s much harder to recover from that kind of error in 5¼-inch disks because there’s no way for the machine to determine whether there’s a disk present until it actually tries to read it.

Even so, 5¼-inch drives are gaining on the vest-pocket drives. I think that’s a shame; the vest-pocket drives are, I think, more convenient, and certainly make for smaller and lighter machines. However, the industry’s failure to agree on a standard—at least three sizes and formats are out there, each with powerful advocates—has hurt the vest-pocket disk’s chances of taking over. Example: the Jonos, a really nice little portable, began with 3½-inch vest-pocket disks, but it can now be bought with 5¼-inch disks.

Meanwhile, few companies seem to have gone with the 5¼-inch removable hard-disk cartridges. These hold 5 megabytes and looked like a good deal last year, although my engineer friend Tony Pietsch was a bit concerned about some of the technical details. Whether it’s spindle wear or something else, I didn’t see any removable cartridge systems, although there may well have been some I overlooked. Certainly, they weren’t very much in evidence.

However, Rana did have on display its new 2.5-megabyte 5½-inch floppy-disk system. This is a special drive that uses a preformatted floppy disk. The formatted floppy disks will cost (initially) about $15 each. Compare that to $90 for a 5-megabyte hard-disk cartridge. Also, the Rana drive system will sell for less than removable hard disks. We’re getting an early copy of the Rana 2.5-megabyte drive; full report in an upcoming column. Meanwhile, this new development may well be the salvation of floppies for some time to come.

Carrying the Mail

Tony Pietsch contracted with Bill Godbout to furnish WRITE, the text editor Tony wrote more or less to my specifications, for the Compupro 10, a multiuser system better known in my columns by the code name Shirley. Shirley uses the MIP/M-8/16 operating system, which has some significantly different quirks from the CP/M 2.2 environment that WRITE was developed in. Tony ground up a new version of WRITE to run on Shirley, but he didn’t get finished until the absolute last minute.

He also hadn’t arranged for a hotel room. That turned out to be a mistake: nobody was accepting reservations in Las Vegas during COMDEX. Tony didn’t want to go up and sleep in the park, so he prevailed on me to carry a copy of WRITE for Shirley, which I duly did. Of course, there were a couple of system options and switches that had to be set right, and nobody knew how to do that, so it took a couple of phone calls to Pasadena to get WRITE going; but by Monday afternoon, I could see WRITE running on four different terminals, all powered by the same central machine.

Interestingly enough, running four at once didn’t slow things down at all; at least I didn’t notice anything, with one exception. When you write to the hard disk, you have to wait your turn; so if two users try to save text at the same time, one has to wait while the other gets done. Even with waiting it takes about as long to save on Shirley as it takes me to save onto floppies with my single-user system.

A Standing Ovation

Ovation Technologies has what may be the best microcomputer software I’ve ever seen.

I met Robert Kutnick, Ovation’s director of development, at the Tandy press breakfast. The Ovation software was running on one of the new Tandy 2000 machines. Alas, I was more concerned with talking with the Tandy design people—on that, see below—and thus never saw a demonstration of Ovation with that machine. However, Dr. Kutnick was kind enough to give me a ride from Caesar’s Palace, where the breakfast was, to the Convention Center, and during the ride he invited me to come see Ovation’s product.

I went more out of gratitude for the ride than anything else. I don’t usually watch software demonstrations; I prefer to get the stuff to Chaos Manor and bang on it myself. Worse, Ovation didn’t even have its software running in its exhibit booth; for marketing reasons I don’t need to understand, it was exhibiting the Real Thing only up in its suite in the Hilton.

It’s nearly impossible to get anywhere in the Hilton during COMDEX. There aren’t enough elevators, and there are too many people looking for free dinner and drinks at hospitality suites. However, the Ovation suite was on the same floor as the Xerox Americare party I was going to, so it wasn’t hard to stop by, which I did, and wow! am I glad.

Ovation has a combination text editor and spreadsheet that interact so that the overall effect is wonderful.

Let me describe. You write a letter. In the letter you put some numbers. Now you go through and put the cursor on each number. You can give that number a variable name. The name is known to the computer; the number in the letter stays the same. But now you can redefine that variable as, say, the sum of some other variables. When you do, kazango!, the number is changed in the letter.

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Suppose it was a pie graph and you decide to change to a bar graph. Nothing to it. Now, use the cursor to change one of the bars on the graph — and the number in the text instantly changes to match it!

There's more, but you get the idea. I don't recommend that people go out and buy software until I've had a chance to wring it out, examine the documents, test it at boundaries, and the like. On the other hand, Ovation isn't ready to sell the program this week anyway.

We're getting Ovation here Real Soon Now. I can hardly wait. It's potentially the most powerful micro software I've ever seen; and it's real easy to use. Too. Before you buy a spreadsheet or text editor for your IBM PC, do try to look at Ovation. You might like it.

Tandy Strikes Again

Tandy introduced its Model 2000 at a press breakfast in Caesar's Palace. After speeches by at least four different people, each of whom repeated what the last one had said, they literally unveiled the machines, which had previously been covered with a tablecloth.

It's nice-looking equipment. The Tandy 2000 — there's nowhere on it the words "Radio Shack" — apparently the company is a bit concerned about its image with the business community, as indeed it darned well ought to be — uses an Intel iAPX186 chip. The "one-eight-six," as it's known in the development community, is one of Intel's 8086 family. It will run any software developed for the 8086 and 8088 chips. It also has some unique instructions of its own, and it's a lot faster than the 8086 or 8088.

What this means is that any PC-DOS software that's hardware independent (not written specifically to
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make use of the IBM PC's graphics and such like) will run with the Tandy 2000. However, there may be problems with some copy-protected software.

The machine will be described in great detail in other BYTE articles, so I'll only mention my impressions. (See "The Tandy TRS-80 Model 2000" on page 306.)

First, we liked the color graphics (see photo 3). The machine seems fast, and it does a nice job with its extensive color capabilities. Alex will probably have more to say on that; he's the graphics freak in Chaos Manor.

Second, it looks like a good, well-made machine, with good all-around capability.

Incidentally, the Tandy 2000 is going with Microsoft operating systems, including Xenix. It's my impression that more companies are drawing away from Xenix, which is a Microsoft "sort of Unix," than are adopting it.

Zenith

Zorro, our Z-100, has become a workhorse here, so I was glad to see new Zenith products. The most impressive was a 25-inch RGB (red-green-blue) monitor. It was displaying Microsoft's new Windows program on a Z-100. Believe me, a 25-inch monitor is big (see photo 4). Zenith also announced an 8087 board for the Z-100. Jim Hudson, who developed the 8087 math board for our Compupro, also has an 8087 for the Z-100. The Zenith one is much simpler, only four chips; Hudson's board uses an S-100 slot and contains 256K bytes of memory. We're getting both boards, so I'll be able to report on them in a future column. Meanwhile, there's a growing list of software that makes use of the 8087. It's a worthwhile capability if you do any number crunching at all; the 8087 does floating-point arithmetic about a zillion times faster than the 8086. Meanwhile, the Hudson and Zenith boards have different niches, and I expect them to coexist.

Alex notes: "Zenith put a quieter fan on its new Z-100s. Even in the noise and haste of COMDEX it was noticeable." That makes me wonder if I can get one of the new fans and retrofit it; we like Zorro, but he is a bit noisy. Alex also notes that the new ROMs and BIOS (basic input/output system) for the Z-100 are much advanced over the versions we have, and it's time to update. Apparently Zenith has made update offers to people who bought its machines, but since Zorro still belongs to Zenith Data Systems we don't always get the notices, alas.

It wasn't at the Zenith booth, but we saw the Macrotech 1-megabyte memory board working in a Z-100. Macrotech's memory still has the lowest cost per kilobyte, as far as I can tell, anyway.

We continue to hear the rumor that Zenith will come out with a Z-100 with a detached keyboard, but there was no sign of one at the show. Maybe it is just a rumor after all.

MPI

Zenith also had the Printmate 150 printer in its booth. This is our favorite dot-matrix printer, for reasons I've given in the column. Having an outside printer in a Zenith booth is a first, since previously only Heath stores carried the Printmate.

MPI, "The Printer People," was displaying the Sprinter in its own booth. The Sprinter is a small portable printer. Like the Printmate 99, it can take tractor feed or single sheets of paper such as letterhead; and like the 150, it has the capability for up to 68K bytes of print buffering.

The Sprinter comes in a hard shell case and is designed to be rugged enough to go as checked luggage. John Matlock of MPI has taken his on three trips now and swears that the only signs of travel are some black marks on the case. I was supposed to receive a demonstration model of the Sprinter at COMDEX so I could test that myself, but Alex and I were so burdened with stuff that we just
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couldn't carry anything more. MPI is shipping one instead, and I'll carry it on my next few lecture tours. I continue to be impressed with MPI's printers.

The portability of the Sprinter generated some humorous advertising, including buttons that said “Handle me,” and “Pick me up,” and “I'll go with anybody,” which seemed a bit daring for a Salt Lake City firm . . .

Teletype

Teletype is back in micro land with a terminal. It's a bit expensive, about $1500, but it has a number of pages, lots of memory, and lots of features. It may well be worth it.

When I went into the Teletype exhibit area, I was approached by a young salesman.

"I want a five-level Baudot machine," I said wickedly.

He was completely nonplussed. Fortunately, a sales manager was nearby, who said, "In the Smithsonian, I imagine."

After all, in the early days of the micro revolution, old Teletype electromechanical bangers were often the only terminal equipment we could get, which is why one of the "devices" in CP/M is to this day the TTY: or Teletype. It's also why to this day some programs have the Delete key "echo" the deleted letter; if you're using the Teletype as a console, it has to be that way because a TTY can't backspace.

Alas, for all its early dominance, Teletype didn't understand what was happening and made no concessions to the micro revolution; and whereas most micro people owned some kind of Teletype device early on, it wasn't long before the micro community had left the company behind.

I don't really miss the sound of the old TTY banging away, and I'm sure glad I don't have to remember what five-level Baudot is; but I'm also glad to see Teletype coming back. It's like welcoming the return of an old friend.

The Mad Computer

The Mad machine was over in the Hilton exhibition hall; this was exceedingly hard to get to because the security people never let us in before show hours, and because the Hilton exhibit area is in a direct line between the Hilton lobby and the main Convention Center, it was always full of traffic. I very nearly didn't go in there at all.

Alex did get there, and persuaded me to go see the Mad computer. He votes the Mad "best-looking computer in the show," and says, "It has one well-kept secret: it has IBM slots in it. Another module can hold four more IBM PC cards. Because it uses the Intel iAPX186 chip, it can't use IBM memory boards (because the 186 is a true 16-bit device, and Big Blue stayed with an 8-bit bus). Most other
Alex also noted, “The gimmicks for Mad are impressively different: modularity and ergonomics. The basic computer has two modules: the computing module and the data module. The computing module has the processor, memory, two serial ports, one parallel port, video, and keyboard interface. The data modules contain either two half-high IBM-type floppies or one floppy and a 10-megabyte hard disk. Of course, you can buy the hard-disk module later and run both. Interestingly, the hard disk is powered by the main computer.

“The Mad’s screen has 720-by-350-dot resolution; add more RAMs, get more resolution. The keyboard (and the whole computer) conforms to European ergonomics standards, but it still looks good. It has a Selectric keyboard layout, without extra keys in the wrong places. If you’re looking for a machine that will look good in the office while working well, look at the Mad.”

I did note that Mad claims high compatibility with the IBM PC, while running much faster than the PC. It certainly is a handsome machine. Alex and I played about with one for a while, and it’s quite fast. Like the Eagle, it’s an improvement on the PC rather than just a copy.

**Mad claims high compatibility with the IBM PC, while running much faster; like the Eagle, it’s an improvement on the PC rather than just a copy.**

### Networks

A number of networking systems were on display; so many that Alex makes them (along with windows) one of the two themes of this year’s COMDEX.

Networking is a subject of sufficient complexity that I want to deal with it in the column rather than in a show report. For here, I’ll just report that there are a lot of ways to get computers to talk to each other, and no one standard method has emerged.

This was one of Bill Godbout’s laments at his press breakfast. Compu-pro has taken a firmly wishy-washy stand on networks by cutting holes and covers for a bewildering variety of plugs and jacks and sockets on the back of its machines. Godbout did cite some studies that indicate that perhaps the best network arrangement is nodal, with perhaps four machines connected together into a node, then one connection from that to similar nodes. The Compu-pro 10 is a four-user system, which isn’t a total coincidence.

Corvus, meanwhile, has taken a firm stand for Omninet. No wonder, since it’s its baby. Omninet has the advantage that the cable connecting systems is simple—just twisted pairs of wires—and the maximum distance between nodes can be about 2000 feet. This is almost as long as Ethernet, which uses coaxial cable and is 10 times as fast but more than twice as expensive. We have a Corvus system here, and we’re beginning to...
string twisted pairs of wire from the back room to my office, so we'll be able to report in detail later.

Meanwhile, there’s no agreement on what will be the network; but there’s wide agreement that networking is desirable.

**Bottom Line**

COMDEX is huge. If you don’t believe that, consider that I was a week in Las Vegas and didn’t manage to make one single wager. Now true, I’m hardly a gambling man, but I do like to buy about $50 worth of chips and shoot craps until it’s gone; but not this time. Between the breakfasts and the evening receptions and the dinner parties, I found COMDEX all work and very little play.

It’s a strenuous show, and I don’t recommend that readers go to it; but it’s a must for anyone trying to keep up with this bewildering world of microcomputers.

Onward and upward. I love it.

Jerry Pournelle welcomes readers’ comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, do BYTE Publications, P.O. Box 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.

Jerry Pournelle is a former aerospace engineer and current science-fiction writer who loves to play with computers.

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Pascal's Design Flaws
Modula-2 Solutions and Pascal Patches

A description of seven subtle problems with Pascal, and a look at how Modula-2 avoids them

by Mark C. Johnson and Allen Munro, Behavioral Technology Laboratories

Niklaus Wirth was only warming to the task of creating the perfect programming language when he developed Pascal. If you regularly program in Pascal you probably have pet peeves about its "bugs" or "gaps"—the design flaws of the language that you encounter again and again. Pascal, like other languages originally designed to teach computer programming, has several serious deficiencies. Wirth's newest structured language, Modula-2, remedies some of Pascal's flaws and also provides mechanisms to enforce modular program design more strictly than does Pascal.

The most important components of Modula-2 are not its ability to "fix" Pascal's structure, but rather the features associated with the concept of the module. Modules provide for secure independent development of different portions of a program in a way that Pascal constructs do not. Even those Pascal implementations that provide separately compiled units such as the UCSD (University of California at San Diego) p-System do not provide for truly modular development.

Our focus here, however, is not Modula-2's underlying design concepts. Instead, we want to examine some of the flaws of Pascal, to see how Modula-2 solves them, and also to show how working Pascal programmers get around these flaws. In addition, our analysis should help you form some opinions on the value of the Modula-2 compensations for some of Pascal's design flaws.

Pascal's Seven Deadly Sins

We will examine seven separate problems with Pascal with different degrees of detail. Many of the solutions may be familiar to you, but you may find a useful Pascal trick or two that you haven't encountered elsewhere. While some of the problems are straightforward, others are more subtle and may call for more than one solution, each appropriate in a different programming context. For each language-design flaw, we present first the nature of the problem, then the approach taken in Modula-2, and finally one or more Pascal method for getting around the difficulty.

Short-Circuited Boolean Expression Evaluation

For processing a Boolean expression (e.g., in an IF statement), the Pascal-language definition does not permit what we call short-circuited evaluation—cessation of the evaluation when the expression is false. In fact, in most implementations, evaluation of a Boolean expression proceeds inexorably from left to right until the end of the expression. This can be inefficient, because the result of a Boolean expression can often be determined without a complete evaluation. Encountering a false part on one side of an AND expression means the result will be false, regardless of the complexity of the other side. For example, consider:

```
IF FALSE AND
  (A=B) OR (B=C) OR (C=D) AND
  (ARCTAN(X*Z) / 99.0= 22.0)
THEN DO_SOMETHING;
```

Clearly, the procedure DO_SOMETHING will never be invoked because of the false on the left side of the AND. In Pascal, the right side will be evaluated anyway, which is inefficient.

In the same manner, a true condition on one side of an OR expression
forces an expression to be true, regardless of the other side. In the statement below, DO_SOMETHING will always be called:

\[
\text{IF TRUE OR (A=B) OR (B=C) OR (C=D) AND (X*2/ 99.0 = 22)}
\]

THEN DO_SOMETHING;

In addition to being inefficient, full Boolean evaluation causes problems when part of the expression is undefined. For example, suppose you wish to see if someone struck the Escape key. You might use the following code:

\[
\text{READLN(STRING);} \quad \text{(STRING is declared STRING)}
\]

\[
\text{IF STRING[1]=CHR(27) \quad \text{(Escape is ASCII 27)}}
\]

THEN WRITE('Escape was detected!');

This works fine, unless the user hits Return without entering anything. In such a case, the variable STRING has a length of zero and that causes a value-range error for the IF statement. In Modula-2, this problem is easily avoided with the following test for the length of the string:

\[
\text{IF (LENGTH(STRING)< >0) AND (STRING[1]=CHR(27)) THEN WRITESTRING('Escape was detected!');}
\]

If the first part of the IF expression, LENGTH(STRING)< >0, is found to be false, then the evaluation is short-circuited, and the second conjunct is never evaluated. This prevents a reference to STRING[1] that produces an error.

If you attempt such an approach in UCSD Pascal, you will discover, to your dismay, that the compiler generates code that blindly evaluates the entire expression. Here, the second conjunct is the IF expression of the IF statement embedded in the IF statement of the first conjunct. A match for either IF expression results in WHATEVER, but the second IF expression is evaluated only if the first is false.

To get the same results provided by the short-circuited evaluation of expressions in Modula-2, you have to put forth more effort in Pascal and the end result is not as readable.

### Machine-level Access

One of the goals of high-level languages is to avoid machine-dependent code. Machine-independent programs are both more portable and more reliable than machine-dependent programs. Of course, in the real world you often find yourself forced to access actual machine addresses, or call subroutines contained in ROM (read-only memory) at some machine address. Since machine independence is a fundamental principle of Pascal, the language has no explicit way to access machine addresses, as BASIC does with PEEK and POKE.

In Modula-2, the standard data-type ADDRESS is provided to enable access to particular locations in memory. ADDRESS is defined as a pointer to a word, so it is machine-dependent—word size is, after all, a machine-dependent quality. Suppose that a variable SOMEADDR is defined as an address and assigned a particular address value. An operation like PEEK can be performed simply by looking at the value of the word pointed to by SOMEADDR:

\[
\text{SOMEWORD := SOMEADDR \_;}\]

To perform the equivalent of a POKE statement, you simply assign an address to a variable of the ADDRESS type and then assign a word to the location pointed to by the address:

\[
\text{SOMEADDR := 28990;} \quad \text{SOMEADDR \_ := SOMEWORD;}
\]

The ADDRESS data type permits the assignment of cardinal values—those between zero and MaxCardinal—directly to its variables.
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Listing 1: Calling a machine-language program in ROM from an assembly-language procedure designed to be linked to Pascal as an EXTERNAL procedure.

(Pascal program which calls a routine at C005 Hexidecimal)

PROGRAM trycall;

PROCEDURE CALL(LOCATION: INTEGER); EXTERNAL;

BEGIN
   CALL(-15104); {-15104=C500Hex address of ROM in slot 5}
END.

Below is the external assembly procedure which calls a routine at the address passed to it.

```assembly
.MACRO POP ;Stores 1 word off stack
   PLA
   STA %1
   PLA
   STA %1+1
.ENDM

.MACRO PUSH ;Loads 1 word onto stack
   LDA %1+1
   PHA
   LDA %1
   PHA
.ENDM

.PROC CALL,1 {procedure call(addr: integer)
   CALLADDR .EQU 0 ; must be page zero address
   POP RETURN ; save return to PASCAL
   POP CALLADDR ; save ADDRESS to be JSR
   JSR #CALLADDR ; jump saving return (call) to address in
                  ; CALLADDR
   ;do any other special stuff here
   ;that may be needed before return to
   ;pascal, if this is not a general-purpose "caller".
   PUSH RETURN ; Push return address to Pascal
   RTS
.RETURN .WORD ; Temporary area for return address
.END
```

Modula-2 implementations may optionally provide a facility to specify a fixed address for a variable when it is declared. This feature has the following form:

```pascal
VAR KEYBOARDSTATUS [28990]: CARDINAL;
```

Another example of machine-level access is provided in the Volition Systems' implementations of Modula-2 that permits the use of CODE procedures. A CODE procedure's body consists of a sequence of machine-code instructions and operands. Because a p-machine approach is used in these implementations, such a procedure consists of p-code instructions rather than the machine instructions of the actual central processing unit. This means that such CODE procedures can give access only to the pseudomachine; it would be interesting to see this capability in a native machine implementation of Modula-2.

Standard Pascal provides no direct means for achieving low-level machine access. Fortunately, there are ways around the problem. A pointer variable in Pascal—as in Modula-2—is a variable that can access actual machine addresses. Suppose we want to PEEK address 23120. We could declare a variable such as IPTR to be an INTEGER type. Using variant records, however, you can define two types of elements that share the same memory location. Define one of the elements to be an INTEGER and the other to be a POINTER to an INTEGER:

```
TRICK: RECORD
   CASE BOOLEAN OF
      TRUE: ( I: INTEGER );
      FALSE: ( IPTR: * INTEGER );
   END;
```

Now, make the assignment

```
TRICK.I:= 23120;
```

Since TRICK.I and TRICK.IPTR share the same location in memory, we in fact have assigned 23120 to IPTR as well. Thus IPTR* refers to the contents of 23120, the desired result.

This technique lets us simulate PEEK and POKE statements in Pascal. But suppose we have a subroutine contained in a ROM that we wish to call. Pascal has no direct analog to the call to an address that BASIC provides. The UCSD implementations, however, make it possible to link an externally assembled subroutine to a Pascal program. Such an EXTERNAL assembly-language routine can actually perform the call to the ROM address. Figure 1 gives a sample program using this technique.

An option to include in-line native-code procedures would probably be more convenient in Pascal than separately linked assembled code, such as that in figure 1. But at least it is possible to use native code modules in Pascal implementations such as UCSD's.

Pascal Lacks Open Array Parameters

How many times have you, as a Pascal programmer, wished you could write a procedure or function that could take arrays of some base type as parameters without regard to the bounds of the array? Wouldn't it be nice to be able to write a single procedure that sorts an array of inte-
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gers into ascending order or that prints out an array of strings, no matter how many elements the array has?

If you write a procedure `SORT_INT(A)`, that sorts an array of integers, your procedure declaration might begin:

```pascal
PROCEDURE SORT_INT (VAR A: ARRAY50);
(*Type ARRAY50 declared as ARRAY[1..50] of INTEGER*);
```

Here `SORT_INT` will sort integer arrays with a lower bound of 1 and an upper bound of 50. But if you need to sort an array of 51 integers, you will have to declare the following new procedure:

```pascal
PROCEDURE SORT_INT (VAR A: ARRAY51);
(*Type ARRAY51 declared as ARRAY[1..51] of INTEGER*);
```

Pascal forces us to redo the whole procedure we wrote for sorting 50 integers in order to sort an array of 51 integers. This approach wastes programmer time and computer memory. It also discourages the writing of modular code for use in more than one program. It would be better if we could write a procedure that sorts integer arrays of any length, place it in a system library, and retrieve it for use in later programs. Without this capability, programmers are forced to write special-purpose code each time an integer array of different length is to be sorted. There are also the attendant risks of error that otherwise would not be present if a well-tested library module could be used for the same purpose.

Modula-2 permits the use of open array parameters. An open array parameter is one that specifies the base type of the array (INTEGER, in the case of the proposed `SORT_INT` procedure) without constraining the bounds of the array. In Modula-2, the opening of the `SORT_INT` declaration could be

```pascal
PROCEDURE SORT_INT (VAR A: ARRAY OF INTEGER);
```

Whatever the upper and lower bounds of the actual array parameter passed to `SORT_INT`, within the procedure they will be considered to be 0..HIGH(A), where HIGH(A) is the number of elements in the array.

As much as a Pascal programmer might wish for open arrays, they aren't available in Pascal. There are ways, however, to get some of the advantages of the Modula-2 open array concept within Pascal. Two methods are illustrated here. One is quite simple, but does not lend itself to the practice of building user-transparent independent library modules. The other requires a more complex method that is suited for use in separate modules.

### Faking Open Arrays

In order to write a Pascal procedure that operates on arrays without specifying the size of the array in the procedure declaration, you must pass two arguments—the first element of the array and the size of the array. A trick must be employed to access other elements of the array, given the first element.

The simple method requires that the programmer using the sort procedure define a variant record.

```pascal
TYPE SINGLE_ELEMENT: ARRAY [1..1] OF INTEGER;
```

then:

```pascal
VAR INTVARIANT: RECORD CASE INTEGER OF
0: (I_ARRAY: ARRAY[1..50] OF INTEGER);
1: (I_ELEMENT: SINGLE_ELEMENT);
END;
```

`INTVARIANT` is a variant record that can contain either an array of fifty integers or a single element. The two variants of `INTVARIANT`, `I_ARRAY` and `I_ELEMENT`, share the same location in memory. Now we can pass `I_ELEMENT` to the sort procedure in order to get at the elements of `I_ARRAY`.

Within the sort procedure you must turn off range checking in order to refer to elements outside the array.
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Listing 2: A program demonstrating calls to a general sort module depending on a user-supplied interface mechanism. To use the sorting procedure PASC___SORT to sort a different array of integers, a separate variant declaration, similar to that of INVARIANT, is required.

PROGRAM VAR_ARRAY_DEMO;

TYPE SINGLE_ELEMENT = ARRAY[1..1] OF INTEGER;

VAR INVARIANT: RECORD CASE INTEGER OF
  0: ( I_ARRAY: ARRAY[1..50] OF INTEGER); (*actual array*)
  1: ( I_ELEMENT: SINGLE_ELEMENT); (*to satisfy Pascal*)
END;

I: INTEGER;

PROCEDURE PASC_SORT_INT (VAR ITEM: SINGLE_ELEMENT; ARRAYSIZE: INTEGER);
(* This procedure sorts an array of integers by increasing value, using a selection sort technique. *)
VAR I,J,TEMP: INTEGER;
BEGIN
(*$R- must turn off range checking *)
FOR I:=1 TO ARRAYSIZE-1 DO
  FOR J:=I+1 TO ARRAYSIZE DO
    IF ITEM[J] < ITEM[I] THEN
      (*ITEM[J] smallest so far. Exchange w/ ITEM[I]*)
      BEGIN
        TEMP:= ITEM[I]; (**save element I in temp**)
        ITEM[I]: = ITEM[J]; (**put element J into element I**)
        ITEM[J]: = TEMP; (**put temp into element J**)
      END;
(*$R+ may turn range checking back on*)
END; (*PASC_SORT_INT*)
BEGIN (*MAIN*)
FOR I:=50 DOWNTO 1 DO INVARIANT.I_ARRAY[I]:=50-I+1;
WRITELN('Sorting array I_ARRAY. Please wait ...');
PASC_SORT_INT(INVARIANT.I_ELEMENT, 50);
END. (*MAIN*)

bounds of the variant passed, I_ELEMENT. For example, the procedure PASC_SORT_INT shown in listing 2 turns off range checking so that it is possible to refer to elements of I_ELEMENT, even though I_ELEMENT is only a single element array. In the body of PASC_SORT_INT, ARRSIZE is used to check that the upper boundary of the actual array is not exceeded. (In Modula-2, a separate size parameter need not be passed, since the standard procedure HIGH( ) is used to return the upper bound of an array.)

This method is quite easy to implement. Unfortunately, it requires that the programmer consciously engage in variant record trickery every time the general procedure for sorting integers is to be used. Every time, you've got to declare the array to be sorted, not as a straightforward array, but rather as a variant record, with one variant the actual array to be sorted. Is there a way to imitate open arrays in Pascal without having to make a variant record declaration global to the call of the sort procedure?

Invisible Open Array Trickery

There is a somewhat more complicated approach that conducts its dirty work invisibly to the calling program or procedure. With this technique, an independent library module such as that given in listing 3 simulates PEEK and POKE statements to place values in the array. You do not have to be aware of the variant record tricks to use this library unit.

The success of the invisible approach to imitating open arrays depends on the version of Pascal employed for the program. As it happens, in the UCSD Pascal Version II.0 implementation (and its offspring, Apple Pascal), the address of the leftmost VAR parameter of a procedure is placed in the memory location immediately before the location re-
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BEGIN (*PLACE_HOLDER MUST be first declared variable. This ensures that address of 'FIRST' is at X[-1]*)
VAR PLACE_HOLDER : ARRAY[0..0] OF INTEGER;
BEGIN
FUNCTION GET_ITEM(VAR FIRST: INTEGER; WHICH_ITEM: INTEGER):INTEGER;
BEGIN (*$S+* )
BEGIN (*VARIANT: RECORD CASE INTEGER OF
 0: ( PTR: AINTEGER);
1: (ADDRESS: INTEGER);
END; (*CASE*)
BEGIN (*$R-*)
(*put location of 'FIRST' into 'address')
VARIANT.ADDRESS := PLACE_HOLDER[ -1 ];
(*$R+*)
(*bump address to access desired element*)
VARIANT.ADDRESS := VARIANT.ADDRESS
+ (WHICH_ITEM-1) * SIZEOF (FIRST);
VARIANT.PTRA: = VALUE;
END; (*PUT_ITEM*)
END; (*GET_ITEM*)
BEGIN (*$S+*)
BEGIN (*VARIANT: RECORD CASE INTEGER OF
 0: ( PTR: AINTEGER);
1: (ADDRESS: INTEGER);
END; (*CASE*)
BEGIN (*$R-*)
(*put location of 'FIRST' into 'address')
VARIANT.ADDRESS := PLACE_HOLDER[ -1 ];
(*$R+*)
(*bump address to access desired element*)
VARIANT.ADDRESS := VARIANT.ADDRESS
+ (WHICH_ITEM-1) * SIZEOF (FIRST);
VARIANT.PTRA: = VALUE;
END; (*PUT_ITEM*)
END; (*GET_ITEM*)

PROCEDURE SORT_INT (*VAR INT: INTEGER; ARRAYSIZE: INTEGER*);
BEGIN
VAR I,J,TEMP: INTEGER;
BEGIN
FOR I:=1 TO ARRAYSIZE-1 DO
  FOR J:=I+1 TO ARRAYSIZE DO
    IF GET_ITEM(INT,J)<GET_ITEM(INT,I) THEN
      TEMP:= GET_ITEM(INT,I); (*save element I in temp*)
      PUT_ITEM( INT,J, TEMP ); (*put temp into element J*)
      PUT_ITEM( INT,I, GET_ITEM(INT,J) );
      (*put element J into element I*)
    END;
END; (*SORT_INT*)
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Constant Expressions

Whenever constants must be used, it is good practice to assign names to them. This increases readability and makes program changes easier. For example, suppose you wish to have several arrays of different types, each having the same maximum size. By defining a constant

\[
\text{CONST ARRAYSIZE} = 20;
\]

you can change the size of the following arrays:

\[
\begin{align*}
\text{VAR } X & : \text{ARRAY}[1..\text{ARRAYSIZE}] \text{OF INTEGER;} \\
Y & : \text{ARRAY}[1..\text{ARRAYSIZE}] \text{OF CHAR;} \\
Z & : \text{ARRAY}[1..\text{ARRAYSIZE}] \text{OF REAL;}
\end{align*}
\]

just by changing the constant ARRAYSIZE.

In Pascal, constants cannot be expressions. This greatly limits the usefulness of the CONST definition. For example, suppose array Y must have limits twice the size of X, while Z must be three times the size of X. Pascal requires that the three upper bounds' constants be declared in a manner that makes their inherent relation invisible. In Modula-2, the relation among the three constants can be made clear in a declaration with the form:

\[
\text{CONST XSIZE} = 20; \\
\text{TWICEX} = \text{XSIZE} \times 2;
\]
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THRICEX = XSIZE * 3;

VAR X: ARRAY[1..XSIZE] OF INTEGER;
Y: ARRAY[1..TWICEX] OF CHAR;
Z: ARRAY[1..THRICEX] OF REAL;

Using this Modula-2 code, to increase the array sizes only requires a change of the single constant XSIZE, and the other arrays change accordingly. In Pascal, the best that we can do is to use constant identifiers that clarify their intended relation, as in:

CONST XSIZE = 20;
TWICEX = 40;
THRICEX = 60;

You have to hope that, if you must later modify the program by doubling the size of the arrays, the names TWICEX and THRICEX will help you to remember to change those constants as well as XSIZE.

Another problem with Pascal is in defining character constants. Suppose we wish to define ESCAPE as ASCII (American National Standard Code for Information Interchange) character 27. Pascal doesn't allow the expression

CONST ESCAPE = CHR(27).

In Modula-2, however, this declaration can be accomplished with

CONST ESCAPE = 33C

which declares that ESCAPE is a character constant with the octal value 33 (decimal 27).

The traditional Pascal programmer's solution to the prohibition of constant expressions is to use global variables as constants. A special initialization procedure is created that assigns to global variables the values that should remain constant throughout the program. The declaration of ESCAPE in Pascal is done like this:

CONST ESC_ORD = 27;
VAR ESCAPE: CHAR;
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PROCEDURE INIT;
BEGIN
   ESCAPE := CHR(ESC_ORD);
   *
   *
   END; (*INIT*)

This approach is much less desirable than the use of true constants, since the
value of a global variable could be inadvertently changed by any proced-
ure in the program. To increase
the probability of program correct-
tness, adopt a special naming convention
for global variables that mas-
querade as constants (e.g., ESC__
CONST for ESCAPE) to reduce the
chances of accidentally assigning
values to them outside of the initial-
ization procedure.

Restricted Declaration Order
In Pascal, all the declarations at a
particular program level must be
made in a particular order: first all
the constant declarations, then the
types, next variables, and finally pro-
cedures and functions. This strict
constraint is likely to reduce program
readability in some contexts, because
it prevents grouping together of re-
lated declarations. In Modula-2, one
can group related constant, type, and
variable declarations for improved
readability, as in:

(* 8-bit declarations *)
CONST MAXBYTE = 255;
   ZERO = 0;
TYPE BYTE = [ZERO..MAXBYTE];
VAR ABYTE, BBYTE: BYTE;

(* 12-bit declarations *)
CONST MAXTWELVEBIT = MAXBYTE * 16 + 15;
TYPE TWELVEBIT = [ZERO..MAXTWELVEBIT];
VAR ATWELVE, BTWELVE: TWELVEBIT;

There is no simple fix for Pascal’s
restrictions on declaration order. To
some extent, the problem can be re-
duced by avoiding global constant and
type declarations where only
local ones are required. Such a prac-
tice promotes natural groupings. At
times, however, Pascal programs
must include long sequences of con-
stant declarations followed by se-
quences of type and variable declara-
tions, whose correspondence can only be determined by careful read-
ing of the declarations and the judi-
cious use of comments.

One method that Pascal program-
mers use to make relationships clear
among constants, types, and vari-
ables is to make use of descriptive
names. If the names of related ele-
ments contain the same meaningful
elements (such as the declarations of
the TWELVEBIT family illustrated
above), the consequences of restric-
tions on declaration order can be par-
tially overcome. But this brings up
another problem with many Pascal
implementations, that of restricted
identifier lengths. Although the Pas-
cal language definition puts no re-
strictions on the names of identifiers,
many implementations are restricted
to eight significant characters. The
only patch for this limitation is to
make certain that your identifiers dif-
fer in the first eight characters. This
can be done quite easily, but it often
results in cryptic acronyms and ab-
reviations that are not easy to inter-
pret. Unfortunately, there is no
simple solution to this problem.

CASE Limitations
The CASE statement is a very use-
ful feature of Pascal. With it, we can
perform one of a group of statements
depending on the value of the CASE
selection variable. For example, con-
sider:

CASE A OF
   1: WRITE('ONE');
   2: WRITE('TWO');
   3: WRITE('THREE');
END;

This code is less readable than that
using CASE selectors, although it
may produce more efficient code.

Static Variables
In Pascal, variables that are local to
a procedure are always allocated dynamically. That is, room for them is allocated automatically on entry to the procedure. When the procedure is exited, the memory used by the local variables is freed up for other use. While this is a useful feature because it saves memory, it can be a problem if the values must be retained between invocations of the procedure.

The easiest solution available to the Pascal programmer is to declare the variables in an outer block. The values of the variables will be retained as long as the block in which they are declared is not exited. But this means variables that really ought to be invisible outside of the procedure must be made global, and therefore visible, to the rest of the program. As global variables, they are vulnerable to modification by parts of the program that should have no knowledge of them.

In Modula-2, it is possible to declare a variable for use in procedures in such a way that its value is preserved across invocations of the procedure—as though the variable is global—while preventing any other part of the program from accessing it. To do this, one declares a module, providing a visibility barrier around the procedure. Suppose we want to count the invocations of a procedure DOSTUFF. The count variable, COUNTDOSTUFF, can be made inaccessible to the rest of the program if it and DOSTUFF are declared inside a module, STUFFMODULE, as follows:

```pascal
MODULE STUFFMODULE;
EXPORT DOSTUFF;
VAR COUNTDOSTUFF: CARDINAL;
PROCEDURE DOSTUFF
(I: INTEGER);
VAR A,B,C: INTEGER;
BEGIN
COUNTDOSTUFF := COUNTDOSTUFF + 1;
WRITELN ĐiStuff, I);
END; (*DoStuff*)
BEGIN (*StuffModule's body*)
COUNTDOSTUFF := 0;
END; (*StuffModule*)
```

If STUFFMODULE is declared at the top level, that is, just within the program module, then its body, which initializes the variable COUNTDOSTUFF, will be executed at the time that the program body is executed. The DOSTUFF procedure, which has been explicitly exported from the module, is available from everywhere else in the program, but its count variable, COUNTDOSTUFF, is inaccessible from outside the procedure DOSTUFF. COUNTDO­STUFF is a global variable in the sense that it exists outside of the procedure DOSTUFF, but it is a local variable in terms of its visibility outside of the procedure. UCSD Pascal also permits this feature of hidden variables that can retain their values in the unit construct. Those variables declared in the implementation portion of the unit, rather than in the interface, are present at the level of the unit, but are invisible to program entities outside the unit.

**Switch or Fight**

Our purpose here has not been to present Modula-2 as a panacea for all of Pascal's faults. In some ways Modula-2 makes life harder for the Pascal programmer. For example, consider the lack of a set of type-insensitive I/O (input/output) procedures, such as Pascal's WRITE and WRITELN. In Modula-2 you cannot mix types in a WRITELN statement. Instead, you must use a separate procedure to output each type, such as use WRITESTRING for strings and WRITEREAL for reals. Furthermore, each write procedure can have only a single parameter.

Like Pascal, Modula-2 is not without faults. Both are well designed, but each has features that at least some programmers will object to.

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Trademarking Software Packages

Trademark clearance can prevent litigation and loss of hard-earned goodwill.

by Robert Greene Sterne and Perry J. Saidman

The scene is all too familiar. The developer of a successful software package sits in the office of a trademark attorney fretting. He holds in his hand a certified letter he received the day before from another lawyer whose client is challenging his use of the brand name Aisle for his software package.

The letter states that the client owns a federal trademark registration for use of the name Isle on software and that he considers the use of Isle and Aisle for the same type of product likely to cause confusion in the marketplace. In addition, the letter warns that the developer “immediately cease and desist from using the Aisle trademark on his software packages” or be subjected to dire legal consequences.

The letter has made the developer furious. He can’t believe that he has been forced to waste time with what he considers legal harassment when he should be working on his new advertising campaign, handling a dissatisfied customer, or taking care of other pressing business concerns that need his attention. But he decides to take the bull by the horns and deal with the matter because the letter says that he must respond within 30 days. He has brought the Aisle package to the marketplace, so he hopes he can take a tough position against the owner of the Isle trademark with the help of his lawyer.

A clearance search determines whether a word chosen as a trademark is already being used.

Choosing a Trademark
The developer’s lawyer asks him to recount how he developed the Aisle package and how he chose its name. The software entrepreneur knows that the time it takes to tell his story will cost him a lot of money in legal fees, but he enjoys describing the history of his creation.

The story is really very simple. In early 1981, the developer saw a need and met it with his Aisle software package. Some of his friends who own computers discovered his useful program and asked for copies, which he provided proudly and gladly. He later decided that he could sell such a package and started analyzing ads in computer magazines for marketing tips. Studying how they were written and designed, he noticed the symbols that appeared with their names: ©, ®, and ™.

He also learned that he must come up with a name for his program by which it could be distinguished from competing programs. Everywhere he looked he saw successful software packages with great names such as Visicalc, Wordstar, and Easy Writer. He finally settled on Aisle after considering many names. When he discussed his choice with his closest friends, they responded enthusiastically. He did not know of anyone else using the name Aisle for the type of software he produced, therefore he began to market the package under that name. A friend advised him to use an ® beside the Aisle name in all of his ads.

The lawyer interrupts the story to ask whether a clearance search of the Aisle mark had been conducted to determine whether anyone was
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using the name on software. The developer says he is unfamiliar with the term clearance search but that he had never consulted a lawyer about the name. In addition, he says, he was unaware of the Isle trademark when he adopted the name Aisle. After he learned of Isle's existence, he also discovered that its sales are confined exclusively to the East Coast, while Aisle software is sold primarily on the West Coast. Becoming agitated, he points out that Aisle differs significantly from Isle. The lawyer calms him, then explains some principles of trademark law.

**Trademarks Afford Protection**

The major issue in most trademark-infringement suits, the lawyer notes, is whether the plaintiff's and defendant's trademarks, used on their respective goods, will likely cause confusion as to the goods' source or origin. Thus, he explains, even if two names differ, a court could find likelihood of confusion in the event the sound, appearance, and meaning of the two are close. In the developer's case, he says, even though the meanings differ, the appearance of the words Isle and Aisle is very similar and the sound is identical. He concludes that a court could therefore find a likelihood of confusion to exist.

The developer objects to the idea that the two words might cause confusion, saying that he did not know of any instance where a customer bought Aisle software thinking it was an Isle package. His lawyer points out, however, that it was the likelihood of confusion that constituted the legal test, not the actual confusion; the fact that no one had ever confused the two programs did not matter.

The lawyer goes on to explain that both the Aisle and Isle marks are arbitrary choices for names of software packages. Under trademark law, arbitrary means that the product's name does not describe its goods—in this case Isle and Aisle do not describe the function of the packages they name. Software, after all, is neither an island nor a lane. The lawyer offers an example to illustrate the point.

The primary meaning of the word “apple” is a type of fruit. Thus, the use of the word “apple” on any type of goods other than fruit, such as Apple bicycles, Apple sportscoats, or Apple computers, is an arbitrary use. Other examples of products with arbitrary trademarks include the Lisa computer, Camel cigarettes, and Dove soap. Arbitrary trademarks, he explains, tend to be strong trademarks that are protectable as soon as they are adopted. In other words, no customer recognition has to be developed through sales to protect them,

**Adopting a new name will constitute trademark infringement if customers are likely to be confused as to source or origin.**

in contrast to primarily descriptive, surname, or geographic trademarks, which do not require customer recognition for protection.

A descriptive name is one that describes a function, property, or characteristic of the goods it labels. An example is Sortfile Plus, used for a software package that sorts files quickly and efficiently. Franklin is a surname used as a trademark for a personal computer, and an example of a geographic trademark is Palo Alto, used on a spreadsheet package. To afford protection, these types of trademarks require customer recognition. Because of their original meaning to the public, a secondary meaning must attach in the market through certain commercial activity. This secondary meaning is an indication of source for the trademarked goods. In other words, the Franklin or Palo Alto must be recognized by the interested public as symbols of computer goods from a particular source before they can be protected.

In the case of the Isle versus Aisle trademarks, the lawyer points out that they are both arbitrary names used for the same type of software,
and therefore are likely to cause confusion. Consequently, the critical legal questions would involve priority and good-faith adoption in a remote geographic area. The general rule in trademark law is that the user who first applies a trademark to goods in a particular geographic area has exclusive rights to it and related products in that area. The law allows another user to use the same or a similar trademark for the same goods only if the second user has adopted, and first used, his trademark in good faith in a geographic area remote from the first user. This legal defense would be available to the Aisle developer under normal circumstances, the lawyer says, because the developer of Aisle was unaware of the Isle trademark when he chose the name Aisle and because he was selling Aisle software in an area remote from that where Isle was sold.

However, the lawyer notes ruefully that the owner of the Isle trademark was smart to take the initiative to obtain a federal registration of Isle. The Isle developer was granted such protection a few months before Aisle’s developer adopted a similar name. The federal registration provided nationwide constructive notice of the Isle trademark, which means that the law will presume people have notice of the trademark. Thus its owner can presume others are aware of its use, and the developer’s defense of good-faith adoption is eliminated.

### Epilogue

Despite his lawyer’s warning, the developer did not respond to the letter, and several months later he was served with a summons in a lawsuit. After spending $30,000 in the defense of a preliminary injunction motion, the case was settled as follows: even though he still felt he had done nothing wrong, the developer agreed to stop using the Aisle mark on his package or “any confusingly similar variation thereof”; to destroy all labels, ads, promotional materials, and actual packages using the Aisle mark; and to pay court costs. Nevertheless, the developer disregarded the court order and subsequently was found to be in contempt of court, which resulted in a stiff fine, addi-
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Circle 136 on inquiry card.
An EPROM Simulator

This versatile project includes battery backup

by Albert S. Woodhull

An EPROM (erasable programmable read-only memory) is a convenient place to store a machine-language program (for instance, a bootstrap loader program for a large system or the entire application program in a data-collection system). The development cycle for such programs involves writing and assembling the program on a development computer system and programming (burning) an EPROM. The EPROM is then plugged into its socket on the target computer system and the program is tested.

EPROMs are great for programs that are already debugged, but they create a bottleneck in the development process. On my development system, the EPROM programmer takes up memory space needed by the editor I use for writing programs, so I have to power down and change the hardware configuration before programming the EPROM. And, of course, once a program is in EPROM it cannot be easily changed, so I can’t use a monitor or debugger on the target computer to try out simple modifications at the machine-language level. A bug requires going back to the development system. I have often wished for something simpler.

There are several alternatives to EPROMs. Steve Ciarcia has written about the new electrically erasable nonvolatile memory chips in the December 1979 BYTE (“Add Non-volatile Memory to Your Computer,” page 36). These devices are an attractive possibility, but they are expensive and cannot be plugged into the same socket as an EPROM. Eric Rehnke described an EPROM emulator in the February 1982 BYTE (“Build an EPROM Emulator,” page 194). This two-port memory gives a development system the ability to control the contents of a portion of the memory of a target system. While this approach is excellent for some purposes, I needed nonvolatile memory for development of bootstrap programs for the development system itself. I chose a third approach, a battery-powered RAM (random-access read/write memory) that could be unplugged from one socket and plugged into another without risk to chips or loss of data.

The EPROM simulator turned out to be an easy project. I decided to use a 2K-byte wide static-memory chip, the Hitachi 6116. I have been using these in my projects and for main memory in my development system. Standard 2716 EPROMs can be used in the same sockets, a convenient arrangement for frequent changes of hardware configuration. The 6116 uses CMOS (complementary metal-oxide semiconductor) technology and requires very little power when deselected. By proper choice of operating conditions, the standby current drain of one of these chips can be held to less than 2 mA (milliamperes). CMOS chips also are relatively tolerant of voltage variations. Hitachi’s data sheets specify the operating voltage of the 6116 as 5.0 volts ±10 percent; many digital integrated circuits require ±5 percent regulation. As I will explain later, the voltage tolerance for retention of data is more permissive than the operating voltage range.

Nicad (nickel-cadmium) rechargeable batteries are an obvious choice for powering the EPROM simulator. The nominal voltage of a nicad cell is 1.2 volts, but when fully charged, a battery of four cells will produce just over 5.5 volts. Nicad voltage holds up well during discharge; a 4.5-volt endpoint enables use of most of the charge. Size AA nicad cells are readily available and are rated at 450 milliampere-hours (mAh), enough to keep a 6116 chip alive for well over a week.
After choosing to power a 6116 RAM with nicad batteries, the problem I had to deal with next was protecting the memory chip and its data from damage while unplugging it from the development system and plugging it into the target computer. Plugging and unplugging solid-state components while power is applied is not a good idea. Pins won’t make connections simultaneously and internal voltages momentarily can be the wrong polarity. Even if you could be sure components would survive the surges of power, there is too much chance of misalignment or short circuit with a large number of closely spaced connections. The answer to this is to use buffer circuits from which the power can be removed without turning off the RAM itself. Only inactive devices will be connected to the external plug during insertion or withdrawal. The buffer chips do not have to draw on the battery; they are needed only when power is available from a host development or target system.

The Circuit

The block diagram in figure 1 depicts the overall scheme. All connections to the 6116 RAM chip are isolated by tristate buffers. The buffer chips get their power from the host computer; the RAM is powered by a 5-volt battery. A diode allows the battery to be partially recharged from the computer but prevents the buffers from draining the battery when the host computer is off or the unit is unplugged. The diode also permits the RAM to get its operating current from the host when it is selected. During a read or write cycle, a selected RAM chip may need as much as 80 mA. The buffers for the address and control lines are always enabled; the data buffers are selected appropriately when the socket into which the simulator is plugged is selected for reading or writing.

Details of the circuit are shown in figure 2. Instead of conventional OR gates, I put an extra 74LS367 buffer chip on the board and used two buffer sections and pull-up resistors to gate the enable signals for the data buffers. I was planning for the future—someday I’ll want to use 4K- or 8K-byte RAM and EPROM chips, and unused buffers then can be wired up for additional address lines. The switches on the CS and W lines are for peace of mind. The CS switch guarantees that no transients will come through when the buffers are powered up or down; the W switch protects the RAM from accidentally
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Figure 2: A detailed schematic diagram of the EPROM simulator. The pin numbers indicate the pinout of the plug that connects to a 2716 or 6116 socket on a host computer; other numbers indicate pin connections on the integrated circuits. For clarity, the enable lines to the buffers (six 74LS367s) are not shown; the connections are summarized at the bottom of the diagram. The control lines with overbars are active low lines, i.e., a zero-volt level on line CS selects the RAM chip. Two sections of IC3, a 74LS367, are used as OR gates; because the output is high impedance when the buffers are not enabled, pull-up resistors are needed. Note that these pull-up resistors connect to the host-derived power, +5H, but the pull-up resistors on the control lines to the RAM chip must be connected to the battery line, +5B.
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Figure 3: A constant-current circuit for charging nicad batteries. The regulator maintains 5 volts across the resistor, which passes a current of about 45 mA. The resistor current and the small operating current of the regulator itself flow through the battery to be charged. The power supply may be rated at anything from 12 to 35 volts.

The battery cannot be fully charged from the host computer power supply with the circuit shown in figure 2. Diodes have a forward voltage drop that is relatively constant over a wide current range; with a germanium diode, this limits the voltage to which the battery can be charged to about 4.75 volts. If the EPROM simulator is constantly plugged into a computer that is used for a few hours each day, this should be good enough to retain data indefinitely, but an external charger will be needed if a full charge is required for maximum duration of data retention.

Standard nicads should be charged at about 10 percent of their Ah (ampere-hour) rating, requiring 14 hours for a full charge. A simple constant-current charger can be made with a standard voltage regulator chip and a resistor, as shown in figure 3. The regulator keeps the voltage across the resistor constant, which means the current through the regulator's common terminal, but there is a small error due to the additional current that flows through the regulator's common terminal, but this is only a few milliamperes. The supply voltage must be greater than the fully charged battery voltage, plus the nominal output voltage of the regulator, plus about 2 volts. A 12-volt supply is adequate for charging the EPROM simulator battery, using a 5-volt regulator chip.

Using the EPROM Simulator

I'll describe the use of the EPROM simulator with an example. I gave it its first test by tracking down an annoying bug in my terminal I/O (input/output) routines, which normally are in EPROM where I can't modify them with the system debugger. I unplugged a RAM chip at a memory address I knew I would not need for my system routines, plugged the EPROM simulator into that socket, powered up, and copied the old system EPROM into the RAM with both the CS and W switches closed. I then opened both switches for protection, powered down the system, and replaced the system ROM with the EPROM simulator plug. With the CS switch on, everything worked as it had with the EPROM in place. Finally, I closed the switch in the W line and used the system debugger to quickly investigate several of the “what-if” questions I had about the program.

This EPROM simulator was a weekend project. By the next weekend I was wondering how I had lived without it. It makes any task involving development of code for an EPROM much more convenient. At the beginning of a project I know my programs will have bugs. Having my code as safe and portable as if it were in an EPROM, yet as easy to modify as if it were in RAM, makes starting such a project much more pleasant.

Albert S. Woodhull (33 Enfield Rd., RFD2, Pelham, MA 01002) has a Ph.D. in physiology and psychology and is an associate professor of computer studies and biology at Hampshire College in Amherst, MA. He uses computers for laboratory instrumentation in research in various aspects of physiology. His hobbies include ham radio operation, hiking, and backpacking.
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Application Note

Simulation with Electronic Spreadsheets

Spreadsheet programs make a career change

by Art Matheny

Electronic spreadsheets aren’t just for financial models. In fact, they can simulate many different types of dynamic processes. In this article, I present examples of dynamic process simulation using Visicalc on an Apple II and Supercalc on an Osborne 1. I assume that you can also apply my examples to other electronic spreadsheet programs.

Using an electronic spreadsheet, you can construct a table with rows and columns of different kinds of entries. The entries may be character data (such as names or labels), numeric values, or formulas. Formulas usually contain references to other entries in the table. If a formula uses an entry that is also a formula, this question is raised: "Which formula is evaluated first?" Visicalc and Supercalc both start at the first row and first column, go down the first column to the bottom of the table, then to the top of the second column, down the second column, then to the top of the third column, and so on until the programs have calculated all the entries. Or you can tell them to calculate by rows instead of by columns.

Ambiguities may arise when one formula refers to another in one of two ways, a forward reference or a circular reference. A forward reference occurs when a formula refers to another formula that comes up later in the calculation sequence—further down the column or in any column further to the right. It is even worse if the second formula refers back to the first one, which is a circular reference. Figure 1 shows a spreadsheet with a circular reference. (The figures in this article use the notation of Supercalc.) Enter the formulas in cells A1 and B1 of figure 1 and recalculate the spreadsheet a few times.

With each recalculation, the numbers drift uncontrollably. You can, however, bring circular references under control. Figure 2 is an example of a useful circular reference. This spreadsheet calculates the balance of a savings account that is compounded monthly. The annual interest rate is entered in cell B2 and the monthly deposit in cell B1. Each time the spreadsheet is recalculated, a new month is computed. You can repeat the recalculations for as many months as you wish. To see how much money would be in the account after 20 years, press the recalculate key 240 times. Cell B3 keeps track of the number of months since the account was started. To reset to the starting condition, simply enter 0 in cell B1. Change the interest rate if you wish and then reenter the monthly deposit in cell B1.

The preceding example is an exact calculation for a savings account that is compounded monthly. The calculation is capable of being exact because the events that change the balance are discrete—that is, the time and interest payments change by fixed amounts that cannot be broken into smaller amounts. But dynamic processes are often continuous rather than discrete; that is, they may have no smallest discrete change because each change is infinitesimally small.

Such processes are described by differential equations. The following differential equation describes the growth of population P with birth rate r:

\[ \frac{dP}{dt} = rP \]

The symbol \( \Delta \) denotes a finite, rather than an infinitesimal, change in some
The differential equation can then be approximated by a finite-difference equation:

\[ \Delta P = rP \Delta t \]

or

\[ P_1 = P_0 + rP_0 \Delta t \]

where \( P_0 \) equals population at the start of \( \Delta t \), and \( P_1 \) equals population at the end of \( \Delta t \); thus, \( P_1 - P_0 = \Delta P \).

The number of births during the time interval \( \Delta t \) is \( rP_0 \Delta t \). This equation can be used iteratively to simulate the population growth process. Given a starting population, the equation yields the population after a small time step, \( \Delta t \). Starting from there, the equation can be used again for the next time step, and the next, and so on.

Figure 3 shows how to do this with an electronic spreadsheet. The formulas at B2 and at B6 contain IF functions. The IF function contains three arguments: the first is a condition and the other two are formulas. If the condition is true, the second argument is used; if the condition is false, the third argument is used. With the spreadsheet as shown, the condition is true in both cases. Thus, the time remains equal to 0, and the old population remains equal to the initial population. There is no change when the spreadsheet is recalculated. Move the cursor to B1 and save the table. It is now ready for use.

To begin the simulation, change the value at B1 to some value greater than 0 (1, for example). Now repeatedly press the F9 key or whichever key produces a recalculation. Note that the value at B8 increases exponentially with time. If you continue until the time equals 100, the population should be well over 1 million. At this point, you may need to change column widths and formats to clean up the spreadsheet. To reset the system, just change the value at B1 back to 0.

The next example, figure 4, is more complex in that there are two quantities that vary with time. This model simulates the decay of nuclear isotopes. Suppose you start with 1000 micrograms of a certain radioactive isotope. Let's call this the parent isotope. Each parent nucleus eventually emits an alpha particle and thus decays into the daughter isotope. It is often the case that the daughter isotope is also radioactive. The daughter nucleus eventually decays into the final product.

Change the time step in B1 to 1 or any other positive value to start the simulation. The value in B8 is the amount of parent isotope that decays during each time step. Those nuclei are all converted into daughter nuclei, which is why B8 is added to the current daughter amount in cell C9. Notice that the daughter amount increases at first, reaches a maximum level, and then declines. A Geiger counter held up to this sample would measure the total activity of both isotopes combined.

You can experiment with different decay rates for the two isotopes by changing the values in cells B6 and C6. The decay rate is the probability that a given nucleus will decay in a unit of time. The half-life of an isotope equals the natural logarithm of 2 (ln2) divided by the decay rate. The time step used in B1 should be less than one-tenth of the shorter half-life.

When you set the time step in any of these examples, you should be aware of the trade-off between accuracy and number of iterations. If the time step is too large, the finite-difference approximation will need only a few iterations, but accuracy will be poor. If the time step is too small, the approximation will need many iterations, but accuracy will be

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MONTHLY DEPOSIT</td>
</tr>
<tr>
<td>2</td>
<td>ANNUAL INTEREST RATE</td>
</tr>
<tr>
<td>3</td>
<td>NUMBER OF MONTHS</td>
</tr>
<tr>
<td>4</td>
<td>OLD BALANCE</td>
</tr>
<tr>
<td>5</td>
<td>INTEREST</td>
</tr>
<tr>
<td>6</td>
<td>NEW BALANCE</td>
</tr>
<tr>
<td>0</td>
<td>.08</td>
</tr>
<tr>
<td>IF(B1=0,0,B3+1)</td>
<td>IF(B1=0,0,B6)</td>
</tr>
<tr>
<td>B2*B4/12</td>
<td>Bl+B4+B5</td>
</tr>
</tbody>
</table>

Figure 2: Compound interest calculated using a circular reference.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TIME STEP</td>
</tr>
<tr>
<td>2</td>
<td>TIME</td>
</tr>
<tr>
<td>3</td>
<td>INITIAL POPULATION</td>
</tr>
<tr>
<td>4</td>
<td>BIRTH RATE</td>
</tr>
<tr>
<td>5</td>
<td>OLD POPULATION</td>
</tr>
<tr>
<td>6</td>
<td>BIRTHS</td>
</tr>
<tr>
<td>7</td>
<td>NEW POPULATION</td>
</tr>
<tr>
<td>0</td>
<td>IF(B1=0,0,B2+B1)</td>
</tr>
<tr>
<td>B1=B5*B6</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3: A spreadsheet simulation of a population explosion.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TIME STEP</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>TIME</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>ISOTOPE</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>INITIAL AMOUNT</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>DECAY RATE</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>OLD AMOUNT</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>AMOUNT OF DECAY</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>NEW AMOUNT</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>TOTAL ACTIVITY</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>LOG (ACTIVITY)</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>IF(B1=0,B2+B1)</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IF(B1=0,C5,C9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1<em>B6</em>B7</td>
<td>(B6<em>B7)+(C6</em>C7)</td>
<td></td>
</tr>
<tr>
<td>C7+B8-C8</td>
<td>LN(C11)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4: A spreadsheet simulation of radioactive decay.
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Figure 5: A spreadsheet simulation of predator-prey interaction.

very good. One way to judge the rate of error is to double the time step and compare the results.

The example in figure 5 is a finite-difference approximation of the Lotka-Volterra model of predator-prey interaction. When the prey population is high, the predators thrive and thus increase rapidly in number. As the predator population grows, however, the prey population declines because it has a difficult time surviving with all those predators around. Fewer prey means starvation for many of the predators, so the predator population falls. With fewer predators around, the prey are able to reestablish themselves in large numbers. Whether this cycle really occurs in nature is open to question, but the mathematics of this model are quite fascinating nevertheless.

The model assumes that if the prey were left alone they would experience unrestricted growth at the birth rate specified in cell C6. It also assumes that the predators have an intrinsic death rate, given in B7. The quantity in B8 is a measure of the skill of the predators in hunting prey, and the quantity in C8 is a measure of the probability that a prey individual will fail to escape an encounter with a predator. Using this simulation, you could construct a graph with the prey population on one axis and the predator population on the other. You could then follow the trajectory of this system for a complete cycle, modify the initial populations in B5 and C5, and draw other trajectories until a pattern emerges.

I have shown how spreadsheets can be used to model several dynamic systems. There are many other dynamic systems, discrete and continuous, that you can simulate with spreadsheets, which proves that spreadsheets can be used for much more than financial analysis.

Art Matheny earned an M.S. in physics at Purdue University. His hobbies are electronics and computer music. He can be reached at 1405 Four Seasons Blvd., Lutz, FL 33549.
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BYTE March 1984 417
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First, teachers understand Logo and are comfortable with it. As a result, they use it with confidence and encourage their students to use it. No other language has been received so well by teachers and has spanned such interest as Logo.

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Michael N. Milone Jr.
Honesdale, PA

You are not alone in your admiration of Logo as a teaching language. Alas, DR Logo requires a color system, and we have only a monochrome for our IBM PC, while the Logo we have won't run with the Z-100, which is a color machine. Ah, well.

One day I'll get to play around with Logo and get Mrs. Pournelle interested in it... Jerry

Legal Clarification

Dear Jerry,

You and your readers are mistaken in most of your views regarding the legality of warranty disclaimers and license agreements sold in mass-marketed software. The following should provide a basic framework of the law:

Warranty Disclaimers
1. A manufacturer cannot disclaim an express promise. If the advertising, packaging, or operator's manual says a product will do "X," then it must.

2. A disclaimer first mentioned after the sale is void. The sales contract is "formed" at that instance. Any attempt to unilaterally modify a previously existing bilateral contract (between the seller and the purchaser) will fail for lack of consideration.

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1. Software "...perpetually licensed" is sold and not licensed.

2. A self-executing license agreement (e.g., break the seal and you are deemed to have accepted the license...
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and its terms) probably has no legal effect. It has never been tested in court. However, such self-serving words when placed on an automobile check (e.g., parking-lot owner is not liable for damage done to your car) have been uniformly declared void.


L. J. Kutter
St. Louis, MO

Thanks for the briefing. However, why do you say I am mistaken? I've always believed those "licensing agreements" were unenforceable and unlikely to get any serious attention from a court, and I've said so, often. If I were a software publisher, I'd rely on copyright law for protection, and not try to be a hog with "licenses." ... Jerry

---

**Correction and Update**

Dear Jerry,

I recently read your review "The User Looks at Books" (December, page 519). I am pleased that your "current favorite beginner's text" is my book, A First Course in Computer Programming Using Pascal (McGraw-Hill, 1982). However, my first name was listed incorrectly. I have listed it below.

I consider learning to program as a process that requires quite some time and effort. It may be possible to cover a little about records and pointers in a first course; however, in-depth coverage of records and pointers is usually included in a second course. Consequently, my book does cover the use of linked lists to .orm stacks and queues. The success of A First Course in Computer Programming Using Pascal encourages me to consider writing a second-course text, in which advanced topics could be given more complete coverage.

Arthur M. Keller
Stanford, CA

I'm sorry I got your name wrong; our copy of the book has fallen victim to the Brotherhood of Book Borrowers, and alas, has gone away forever.

I don't disagree with your decision to limit the scope of an introductory book, but I did feel obliged to let the readers know when you get the next book done, I'd like to see it. ... Jerry
Oh, mentor of highest wisdom, help all mystified first-time buyers discover the ultimate truth about personal business computers.

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**BYTE's User to User**

**Encryption and Security**

Dear Jerry,

Here is the letter you requested outlining my thoughts on cracking Charlie Merrit's encryption program (see "Interstellar Drives, Osborne Accessories, DEDICATE/32, and Death Valley," July, page 323). The first point I would like to emphasize is that the purpose of this exercise, in my view, is not to see whether the trapdoor algorithm can be broken. I know enough about number theory and NP-completeness to know that the algorithm is fundamentally sound, and that nothing short of a major mathematical revolution is going to change that. What I am concerned about is the implementation of the algorithm. A flawed implementation can reduce the algorithm to total worthlessness. It is entirely possible that people could be buying encryption programs they believe to be "unbreakable," which in reality provide little or no security. The purpose of this exercise is to point out that it takes more than a good encryption algorithm to make data secure.

Merrit's program provides the service of generating the prime-number keys for the user. This is a valuable service, as it would be unreasonable to expect the average user to come up with 200-digit prime numbers! However, this service can also provide some security problems. Let's assume the existence of a similar program written by someone who decided to take a shortcut and built a table of possible keys into the program (acknowledging that Merrit's program does not do this). The keys are very large because the larger the keys, the harder it is to distinguish the private key from the public key. Let us further assume the program is a roaring success, and there are hundreds of thousands of users of it. Does the program really provide security? The answer is no. Now let there be a hacker who, as hackers are wont to do, decides to disassemble the object code to see what makes the program tick. Never mind how protected the object code may be; there always seems to be a way to get around the protection. Now, the hacker is obviously going to discover the table of primes. In all probability, this table will be quite large, so as to provide the maximum number of keys practical to give the user. However, even if there were 10,000 keys in this table, it would be a simple matter to have a computer try each one in turn to see if it is the private key that matches the known public key. A larger key length in this case would not offer much more security.

Even if the program in question did not use a table, but instead used a random-number generator, for example, there can still be problems. For example, if the random-number generator used a 16-bit seed, then the generator could produce only 65,536 distinct keys at most, no matter how long the keys were. Again, an exhaustive search for the private key becomes feasible. Even if the seed were significantly larger, there is still the problem of where the initial random seed comes from. Also, the random-number generator might be a very poor generator of random numbers. Just because the seed is a 64-bit number does not necessarily mean that the generator will produce all possible 2^64 numbers. Especially if the programmer naively assumed that a super-duper complicated generator will produce "more random" numbers than a simpler, but mathematically guaranteed, producer of random numbers.

Even if it were not possible to get at the object code, it is still possible to crack the program if it can only produce a limited number of possible keys. Mathematically, there is no distinction between public and private keys; the two can be freely interchanged. Therefore, the key generator might produce the same key sometimes as a private key and sometimes as a public key. By running the key generator many times and saving the keys produced, it becomes possible that one of those keys might be the private key to go with the public key in question. Of course, with this approach, there is no way to know in advance whether it will work without trying it.

From what I have been told, I doubt that Charlie Merrit's program can be broken. However one can never be sure, and there's only one way to find out.

Jeff Cohen
Sunnyvale, CA

I've talked to Charlie Merrit, and he just chuckles; but he's willing to furnish you with a copy of his encryption program to work on. He says he uses the refresh counter on the Z-80 chip for his random-number source, and that's affected by barometric pressure and the phases of the Moon.

It really looks as if we've got unbreakable codes we can implement on micros. The implications are a bit staggering. "But Your Honor, I only have the public key. I can't decode those records . . ." . . . Jerry
For nearly a hundred years, the Statue of Liberty has been America's most powerful symbol of freedom and hope. Today the corrosive action of almost a century of weather and salt air has eaten away at the iron framework; etched holes in the copper exterior.

On Ellis Island, where the ancestors of nearly half of all Americans first stepped onto American soil, the Immigration Center is now a hollow ruin.

Inspiring plans have been developed to restore the Statue and to create on Ellis Island a permanent museum celebrating the ethnic diversity of this country of immigrants. But unless restoration is begun now, these two landmarks in our nation's heritage could be closed at the very time America is celebrating their hundredth anniversaries. The 230 million dollars needed to carry out the work is needed now.

All of the money must come from private donations; the federal government is not raising the funds. This is consistent with the Statue's origins. The French people paid for its creation themselves. And America's businesses spearheaded the public contributions that were needed for its construction and for the pedestal.

The torch of liberty is everyone's to cherish. Could we hold up our heads as Americans if we allowed the time to come when she can no longer hold up hers?

Opportunities for Your Company.

You are invited to learn more about the advantages of corporate sponsorship during the nationwide promotions surrounding the restoration project. Write on your letterhead to: The Statue of Liberty-Ellis Island Foundation, Inc., 101 Park Ave, N.Y., N.Y. 10178.
Reflections on PL/I

Dear Jerry,

As a long-time science-fiction buff I have always enjoyed your writing, in Analog as well as BYTE. But I should introduce myself . . .

My name is Kelly Cook. I was employed for 19 years at Kitt Peak National Observatory, first as an observer, later as an optician. As such, I specialize in the testing of large mirrors, which is how I got involved with computers and programming. In 1981, I left Kitt Peak to attempt a career change to programming. On the nonprofessional side, my main passion is designing war games.

What prompted this letter was your mention in BYTE about gathering times on different systems for your benchmark. Your benchmark ran so fast that I added a 10-iteration loop to give my simple watch a better handle on it. The result of 92 seconds can then be divided to give a corrected time of 9.2 seconds (20 by 20 arrays). CP/M-86's Stat gave the object file size as 2K, but that is the smallest size that Stat can report so it's probably not very accurate. Linkage is another story. To make an object file into an executable COM file, it first has to be linked with PL/I's library of Built-In Functions. This means a great deal of disk grinding and a final file that Stat reports as 20K!

I had heard the tales about PL/I being as tricky in Ada or FORTH. It should be a snap for anybody who already knows Pascal. Just read the listing of your benchmark and see for yourself! The provisions for pointers and recursion can be tricky, but that is intrinsic in those concepts. Those things are just as tricky in Ada or C. And they are options, after all, so you can just ignore them if you want.

The bottom line is that PL/I-86 can be a bona fide lifesaver for anybody doing large-scale number crunching on a micro.

Kelly Cook

Tucson, AZ

My late mad friend, Dan MacLean, became a PL/I enthusiast in his last year. Had he lived, I make no doubt that he would have converted me; Dan had his ways.

However, without his stimulus I became a backslider. Most of my previous programs have been done in CB-80. Most of my future ones will be done in Modula-2. We have PL/I, but so far I've done almost nothing with it.

But Dan Alderson (inventor of the Alderson Drive for those who've read The Mote In God's Eye) is a PL/I enthusiast, and as soon as he's properly set up with a machine, I'll have a PL/I consultant. . . Jerry
Listing 1: The program below performs a series of matrix operations to provide a benchmark. The original benchmark was published by Jerry Pournelle in "A BASIC and Pascal Benchmark, Elegance, Apologies, and FORTH" (October 1982, page 254). It's run ten times to allow more accurate measurement.

```
MATRIX:

procedure options(main):
    % replace
    maxsize by 45,
    m by 20,
    n by 201
    declare
    i, j, main-loop,
    (A, B)(m,n) float,
    C(m,n) float static initial(0,0),
    Summ float static initial(0,0),
    BELL char,
    GUP var char(80)

    put skip list('input any darned number to start it. ')
    put list(GUP)

    do main-loop = 1 to 10;
    call FILLAI
    put skip list('A filled.');
    call FILLBI
    put skip list('B filled.');
    % fillC call replaced by "initial" option during declaration */
    call MATMULTI
    put skip list('Multiplied. ');
    call SUMMIT
    put skip list('Sum is ', Summ);

    FILLAI procedure;
        do i = 1 to m;
            do j = 1 to n;
                A(i,j) = i + j;
            end;
        end;
        end FILLAI;

    FILLBI procedure;
        do i = 1 to m;
            do j = 1 to n;
                B(i,j) = fixed((i + j) / j);
            end;
        end;
        end FILLBI;

    MATMULTI procedure;
        declare k;
        do i = 1 to m;
            do j = 1 to n;
                do k = 1 to m;
                    C(i,j) = C(i,j) + A(i,k) * B(k,j);
                end;
            end;
        end;
        end MATMULTI;

    SUMMIT procedure;
        do i = 1 to m;
            do j = 1 to n;
                Summ = Summ + C(i,j);
            end;
        end;
        end SUMMIT;

    end main-loop

    BELL = ascii(7);
    put list(BELL);
end MATRIX;
```

BYTE's User to User
Create a brilliant new video game and you could be on your way to becoming a millionaire. This fantastic competition, organised by I.R.P. (The International Register of Independent Computer Programmers Ltd) and the famous Mark McCormack International Management Group, offers programmers and inventors the opportunity of a lifetime. There are huge, immediate cash prizes and the on-going revenue of 10% of the sales of all games to distributors throughout the world, plus the chance to appear on an international TV show. Your skill and imagination could bring you fame and fortune!

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**BYTE’s User to User**

**A Mariner Queries**

Dear Jerry,

I just recently began reading BYTE and liked it so much that I rounded up some old issues. In your discussion of the 8087 (“New Computers, Boards, Languages, and Other Tidbits,” October, page 107), you mentioned a lack of supporting software. Probably you know this by now, but Microsoft’s implementations of FORTRAN and Pascal both fully support the 8087.

The real reason I’m writing is to find out if you have tested the piggyback 8087 board in your Z-100. If not, could you be persuaded to do so? I will be buying an H-100 in a few weeks. It will eventually be installed in the ocean-cruising sailboat I’m building, where it will serve as a navigation tool. Since number crunching is an inherent feature of navigation, I am extremely interested in having the 8087. It seems to me that a board that works in the Compupro ought to work in the Z-100, but it would sure be nice to know for certain. Can you help?

The last issue of the Heath Users’ Group magazine, REMark, contained a couple of pieces of information that might interest you. Zenith is working on an interlaced scan routine to double the vertical resolution of the Z-100 display. At 640 by 450 pixels, it should be fantastic. Also, Zenith won a DOD contract competition and the Z-100 will be the desktop computer in all four military services. Will we be seeing Ada before long?

Robert D. Williams
Hampton, VA

Regarding 8087 boards for the Z-100, watch my column. The Hudson board for the Compupro will not work with the Z-100; but the good news is that yesterday Jim Hudson called to say he’d finished the prototype Z-100 board. I haven’t seen that board working yet, but I do have his add-on for my Compupro; and I know Jim well enough to have some confidence that his final product will be reliable. He’s a perfectionist, and does his own work.

I’ve asked around, and my colleagues tend to agree that the H-100 is a good choice for your navigation computer, provided that you’ve given sufficient thought to waterproofing. I presume you’re enough salt-water experience to appreciate just how serious corrosion problems can be. I’d particularly worry about the mechanical parts, such as switches, keyboards, fans, and floppy disks.

The Zenith is a good, rugged machine. The only one I can think of that’s even more so is the Compupro, and that’s heavy enough to serve as a keel.

Good luck on your cruise, and keep me posted. Long ago I did a bit of blue-water midget ocean racing, and I’ve read Slocum and Hiscock and the other classics. I still delude myself that one day I’ll take a long sailing cruise. . . .

Jerry

---

**A General Comment from Jerry**

In the interests of sanity, we threw away all the mail dated prior to September 1, 1983. This wasn’t easy to do, because there were some excellent letters that deserved reply; but it became obvious we just weren’t going to keep up, and the sight of all that unanswered mail was depressing.

If you wrote earlier than that and still want an answer, please write again. This includes discussions of software for review. We have a somewhat better system now, and we’re caught up for the moment.

Jerry Pournelle is a former aerospace engineer and current science-fiction writer who loves to play with computers.

Jerry Pournelle welcomes readers’ comments and opinions. Send a self-addressed 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.

---

**BYTE’s Bits**

**Call for Papers**

A call for papers has been issued by Computer Fair, sponsors of the annual West Coast Computer Faire and the PC Faire. The call is for papers to be delivered at next year’s conference programs. The West Coast Computer Faire will be held in San Francisco on March 23-25, 1984. The dates for the PC Faire, also to be held in San Francisco, will be October 26-28, 1984.

Interested parties are invited to request a speaker’s kit from Computer Fare Inc., 570 Price Ave., Redwood City, CA 94063, (415) 364-4294.
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**Ask BYTE**

Conducted by Steve Ciarcia

---

**S-100 Versatility**

Dear Steve,

I would like to learn assembly-language programming for the Motorola MC68000. There seem to be add-ons for the Apple that let you get an inexpensive system for a reasonable price, but none is available for a CP/M system. I have an S-100 Delta CP/M system with 64K bytes of RAM. Can I buy an inexpensive (much less than $2000) S-100 board that would let me do it? Whatever system I bought would have to include a 68000 software-development system.

Would it be possible to design a modular system so that a person with a complete, one-processor system could add one or more additional processors, some RAM, or whatever was needed? What I'm asking about is a generalized hardware converter analogous to software converters for disk formats. The S-100 bus was supposed to be something like that, but I have had my Delta for two years and have yet to add my first board to it because I've never seen anything I wanted badly enough to pay the "Rolls-Royce" prices of some of the commercial boards offered for the S-100 bus. The way around these prices is to buy bare boards or to construct your own boards. A good reference manual for interfacing your own boards to the S-100 bus was written by Sol Libes and Mark Garetz, Interfacing to S-100/IEEE 696 Microcomputers, published by Osborne/McGraw-Hill. For example, you should be able to interface the speech generator with the information in this reference.

Another good source for S-100 and CP/M information is the monthly publication called Microsystems. Some advertisers in Microsystems have been addressing the question you have on running 68000 software with your 8-bit system. For example, HSC Inc. is advertising a CO16 resource processor to run CP/M-86, CP/M-8000, MS-DOS, or Unix on a Z80 system (see Microsystems, September 1983, page 23). Avocet Systems Inc. is advertising several cross- assemblers that run on any computer with CP/M. Its ad claims to have a 68000 version coming soon (see BYTE, November 1983, page 435). . . . Steve

---

**Income Tax Software**

Dear Steve,

I have a Commodore 64 with a floppy disk, and I'm running Microsoft BASIC and CP/M-80. Could you tell me what software is available for state and federal corporate and personal income taxes? Thanks.

Chester Fuchs

Yonkers, NY

Several income tax programs are available for the Commodore 64. Two that recently have been advertised are: The Complete Personal Accountant (Programmer's Institute, POB 3470, Dept. C, Chapel Hill, NC 27514, (800) 334-7538), which is a combination of programs for accounting, budget, mailing lists, spreadsheets, and income taxes; and Tax Command (Practical Programs Inc., POB 93014-S, Milwaukee, WI 53203, (414) 278-0829), which features built-in tax tables and most of the commonly used schedules.

From the advertisements, it appears that both programs are designed for personal income tax preparation. I am not aware of a program for corporate or state income tax for the Commodore 64. . . . Stevo

---

**Portable Terminal**

Dear Steve,

I'm looking for a small portable terminal. My current line of thinking is to adapt a Radio Shack Pocket Computer, but I have had no luck obtaining technical information. Can you provide a source for technical information on the construction and internal operation of the PCs? Thank you for your help.

Tim McDonough

Springfield, IL

The IXO Telecomputing System sounds like the ideal solution to your problem. It features a keyboard with a full ASCII character set, has a built-in modem with autodialer, can emulate other terminals, has an uninterruptible power supply (battery), and can fit in your pocket. In addition, it has optional RS-232C and video interfaces and a 20-column printer. Best of all, its price starts at about $500. A review of this unit was presented in the April 1982 BYTE (page 6) and the May 1982 Popular Computing (page 16). For further information, contact IXO Industries Inc., 6041 Bristol Parkway, Culver City, CA 90230, (213) 417-8080.

If you have the urge to build your own, see my January and February 1984 article ("Build the Circuit Cellar Term-Mite ST Smart Terminal") on a low-cost, high-performance terminal. . . . Stevo

---

**Give Me a Break Key**

Dear Steve,

I have written a communications program for my Commodore VIC-20 that lets me do much work from home. I am communicating with a Honeywell 6000 Level 66 mainframe. The problem is that the VIC-20 doesn't have a Break key, so I cannot exit any loops. I have tried sending many different ASCII values but have had no success. The Honeywell documentation does not mention how its terminals implement the Break function. If you know how to solve this problem, I would greatly appreciate it.

Michael J. McCarthy

Pittsburgh, PA

The Break key is used to indicate a need for immediate attention. It is a unique signal and is not in the standard ASCII code. Pressing the key causes the data line to go high for approximately 300 milliseconds, which is interpreted by the computer as a Break signal. This condition always occurs when operating in a full-duplex mode, but it can oc-
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car during half-duplex operation
only when the terminal is transmitting. When the computer
is transmitting, the Break key is
unrecognized. A simple way to
achieve this 300-ms pulse is
through the use of a one-shot
circuit activated by the Break
key. . . . Steve

Laboratory Automation

Dear Steve,

I am a radiological physicist
and part of my work consists
of the calibration of X-ray
generators used in the treat-
ment of cancer. Much of the
work consists of the manual
positioning of an ionization
probe or diode within the
radiation beam and then
sampling the probe with an
electrometer. The elec-
trometer has a convenient
output for use with analog
plotters with inputs ranging
from 0 to 10 volts (V) DC.
This voltage is proportional
to the radiation intensity.

The problem is the time,
energy, and wear and tear on
the equipment, and myself,
when taking these measure-
ments. Entering the room,
walking a distance of 50 feet
or so, opening and closing a
one-ton door, positioning the
probe, and starting and stop-
ning the machine is a process
that takes nearly four
minutes per reading. Acquir-
ing enough points to
generate a beam profile can
take several hours.

I have a TRS-80 Model III
and a Starbuck Data Model
8882. The latter has an
8-channel 8-bit analog-to-
digital (A/D) converter, eight
on/off switch inputs, and
eight on/off switch outputs.
I am very happy with the
8882, and with the addition
of a few simple circuits,
which I hope you can pro-
vide, I will be able to perform
my job much more effec-
tively.

First, I would like to be able
to control a three- or four-
phase stepper motor with the
opto output switches of the
8882. The stepper must have
about 30 ounce-inches of
torque to function effective-
ly. I intend to keep track of
the position of the probe by
the number of pulses in
either direction. I need a sim-
ple stepper-motor controller
capable of direction and step-
ing logic from two of the
eight output switches of the
8882.

Second, I need a limit
switch capable of accurately
sensing a position to a milli-
meter or less, possibly some
sort of optical device. This
circuit would be used to
reference the stepper motor.

Third, I need a circuit that
would convert film optical
density into a voltage propor-
tional to film density. I will
use this device to convert a
film exposed to the radiation
beam into a dose profile. The
stepper will be used to auto-


Figure 1: Stepper-motor controller.

Figure 2: Position-limit sensor.

Figure 3: DC amplifier/scaler.

matically move the film over
the density reader.

Last, I need a DC amplifier
that will convert a voltage
from the electrometer, or
film-density reader, into a
voltage in the range of 0 to 5
V for the Starbuck 8882 A/D.
Because the electrometer
may range from 0 to 10 V and
the film-density reader also
may vary out of the 0- to 5V
range, I need the capability of
offset as well as amplification
greater than and less than
one to get the voltage be-
tween 0 and 5 V for the 8882.
This will enable me to get full
resolution out of the 8882.

I need circuits that are sim-
ple to build and understand
because I have a very limited
knowledge of electronics.

Your help could make a
substantial contribution to
the effectiveness of my job
and the treatment of our
patients.

Dwight T. Still
Lawrenceville, GA

Automating your TRS-80 to
acquire beam profiles can be
accomplished with some simple
circuits and a little research in
stepper motors.

Several manufacturers are
now producing stepper motors
that will match your needs. In
particular, North American
Philips Controls Corporation of-
fers both the stepper motors and
an integrated-circuit pulse-to-
step drive controller in 16-pin
DIP (dual-inline package). It
also offers a Stepper Motor
Handbook with all the infor-
mation needed to design a
stepper-motor device. You can
obtain this handbook from North
American Philips Controls
Corp., Cheshire, CT 06410,
(203) 272-0301.

Figure 1 was gleaned from the
Stepper Motor Handbook
and shows how simple the cir-
cuity is with the SAAX027
controller. The direction of rotation
is controlled by applying a low
or high level to pin 3. The motor
will step when a low-to-high
transition occurs on pin 15. The

432 BYTE March 1984
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For Multiplexing/DeMultiplexing...
Model 524E/319. BayTech's Model 524E, with its four buffered peripheral ports, allows four lines of data to be multiplexed and sent sequentially over a single communication line, then automatically de-multiplexed by another 524E with distribution to the corresponding peripheral ports. 524E's configured back-to-back allow economical utilization of telephone communications.

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Model 524F/329
The Model 524F is BayTech's most versatile serial port expander. With its host port and four peripheral ports capable of any-port-to-any-port interconnection, applications are virtually unlimited. Because of its features, the 524F allows the user to create a local network providing simultaneous communication for four RS-232C devices.

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values of $R_1$ and $R_2$ depend on the stepper motor chosen and the value of $V_0$. These values are tabulated in the handbook for various stepper motors.

Figure 2 shows a simple method of obtaining a reference position for the stepper motor. The method is analogous to the methods used in disk drives. An opaque disk with a small hole or slot can be mounted on the shaft of the stepper motor. A light source, such as an LED, can be mounted on one side of the disk and a phototransistor on the other side. When the light passes through the slot, the phototransistor will conduct and the voltage at pin 1 of the 74C14 Schmitt trigger will go to approximately 0 V. The Schmitt trigger will now convert this voltage change into a sharp step V-to-5-V transition at its output. This transition can now be monitored by a voltmeter or fed into one of the on/off switch inputs on the Starback 888.

Figure 3 shows one simple method of converting a film density into an analog voltage. Again, a light source is applied to one side of the film, and a phototransistor is used to sense the light on the other side. However, in this case, the magnitude of the light is monitored by your A/D circuitry through the 741 operational amplifier. The first connected as a simple inverting amplifier with gain controlled by the variable resistor $R_1$. The output voltage $V_0$ is given by $V_0 = V_i \times R_2/R_1$ where $V_i$ is the input voltage at the junction of the phototransistor and $R_3$. A shielded cable may be needed if the amplifier is placed a long distance from the phototransistor.

The circuit in figure 3 is simple in design and has no provisions for DC drift that can be caused by several factors, including ambient temperature changes. If small drift errors are a problem, you can find any number of texts on operational-amplifier design at most public or company libraries and at most bookstores.

Compatibility Revisited

Dear Steve,

As a businessperson who is a small computer user, I share the sentiments and frustrations of the first-, second-, and even third-time purchasers of small computers. In their ads, many companies claim "Apple compatible," "will run most software," etc.

What are the main aspects of a computer and software that would make them truly "IBM" or "Apple" compatible? An article on this would be of great service to those of us who don't hold advanced degrees in computer science and engineering.

Jeff Van Buren
Morehead City, NC

There are almost as many definitions of "compatible" as there are "compatible computers." A good definition of a compatible computer is one that will run the same software and accept the same hardware expansion and accessory cards as the computer with which it is supposedly compatible. Some of the compatibles offer more features at a lower price and have captured a small share of the market.

To be truly 100 percent compatible requires the same operating system and interface address locations. This is difficult to achieve without violating software copyrights, so most "compatible" computers lack certain features. CP/M allows the closest compatibility because the operating system is the same and the BIOS (basic input/output system) accounts for the hardware variations. Unfortunately, disk sizes and formats have not achieved this level of compatibility.

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subject for an article, but it would have to concentrate on a particular computer. Trying to cover the field would require an encyclopedia. . . . Steve

ZX81 Floppies and Interfaces

Dear Steve,

I have a Sinclair ZX81 and would like to use a floppy-disk drive with it. I know that I will also need an interface. Are there a drive and an interface that you know about that could be used? Thank you.

Denis Boulaix
Iberville, Quebec, Canada

A floppy-disk interface is available for the Sinclair ZX81/Timex 1000 that will allow the use of the popular Shugart SA200 disk drives. Software commands include saving and loading BASIC programs as well as data, initialization of a disk, CREATE, READ, WRITE, KILL, STAT, DIR(ectory), and NEWD(isk). All of these functions can be called from programs or from the immediate mode.

The FDC-100 interface is available for $399. A single-drive package that includes interface, drive, and power supply (FDC-101) is $499; a two-drive package (FDC-102) costs $799. Contact Compusa, 1101 Bristol Rd., Mountainside, NJ 07092, (201) 654-7220. . . . Steve

Prototype Boards

Dear Steve,

I have been looking for a prototype board like the one pictured on the front of your book, Build Your Own Z80 Computer. The only boards I can find have extra pads for regulators, etc., which make them unsuitable for your application.

Would you please let me know the manufacturer and model number of the card you used?

Robert Kanen
Long Valley, NJ

Vector Electronics has a complete line of prototype boards for many computer buses. The board shown on the cover of my book uses a 72-pin connector and was designed for the Digital Group system. I am not sure if this particular board is still available. Even if it is, obtaining 72-pin sockets will be very difficult.

I recommend one of the S-100 prototype cards that are made by Vector. The company has almost a dozen different combinations, from a blank, unetched printed-circuit board to one with power buses and pads. You will need a catalog to choose. Remember, too, that traces can be cut and rerouted to accommodate your layout.

Should you decide to expand your system, motherboards and cabinets will be readily available with the S-100 pinout and geometry.

A catalog can be obtained from your local electronics dealer or from Vector Electronics Company, 12460 Gladstone Ave., Sylmar, CA 91342, (818) 365-9661. . . . Steve

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March-April

March-April
Courses from Integrated Computer Systems, various sites throughout the U.S. "Implementing Local Area Networks," "Designing Dedicated/Embedded Computer Systems," and "Computer Network Design and Protocols" are a few of the courses to be presented. For course information, contact Ruth Dordick, Integrated Computer Systems, 6305 Arizona Place, POB 45405, Los Angeles, CA 90045, (213) 417-8888.

March-April
Courses in C Language and Unix, various sites throughout the U.S. Three five-day courses are offered: "C Programming Workshop," "Advanced C Topics Seminar," and "Unix Workshop." For complete details, contact Joan Hall, Plum Hall Inc., 1 Spruce Ave., Cardiff, NJ 08232, (609) 927-3770.

March-April
Electronic Motion Control Association Seminar, Dallas, TX and Uniondale, NY. This two-day program combines tutorial sessions with technical paper presentations and displays of devices and systems. It also reviews DC motors and control systems and overviews step motors and step-motor drives. Registration forms and information are available from the Electronic Motion Control Association, Suite 1200, 230 North Michigan Ave., Chicago, IL 60601, (312) 372-9800.

March-June
Productivity '84, various sites throughout the U.S. This series of two-day programs serves as a showcase for Hewlett-Packard products. Seminars are available, and more than 25 products are to be demonstrated, including the HP 150 personal computer and laser printers. Admission is free to the public. For more information, contact Hewlett-Packard, Public Relations Department, 3000 Hanover St., Palo Alto, CA 94304, (800) 554-4466.

March-June
Seminars from Datapro Research Corporation, various sites throughout the U.S. Subject areas include data communications, microcomputers, and information systems. In-house presentations of technical programs can be arranged. For a 40-page catalog of seminars, contact Datapro Research Corp., 1805 Underwood Blvd., Delran, NJ 08075, (609) 257-9406; in New Jersey, (609) 764-0100.

March-July
Reliability and Maintainability Engineering Institutes and Short Courses, various sites throughout the U.S. A few of the programs to be offered are "Reliability Engineering, Testing, and Maintainability Engineering" and "The Tenth Annual Reliability Testing Institute." For a complete schedule, contact Dr. Dimitri Kececioglu, College of Engineering, Aerospace and Mechanical Engineering Department, University of Arizona, Tucson, AZ 85721, (602) 621-2495.

March-August
Conferences and Expositions from the Society of Manufacturing Engineers, various sites throughout the U.S. and around the world. More than 25 conferences and expositions are scheduled. For a calendar, contact the Public Relations Department, Society of Manufacturing Engineers, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-0777.

March-October
Tutorial Short Courses from Hellman Associates, various sites throughout the U.S. Among the courses offered are "VLSI Design," "Digital Control," and "Error Correction." Fees are generally $859. For a descriptive brochure, contact Hellman Associates Inc., Suite 300, 299 California Ave., Palo Alto, CA 94306, (415) 328-4091.

March-12
Auditing and Controlling Microcomputers, Houston, TX. This seminar reviews the technology behind microcomputers and shows how they can be used by an auditor for practice management or as a tool in an audit engagement. For a course outline, contact Miriam Hoyt, MIS Training Institute Inc., 4 Brewster Rd., Framingham, MA 01701, (617) 675-7599.

March-12
Softside of Software, Hilton Harvest House, Boulder, CO. Examining the many facets of writing user-friendly software and documentation, this seminar focuses on documentation techniques, standards, software engineering tools, and designing on-line help. User and customer training are also addressed. The cost for all three days is $595. For registration details, contact Cross Information Co., Suite B, 934 Pearl Mall, Boulder, CO 80302-5181, (303) 499-8888.

March-15
Interface '84, Convention Center, Las Vegas, NV. For details on this twelfth annual data communications/information-processing conference and exposition, contact the Interface Group Inc., 300 First Ave., Needham, MA 02194, (800) 322-3330; in Massachusetts, (617) 449-6600.

March-16
Auditing in the Contemporary Computer Environment, New York, NY. Participants will learn a comprehensive audit approach for computer-based systems. Topics include how to evaluate controls, how to prepare an audit report, and how to design a program of tests using questionnaires, checklists, software tools, and flowcharts. Contact the EDP Auditors Foundation, 373 South Schmale Rd., Carol Stream, IL 60187, (312) 682-1200.

March-13
NorWesCon-84, Red Lion Inn Convention Center, Bellevue, WA. The theme of this ninth annual Pacific Northwest industrial electronics trade show is "Discover Solutions in Technology." Almost 50 manufacturers will present exhibits, demonstrations, and seminars of original equipment manufacturing and end-user products for
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March 13-15
CIMCOM, Convention Center, Washington, DC. The Computer-integrated Manufacturing and Communications (CIMCOM) conference and exposition is sponsored by the Computer and Automated Systems Association of the Society of Manufacturing Engineers (CASASME). It will focus on software development and applications, beginning with manufacturing planning and continuing through the manufacturing-control processes. For information, contact CASASME, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-1500, ext. 521.

March 13-15
MicroSET 84: Microcomputer Expo for Science, Engineering, and Technology, Engineering Society of Detroit, MI. Papers emphasizing microcomputer applications in research, design, engineering, and manufacturing will be presented. Complementing the conference program will be displays of scientific, engineering, and technical microcomputer hardware and software. For more information, write to the Conference Manager, Engineering Society of Detroit, 100 Farnsworth, Detroit, MI 48202.

March 13-15
Online Business Strategy Conferences and Exposition, Barbican Centre, London, England. Three concurrent conferences will be held: Mobile Communications, Telecoms Today, and Satellite Communications. Multiple-conference session registra-

tion is optional. Organized by Online Conferences Ltd., Registrations Dept., Pinner Green House, Ash Hill Dr., Pinner HA5 2AE, Middlesex, UK; tel: 01-868 4466; Telex: 923498 ONLINE G.
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Managing the Audit Computer-based Bank Systems, Washington, DC. This course provides a comprehensive audit approach for evaluating and testing controls in computer-based bank systems. Information is available from Darlene Floading, Bank Administration Institute, 60 Gould Center, Rolling Meadows, IL 60008, (312) 228-6200.

Technology Outlook, Wisconsin Center, Madison, WI. This seminar, conducted by the University of Wisconsin—Extension Engineering and Applied Science program, is designed for industrial executives seeking an understanding of telecommunications, automation, computer advances, and genetics. The fee is $475. For information, contact the University of Wisconsin—Extension, Department of Engineering and Applied Science, 432 North Lake St., Madison, WI 53706, (608) 262-3748.

The Sixth Annual Delaware Computer Faire, Delaware State College, Dover. Workshops, demonstrations, and sessions on the uses of computers in the classroom will be held. This program is tailored for kindergarten through senior high school teachers, administrators, and parents. Hardware and software will be exhibited. Contact Dr. William J. Geppert, Department of Public Instruction, Townsend Building, POB 1402, Dover, DE 19903, (302) 736-4885.

Saudicomputer '84—The Business Computer Show, al-Dhiafa Exhibition Centre, Riyadh, Saudi Arabia. For information, contact Philip Jenkins, Saudicomputer '84, Overseas Exhibition Services Ltd., 11 Manchester Square, London WIM 5AB, UK; tel: 01-486 1951; Telex: 24591 Montex G.

The First Annual Computer Furniture and Home Office Show, Serra Grand Ballroom, Convention Center, Monterey, CA. Approximately 100 exhibits are planned. Seminars designed to introduce manufacturers and retailers to marketing and merchandising techniques will be conducted. For further details, contact National Fairs Inc., 1902 Van Ness Ave., San Francisco, CA 94109, (415) 474-2300.

Material Characterization Techniques for Integrated-Circuit Processing, San Mateo, CA. This three-day course is designed to acquaint participants with current techniques for integrated-circuit development, process monitoring, and failure analysis. The course fee is $450 for lectures only or $695 for the third-day lab session. For information, contact Continuing Education in Engineering, University of California Extension, 2223 Fulton St., Berkeley, CA 94720, (415) 642-4151.

Automated Manufacturing Conference and Exhibition (AM84), Textile Hall, Greenville, SC. Representatives from more than 200 firms will present the latest automated manufacturing technologies at this combination exhibition and seminar. Conference details can be obtained from the AM84 Registration Control Center, POB 5616, Station B, Greenville, SC 29606, (803) 242-3730, ext. 260. Exhibition details are available from AM84, POB 5823, Greenville, SC 29606, (803) 233-2562.

Computers in Construction, New York, NY. This seminar is designed to assist construction contractors and construction management firms in acquiring computer systems. The fee is $425 per registrant. More details are available from CIP Information Services Inc., 1105-F Spring St., Silver Spring, MD 20910, (301) 589-7933.

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March 22-25
The Ninth West Coast Computer Faire, Civic Auditorium and Brooks Hall, San Francisco, CA. This is one of the largest annual computer shows. For information, contact the Computer Faire Inc., Suite 201, 181 Wells Ave., Newton, MA 02159, (617) 965-8350; in California, (415) 364-4294.

March 23
The 1984 Computer Law Institute, Cleveland, OH. This event, sponsored by the Bar Association of Greater Cleveland, will cover current legal and tax issues that affect the computer industry. For details, contact Carole Falcone, Mall Building, Cleveland, OH 44114, (216) 696-3525.

March 24
The Seventh Annual Philadelphia Area Computer Society Computer Games Festival, La Salle College Ballroom, Philadelphia, PA. Recreational and educational games will be featured. For more information, contact Dr. Stephen A. Longo, Physics Department, Box 312, La Salle College, Philadelphia, PA 19141, (215) 951-1255.

March 25
The Fifth Annual Lake County Hamfest and Computer Fest, Madison High School, Madison, OH. Admission is $5 in advance. For information, send a self-addressed, stamped envelope to Lake County Hamfest Committee, POB 150, Mentor, OH 44061, (216) 953-9784.

March 26-29
The 1984 National Design Engineering Show & ASME Conference, McCormick Place, Chicago, IL. More than 600 companies will display and demonstrate products and services in this conference program sponsored by ASME (American Society of Mechanical Engineers). Almost 50 technical sessions and 20 short courses will cover engineering management and operations, CAD/CAM and CAE, materials and processes, mechanical and fluid systems, and electronics. Information is available from the National Design Engineering Show & Conference, 708 Third Ave., New York, NY 10017, (212) 661-8410.

March 26-29
Personal Computer Interfacing and Scientific Instrument Automation, Blacksburg, VA. These hands-on workshops, sponsored by the Virginia Polytechnic Institute and State University, provide participants with experience in wiring and testing interfaces on popular personal computers. For information, contact Dr. Linda Leffel, C.E.C., Virginia Tech, Blacksburg, VA 24061, (703) 961-4848.

March 26-30
The Sixth NC Industrial Automation and Robot Conference and Exhibition, Milan Fair, Milan, Italy. Controls for automated material handling, variable mission manufacturing systems, and quality control will be featured. A concurrent conference consisting of 20 sessions will be presented. For more information, contact the Society of Manufacturing Engineers, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-0023.

March 26-27
The Eighth Annual Computer Expo, University of Dayton Arena, Dayton, OH. Terminals, minicomputers, microcomputers, and word processors will be featured. Details can be obtained from Dan Schumacher, University of Dayton, 300 College Park Ave., Dayton, OH 45469, (513) 229-3511.

March 27-28
Meetings of the American National Standards Institute, Marriott Crystal Gateway Hotel, Arlington, VA. Two meetings are planned: the Annual Public Conference of the ANSI and the Seminar on Administering Domestic Standards Activities. The theme for the former is "Standards and the Law." The latter will focus on due process and such issues involved in standardization as the interpretation of standards and coordination of domestic and international activity. Contact Deborah R. Maskin, Communications Department, American National Standards Institute Inc., 1430 Broadway, New York, NY 10018, (212) 354-3315.

March 27-29
Southwest Computer Conference (SWCC), Myriad Convention Center, Oklahoma City, OK. This seventh annual business and industry conference is aimed at both management and technical personnel. It will feature more than 50 seminar presentations and 250 exhibits. For details, contact E. Z. Million, SWCC, POB 950, Norman, OK 73070, (405) 329-3660.

March 28-30
The Sixth Annual Computer Graphics Conference, Doral Hotel On-the-Beach, Miami Beach, FL. The theme for this conference is "Forecast and Assessments." Further details are available from Carol Sapchin, Frost & Sullivan Inc., 106 Fulton St., New York, NY 10038, (212) 233-1080.

March 30-April 1
The NY Personal Computer Show, Exposition Rotunda, Madison Square Garden, New York City. Formerly called the Eighty/Apple/PC Computer Show, this event will feature products and services for all small computer systems. Complete show details can be obtained from the Kengore Corp., POB 13, Franklin Park, NJ 08223, (201) 297-2526.

April 1-4
The 1984 EFT Expo, Hyatt Regency, Grand Cypress Resort, Orlando, FL. This annual convention and exposition, sponsored by the Electronic Funds Transfer (EFT) Association, provides the op-
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potency to meet with leaders and experts in the field of automated payments systems and services. The fee is $495 for EFT members and $625 for nonmembers. For details, contact the Convention Coordinator, EFT Association, Suite 800, 1029 Vermont Ave. NW, Washington, DC 20005.

April 2-4

Speech Tech-84, St. Moritz Hotel, New York City. This voice-synthesis and recognition applications show covers voice input/output as applied to computers, telecommunication, defense electronics, robotics, education, and aids for the handicapped. The registration fee is $150. For information, contact Stanley Goldstein, Media Dimensions Inc., 525 East 82nd St., New York, NY 10028, (212) 680-6451.

April 2-5

The 1984 Test & Measurement World Expo, Brooks Hall, San Francisco, CA. This is the third annual expo sponsored by Test and Measurement World, a magazine from Interfield Publishing. For details, contact Meg Bowen, Test & Measurement World Expo, 215 Brighton Ave., Boston, MA 02134, (617) 254-1445.

April 2-6

The Third Conference on Computing in Civil Engineering, Holiday Inn at the Embarcadero, San Diego, CA. Seminars, tutorials, and vendor displays will focus on computers in education, special applications, and future directions. Emphasis will be on computer-aided design and drafting. Complete conference particulars are available from the Society for Computer Applications in Engineering, Planning, and Architecture Inc., 358 Hungerford Dr., Rockville, MD 20850, (301) 762-6070.

April 3-5


April 4-6

Introduction to Computers and Their Applications, Pinehurst Hotel and Country Club, Chapel Hill, NC. This educational workshop is designed for professionals and executives. For a brochure, contact Learning at Pinehurst, POB 2328, Chapel Hill, NC 27514, (919) 967-6996.
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April 4-11
CeBIT, Hannover, West Germany. This office-equipment and data-processing technology exhibition will bring together exhibitors from more than 25 countries. For information, contact Hannover Fairs Information Center, POB 338, Route 22 E, Whitehouse, NJ 08888, (800) 526-5978; in New Jersey, (201) 534-9044.

April 5-7
COMDEX/Winter, Convention Center, Los Angeles, CA. For information, contact the Interface Group Inc., 300 First Ave., Needham, MA 02194, (800) 325-3330; in Massachusetts, (617) 449-6600.

April 7-8
Eastern States Conference, Franklin Plaza Hotel, Philadelphia, PA. Speakers, demonstrations, and workshops focusing on "Computers and Reading/Learning Difficulties" are planned. For additional information, contact Educational Computer Conferences, Department N, 1070 Crows Nest Way, Richmond, CA 94803, (415) 222-1249.

April 8-11
World Retailers Business & Equipment Exposition, Palais des Congres, Paris, France. This exposition is sponsored by the National Retail Merchants Association (NRMA) and runs concurrently with NRMA's Ninth World Conference of Retailers. The exposition is designed to introduce store merchants to new developments, equipment, and procedures. Admission is free, although retail store merchants must show ticket. For complimentary tickets and details, write to Dan Soskin, NRMA Enterprises, 100 West 31st St., New York, NY 10001.

April 9-12
Intergraphics '84, Sasakawa Memorial Hall, Tokyo, Japan.

This conference and exposition is cosponsored by the Society of Manufacturing Engineers (SME) and the World Computer Graphics Association (WCGA). It will focus on the growing importance of computer graphics in business and manufacturing industries. For information, contact James McLaughlin, Society of Manufacturing Engineers, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-0023.

April 10-11
Business Expo & Conference '84, Convention Center, San Jose, CA. More than 30 workshops, seminars, and panel discussions have been scheduled. A few of the presentations are "Handling Training Crisis in Office Automation Explosion," "How to Select Small Business Computers," and "Managing Your Small Business." Complete details are available from Expo '84 Management, Cartlidge & Associates Inc., Suite 205, 4030 Moorpark Ave., San Jose, CA 95117, (408) 554-6644.

April 12-14
Computers and Writing—Research and Applications, University of Minnesota, Minneapolis. Papers and panel discussions will focus on local-area networks, empirical studies of writer's behavior, and automatic evaluation or correction of writing. Demonstrations of hardware and software are planned. For further information, contact the Program in Composition and Communication, University of Minnesota, 209 Lind Hall, 207 Church St. SE, Minneapolis, MN 55455, (612) 373-2541.

April 13-14
The Fourteenth Annual Virginia Computer User's Conference, Sheraton Hotel, Blacksburg, VA. This con-
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Ference is sponsored by the Virginia Tech Student Chapter of the ACM (Association for Computing Machinery) and the computer science department of Virginia Tech. Topics include modeling and simulation, STARs and Japanese fifth-generation computer, and microcomputers. For information, contact Suzanne Nagy or Roger Goff, VCUJUC-14, 562 McBryde Hall, Virginia Tech, Blacksburg, VA 24061.

### April 13-15

**The International Personal Robotics Congress and Exposition**, Convention Center, Albuquerque, NM. International corporations and high technology executives can view the latest in robots designed to serve personal needs. For details, contact Albuquerque Convention and Visitors Bureau Inc., POB 26866, Albuquerque, NM 87125-6866, (505) 243-3696.

### April 13-15

**Interstellar Personal Computer Show**, Interstate Fairgrounds, Spokane, WA. For details, contact Heymac Promotions, East 3607 33rd, Spokane, WA 99203, (509) 534-3661 (mornings) or (509) 327-4842 (afternoons).

### April 14

**Microcomputers and Basic Skills in College**, Instructional Resource Center, City University of New York, NY. Papers will explore the use of microcomputers in post-secondary school basic-skills instruction, including English as a second language, reading, writing, and speech. Address inquiries to Geoffrey Akst, Conference Chair, Instructional Resource Center, City University of New York, 535 East 80th St., New York, NY 10021, (212) 794-5425.

### April 14

**Third Semi-annual Meeting of the Massachusetts Association of Computer-using Educators**, Simmons College, Boston, MA. This meeting will feature demonstrations on the uses of computers in the classroom. Contact Dr. Leonard Huber, Hampshire Educational Collaborative, Center School, 36 Hadley St., South Hadley, MA 01075, (413) 534-4563.

April 14-15

**The Ninth Annual Trenton Computer Festival**, Trenton State College, Trenton, NJ. More than 100 commercial exhibitors will complement five acres of flea-market tables. Contact Marilyn Hughes, Trenton State College, Trenton, NJ 08625, (609) 771-2487.

April 16-18

**Softside of Software**, Loew's L'Enfant Plaza Hotel, Washington, DC. For details, see March 12-14.

April 16-18

**Videotex '84**, Chicago, IL. The focus of this international conference and exhibition is commercial applications and activities of videotex. For details, contact Sally Summers, London Online Inc., Suite 1190, 2 Penn Plaza, New York, NY 10121, (212) 279-8890.

April 17-19

**IPAD II**, Marriott Hotel, Denver, CO. This is the second national symposium to promote a wider awareness of the technology surrounding the Integrated Program for Aerospace-vehicle Design (IPAD). The focus will be on advances in distributed database management technology to support integrated CAD/CAM requirements. It is sponsored by the National Aeronautics and Space Administration, the Department of the Navy, and the Industry Technical Advisory Board for IPAD. Information is available from the IPAD Project Office, Mail Stop 246,
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April 18-19
Minnesota Office Systems Association Symposium and Exhibition, Hyatt Regency, Minneapolis, MN. Speakers, more than 100 exhibits, and 21 seminars will highlight this eleventh anniversary event focusing on "Evolving Technologies." Further information is available from the Minnesota Office Systems Association, POB 2144, Loop Station, Minneapolis, MN 55402-0144, (612) 293-1395.

April 18-20
The 1984 Rocky Mountain Data Processing Expo & Conference, Denver, CO. This is the seventh annual expo sponsored by the Mile High Chapter of the Data Processing Association. Displays will include mini- and microcomputers, word processors, software, educational services, and network systems. It is being held in conjunction with the DPMA's Region 4 conference. For information, contact Industrial Presentations West Inc., Suite 304, 3090 South Jamaica Court, Aurora, CO 80014, (303) 696-6100.

April 23-27
Auditing in the Contemporary Computer Environment, Philadelphia, PA. For details, see March 12-16.

April 24-25
Workspace 84, Moscone Center, San Francisco, CA. This second annual conference and exposition, sponsored by National Fairs Inc., will be devoted to the concerns of the automated office. For details, contact Charley Yourd, National Fairs Inc., 1902 Van Ness Ave., San Francisco, CA 94109.

April 26-28
Science Park '84, New Haven, CT. This microcomputer conference and exposition is designed for small-business executives. For details, contact Science Park '84, Five Science Park, New Haven, CT 06511, (203) 436-3089.

May 1984

May-July
Courses from Integrated Computer Systems, various sites throughout the U.S. Among the courses to be presented are "Designing with 16-bit Micros," "Programming in C: A Hands-on Workshop," and "Hands-on Unix Workshop." The fee for each course is $895. Enrollment details are available from Ruth Dordick, Integrated Computer Systems, 6305 Arizona Place, POB 45405, Los Angeles, CA 90045, (213) 417-8888.

May 1-3
Electronic Production Efficiency Exposition, National Exhibition Centre, Birmingham, England. This exhibition brings together various organizations involved in producing hardware and software for automated factories. Technical sessions will cover such issues as computer-aided design and manufacturing, integration, test diagnosis and repair systems, and electronic-manufacturing assembly techniques. Contact Network Events Ltd., Printers Mews, Market Hill, Buckingham, MK18 1JX, England; tel: (0280) 815226; Telex: 83111.

May 4-6
The Serious Computer Show, Currigan Hall, Denver, CO. Conference topics include "Reducing Information Storage Costs Through Micrographics," "Software Integration for the '80s," and "The Law as It Relates to the Computer World." Microcomputers, peripherals, services, accessories, and supplies will be exhibited. For complete particulars, contact Industrial Presentations West Inc., Suite 304, 3090 South Jamaica Court, Aurora, CO 80014, (303) 696-6100.

May 5
The Sixth Annual Computer Conference for Educators, Lesley College, Cambridge, MA. Panel discussions, more than 20 presentations, and sessions that include hands-on workshops on software in science, social science, language arts, and mathematics will be offered. Additional information is available from Susan Friel or Nancy Roberts, Lesley College, 29 Everett St., Cambridge, MA 02238, (617) 868-9600.

May 7-9
EDP Audit, Controls, and Security Symposium, Woodfield Hyatt House, Woodfield, IL. This symposium provides seminars, workshops, and exhibits relating to the state of the art in electronic data-processing auditing. Address inquiries to EDP Audit Associates Inc., POB 255, Chicago Ridge, IL 60415, (312) 582-4622.

May 7-11
Tutorials for Professional Development, Marriott O'Hare, Chicago, IL. Two tracks, "Software Engineering" and "Networks and Communications," compose this program sponsored by the IEEE Computer Society and the Association for Computing Machinery. For a copy of the program, contact Tutorials for Professional Development, POB 639, Silver Spring, MD 20901, (301) 589-8142.
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May 9-11
Session 84, Calgary, Alberta, Canada. This is the annual national conference of the Canadian Information Processing Society. The theme is "1984: Images of Fear, Images of Hope." Parallel seminars, panel discussions, technical papers, and exhibits of hardware, software, and services will assist in the exchange of views between users and suppliers. Conference information can be obtained from Ms. Marilyn Harris, Suite 722, Suncor Tower, 500 4th Ave. SW, Calgary, Alberta T2P 2V6, Canada, (403) 261-5903.

May 12-14
Softwest '84, Regency Hotel and Conference Center, Denver, CO. This conference and exhibition features seminars, lectures, and panel discussions on software, equipment, and peripherals for Apple and IBM computers. For information, contact Colorado Conference Group, Suite C, 3312 Cripple Creek, Boulder, CO 80303, (303) 499-1034.

May 13-17
Computer Graphics '84, Convention Center, Anaheim, CA. This is the fifth annual conference and exhibition sponsored by the National Computer Graphics Association (NCGA). For details contact the NCGA, 8401 Arlington Blvd., Fairfax, VA 22031, (703) 698-9600.

May 14-16
Annual Conference of ADCIS, Ohio State University, Columbus. This annual conference is sponsored by the Association for the Development of Computer-based Instructional Systems (AD­CIS). Papers and demonstrations of hardware, software, and courseware will emphasize portability. For details, contact ADCIS International Headquarters, 409 Miller Hall, Western Washington University, Bellingham, WA 98225, (206) 676-2860.

May 15-17
Criminal Justice Systems Conference, Virginia Commonwealth University, Richmond, VA. Presentations and panel discussions on recent developments in criminal justice applications of computer technology are planned. Additional sessions will address the uses of microcomputers in law enforcement. The fee is $20. Information is available from Ben Wood, Department of Criminal Justice Services, 805 East Broad St., Richmond, VA 23219, (804) 786-4000.

May 15-17
Micro City '84, Exhibition Complex, Bristol, England. More than 100 companies will exhibit computers, business systems, and communications equipment. For complete details, contact Tomorrow's World Exhibitions Ltd., 9 Park Place, Clifton, Bristol BS8 1P, England; tel: (0272) 292156/7.

May 16-18
Teaching Math with Microcomputers, Marriott Hotel, Miami, FL. This program, sponsored by the National Council of Teachers of Mathematics (NCTM), is designed to inform elementary, intermediate, and secondary school teachers of mathematics how to effectively use the microcomputer as a classroom tool. For further information, contact NCTM, 1906 Association Dr., Reston, VA 22091, (703) 620-9840.
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The Seventh Annual Show & Tell Microcomputer Conference, University of Oklahoma Mathematics and Physical Science Complex, Norman, OK. Computer hobbyists are invited to speak briefly, demonstrate an example of their presentation, and answer questions in a Show & Tell period. For details, send a self-addressed, stamped envelope to Show & Tell, Dr. Richard Andree, University of Oklahoma, Mathematics Department, 601 Elm St., Norman, OK 73019.

May 20-23

The Thirteenth Mid-Year Meeting of the American Society for Information Science, Indiana University, Bloomington. The theme for this meeting is "The Micro Revolution: Implications for the Information Age." Joseph Weizenbaum, author of Computer Power and Human Reason and a computer science professor at MIT, will speak. For more information, contact Stephen Harter, School of Library and Information Science, Indiana University, Bloomington, IN 47405, (812) 335-5113.

May 20-25

The Fourth Jerusalem Conference on Information Technology—JCIT, Jerusalem, Israel. Papers, panel discussions, workshops, and exhibits will emphasize software engineering and manufacturing related to the theme of this international event, the "Next Decade in Information Technology." Until April 30, the registration fee is $200. After that date, the fee is $225. Isratech '84, the national exhibition of high technology, runs concurrently with JCIT. For information on Isratech '84, contact the Government of Israel Trade Center, 350 Fifth Ave., New York, NY 10118, (212) 560-0660. For details on JCIT, contact the Fourth Jerusalem Conference on Information Technology, POB 2933, 61292 Tel Aviv, Israel; tel: (03) 258-535.

May 21-23

AAMS Congress 1984—The Third Spring Joint National Congress, Hilton Hotel, San Francisco, CA. Invited and contributed papers, special sessions, tutorials, reviews, panel discussions, and demonstrations will explore the applications of computers and information technology and systems to all fields of medicine. A dozen professional organizations have joined the American Association for Medical Systems and Informatics (AAMS) as program sponsors. For particulars, contact AAMS, Suite 402, 4405 East-West Highway, Bethesda, MD 20814, (301) 657-4142.

May 22-25

COMDEX/Spring, Georgia World Congress Center, Atlanta. For details, contact the Interface Group, 300 First Ave., Needham, MA 02194, (800) 325-3330; in Massachusetts, (617) 449-6600.

May 22-26

Oficomp Korea 84—The International Korean Office and Information Management Exhibition and Conference, Korea Exhibition Center, Seoul, South Korea. Exhibits will include demonstrations of computers, communications equipment, and business machines. Contact Clapp & Pollak International, POB 70007, Washington, DC 20088, (301) 657-3090.

May 23-24

Automach-Australia '84, Royal Hall of Industries Showground, Sydney. This trade show serves to update Australian manufacturing industries on automated, integrated factory systems incorporating numerically controlled machinery, CAD/CAM, and robotics. Contact SME World Headquarters, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-1500. In Australia, contact Mr. Groco, Howard Rotator Pty., POB 82, Parramatta 2150, New South Wales, Australia; tel: 630-1231; Tele: AA21328.

May 23-24

The 1984 Trends and Applications Conference, National Bureau of Standards, Gaithersburg, MD. Presentations will address current systems and applications as well as research into advanced concepts relating to the theme, "Making Database Work." Information can be obtained from Trends and Applications 84, POB 639, Silver Spring, MD 20901, (301) 921-3491.

May 23-25

The Eighth Conference on Computer Applications in Radiology, Stouffer's Riverfront Towers, St. Louis, MO. Patient information systems, personal computers and computers for the private office, teleradiology, computer-assisted instruction, and artificial intelligence are a few of the topics to be covered. Exhibits are included. The fee is $350. For details, contact American College of Radiology, 20 North Wacker Dr., Chicago, IL 60606, (800) 227-5463; in Illinois, (312) 236-4963.

May 25-29

The Third Annual European Semiconductor Industry Conference, Hotel Kempinski, Berlin, West Germany. International industry leaders will discuss issues facing the semiconductor industry. Contact Barbara Chupp, Dataquest Inc., 1290 Ridder Park Dr., San Jose, CA 95131, (408) 971-9000.

May 29-31

Gulf Coast Computer and Office Show, New Orleans, LA. Speakers, technical sessions, and product displays will highlight this exhibition. For full details, contact Gulf Coast Computer and Office Show, 119 Avant Garde Circle, Kenner, LA 70062, (504) 467-9949.

In order to gain optimal coverage of your organization's computer conferences, seminars, workshops, courses, etc., notice should reach our office at least three months in advance of the date of the event. Entries should be sent to: Event Queue, BYTE Publications, POB 372, Hancock, NH 03449. Each month we publish the current contents of the queue for the month of the cover date and the two following calendar months. Thus a given event may appear as many as three times in this section if it is sent to us far enough in advance.

BYTE's Bits

Call for Papers

The conference chairperson for COMPCON Fall 1984 (September 16-19, Hyatt Regency Crystal City, Arlington, VA) has issued a call for papers on the theme "The Small Computer (R)evolution." Suitable topics include user friendliness, embedded systems, and the architecture of small computer applications and products. Send three copies of your 1000- to 5000-word paper to Joe Batz, Small Computer (R)evolution, POB 639, Silver Spring, MD 20901, before April 2.
The Micromint Collection

Micromint. Supporting the varied projects that appear in Steve Ciarcia’s monthly article in BYTE Magazine, “Ciarcia’s Circuit Cellar.” Offering a wide range of computers and peripherals designed to meet the exacting demands of the hobbyist as well as worldwide corporate clients.

TERM-MSTE SMART TERMINAL BOARD

As featured in Ciarcia’s Circuit Cellar
BYTE Magazine, January 1984
You need to build a Smart Video Terminal equivalent to the types advertised for $19.00 or more in a Term-Mite ST circuit board, scanned or parallel keyboard, video monitor and power supply.

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BCC22 Complete Kit $244.

28 BASIC SYSTEM CONTROLLER NEW!!!

As featured in Ciarcia’s Circuit Cellar: BYTE Magazine, July & August 1984

The 28 Basic System Controller is an updated version of our popular BCC20. The price has been reduced and features added. The entire computer is 4” x 4” and includes a built-in interface, up to 64 bytes of RAM and EPROM. Ours RS-222 serial port with switchable baud rates and two parallel ports. BASIC or machine language programming is accomplished simply by connecting a CRT terminal. Programs can be transferred to 2732 EPROMs with an optional EPROM programmer for auto start applications. Additional 28 peripheral boards include memory expansion, serial and parallel I/O, real time clock, a C007 Converter and an EPROM programmer.

- Uses Diblo 28 single chip microcomputer.
- Data and address buses available for D/A memory.
- Can be battery operated.
- Comes assembled for various computers.

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- 8K bytes of additional RAM or EPROM
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- Cassette interface — 300 baud & standard
- Software real time clock
- BCC28 with RAM Assembled & Tested $150.
BCC28 4K RAM Assembled & Tested $180.

28 EPROM PROGRAMMER

- Transfer BASIC or Assembly Language application programs from RAM to 2716 or 2732 EPROM
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With the new Z8 in board A4, FORTH you can program high speed control functions in a very simple high level language command. Perfect for data reduction, process control and high speed control applications.

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DC04 APPLE II Complete Kit $294.

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- IBM PC Complete Kit $298.

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- With sound generator & joystick interface.
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Visitors Welcome in Atlanta

The Atlanta IBM-PC Users Group, a nonprofit corporation that assists users of the IBM Personal Computer and similar personal or desktop computers, welcomes visitors to its monthly meetings. General meetings are held the second Wednesday of every month at 7:30 p.m. and business-users meetings convene at the same time on the third Wednesday of every month. The club maintains a software library, a bulletin board, and a monthly newsletter, Atlanta PC News. A discount is offered to members at local computer stores. Annual dues are $20 a year. For details, contact the Atlanta IBM-PC Users Group Inc., POB 76516, Atlanta, GA 30358, or call Will Macoy at (404) 433-4500.

Windy City Atarians

Suburban Chicago Atarians (SCAT) is an independent computer user group that meets on the first Saturday of each month at 11 a.m. A monthly newsletter containing articles, minutes of the meetings, and programs is produced. Membership is $15 annually, which includes a subscription to the newsletter. Write to SCAT, POB 72266, Roselle, IL 60172.

A Real Network

The Real Estate Information Network Inc. (REINET) provides programs and other information for real estate professionals, appraisers, investors, syndicators, brokers, property managers, and attorneys. It supports various newsletters, a financial database, current sales and rental data, and other items of interest for realty professionals. REINET takes special interest in the TRS-80 Model 100. A quarterly publication, REINFO, is produced. Membership requires a one-time connect charge of $100; the hourly rate is $4.50. For membership information, send a self-addressed, stamped envelope to REINET, POB 257, Nyack, NY 10960, or call Compuserve 72235,301.

Over Hill, Over Dale

Field Portable Computing, an independent quarterly newsletter produced by Breakthrough Inc., contains product reviews, industry trends, analyses, and information of interest to both users and manufacturers of battery-operated briefcase-style computers. Single issues are $15; an annual subscription is $48. For details, contact Breakthrough Inc., POB 230, Logan, UT 84321, (801) 753-7555.

Printscreen in the Bay Area

The Stanford/Palo Alto Users Group for the IBM PC meets at 7 p.m. on the last Wednesday of every month. The monthly newsletter, PritSc, is free with an annual $25 membership. For information, write to Linda de Sosa, POB 3738, Stanford, CA 94305, or call (415) 856-6281.

The Cottage Industry

Cottage Computing, a monthly publication from Home Business News, contains the latest information on computer-based businesses, book and software reviews, and business techniques. It contains bulletin-board listings, an education column, product briefs, classified advertisements, and events. Nontechnical articles and paid advertising are accepted. Single issues are $1 and subscriptions are $12 a year. For information, contact Home Business News, 12221 Beaver Pike, Jackson, OH 45640.

An Original Eye Opener

The Original Apple IIIrs is a nonprofit organization that meets at 7:30 p.m. on the third Wednesday of each month in San Francisco. The newsletter, Open Apple Gazette, is produced monthly and contains articles on important points about the Apple III. Annual membership is $30. Further details are available from Original Apple IIIrs, 1850 Union St. #494, San Francisco, CA 94123.

Model 100 Club in Britain

Users of the TRS-80 Model 100 in England have formed a club to ensure the machine's capabilities are realized. A quarterly newsletter is planned. An annual subscription is £12. Send a self-addressed envelope for details to REMSOFT, 18 George St., Brighton BN2 1RH, England.

Apples In Oak Ridge

Users of Apple, Franklin, and compatible computers are welcome to join a club in Oak Ridge, Tennessee, that meets to exchange knowledge, skills, and software in the areas of members' interests. An annual membership is $15. For details, contact the Computer & Program Exchange Club (CAPEC DEP-D), POB 1142, Oak Ridge, TN 37831.

Dues for News or Floppies

The Robin Owners Group is a nonprofit group dedicated to spreading information to owners and users of the DEC Robin (VT100). A newsletter is produced and costs $2 for every four issues. Floppy disks containing public-domain software are $2 and include a formatted disk. For details, contact John Comella, 2 Mockingbird Lane, Maynard, MA 01754.

Mother Hubbard Invites Women

The Mother Hubbard Users Group meets every month, alternating between mornings and evenings to allow all members to participate. This women's user group is designed to introduce computer novices to the uses of the Apple computer. Meetings are free and are held either in the Long Beach/West Orange County area of California or at CompKids Inc. in Seal Beach. For details, contact Dory Spencer at (213) 438-5643 or Mary Kay Tumajian at (213) 597-6330, or write to CompKids Inc., Rossmoor Shopping Center, 12385 Seal Beach Blvd., Seal Beach, CA 90740, (213) 430-7226.

C-64 Users of the South Bay

The South Bay Commodore 64 Users Group meets on the second and fourth Tuesdays of each month to discuss problems, programs, and hardware. Classes and...
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North American Readout

The North American Computer Service Association (NAC/SA) is composed of charter memberships by participating companies and corporations. NAC/SA promotes the development of computer maintenance, services, and industry. The group offers courses, conducts surveys, sponsors conferences, and produces a newsletter entitled Readout. Associate memberships by participating companies and corporations are based on the size of the company; a flat rate is available for individuals and educational institutions. For additional information, contact David Glasscock, NAC/SA, 227 North Magnolia #202, Orlando, Fl. 32801, (305) 442-2000.

Virginia's Technical Network

CPro Users Group, a national users group for owners and users of Godbout's Computer, is designed for technical people to share information, solutions, and applications. A monthly newsletter is produced, a bulletin board is maintained, and publication of the member list is anticipated. Membership is $10. For details, contact Curt Hess, CPro Users Group, POB 2474, Woodbridge, VA 22193, (703) 690-3312.

Japanese Atari Club

An Atari users group, the Ryukyu Atari Motivators (RAM), welcomes new members, information, and newsletter exchanges. RAM is an affiliate of the Okinawa Computer Club, which serves users of many kinds of computers. For details, write W. Martin Justice, PSC#2, Box 11165, APO SF, CA 96367.

What You Can Do For Your Club

The Society of Pet Handlers for Information Exchange (SPHINX) is a Commodore users group in the San Francisco area. Meetings and classes are held, a newsletter is produced, and a bulletin board is maintained. SPHINX also distributes public-domain software and equipment. Suggestions are welcome. Annual membership dues are $24. For information, send $2 for a catalog, or contact SPHINX, 267 Arlington Ave., Kensington, CA 94707, (415) 527-9286.
See BASIC News

CBNews, the monthly newsletter of the CBASIC Compiler Users Group (CBUG), is produced by Software Magic for the benefit of CB80 users. It covers corporate news, letters, new products such as conversion tools, and bugs. Call the CB80 hotline, (213) 765-3957, with problems or questions. A 12-issue subscription is $12. Contact CBNews, Software Magic, 11669 Valerio St. #213, North Hollywood, CA 91605, (213) 765-3957.

National Capital Group for Apple

Washington Apple Pi meets at 10 a.m. on the fourth Saturday of each month in Bethesda, Maryland, on the campus of the National Naval Medical Center. Meetings include speakers and cover such topics as databases and the uses of personal computers by disabled persons. A sign interpreter and reserved seating are provided. The club maintains a hotline serving 4000 members and produces a monthly publication. For further information, contact Washington Apple Pi, Suite 201, 8227 Woodmont Ave., Bethesda, MD 20814, (301) 654-8060.

Massachusetts CP/M Users Meet

The Central Mass CP/M Users Group welcomes CP/M and VT-180 users to meetings held at 2 p.m. on the first Sunday of every month in Shrewsbury, Massachusetts. The intention of the meetings is to distribute information and there are no dues. For further details, contact Brother Jim Smith, Saint John’s High School, 378 Main St., Shrewsbury, MA 01545, or call (617) 845-1878.

Applications for the Blind

Raised Dot Computing Newsletter is free to owners of Braille-edit, a software program that works in print, braille, and voice. The monthly newsletter will cover the applications of small computers for the blind and for transcribers, low-cost braille devices and translation, and voice synthesis. Subscriptions are available in the two forms of print or audio; 12 print issues cost $12 and 12 cassettes cost $20. A sample print issue is free; back issues are $2 each. For information, contact Raised Dot Computing, 310 South 7th St., Lewisburg, PA 17837, (717) 523-6739.

CP/M Grows in Napa Valley

The Napa Valley CP/M Users Group (NVCPMUG) meets at 7:30 p.m. on the second Wednesday of each month at the Napa Valley College Campus and welcomes anyone interested. Meetings are free and there are no membership dues. Topics include system languages and hardware applications related to CP/M. The newsletter is on line 24 hours a day on the club’s remote CP/M bulletin-board system (RCPM). To access the Napa Valley RBB5/RCPM, call (707) 257-6502, or mail a self-addressed, stamped envelope to NVCPMUG, POB 4096, Napa, CA 94558.

Cooking With Gas

The Sacramento Area Users of Televideo Equipment (SAUTE) meets twice a month to listen to lectures prepared by one of the members on applications relevant to programmers and systems analysts who use Televideo TS802 and TS803 systems. After each meeting is an open discussion; printed minutes are distributed. Exchanges of information or out-of-town members who would benefit from the communications are welcome. Dues are $12 a year. For details, contact Ron Odom, SAUTE’, 8200 Longden Circle, Citrus Heights, CA 95610.

Silicon Valley Hosts dBASE II Users

The dBASE II User Group/Silicon Valley meets at 7 p.m. on the first Wednesday of each month in Sunnyvale, California. It is designed for all levels of users of Ashton-Tate’s dBASE II. There are no dues. For details, contact Melissa Gray, dBASE II User Group/Silicon Valley, POB 190, Mountain View, CA 94042-0190.

If you would like BYTE readers to know about your club or newsletter send the details accompanied by no more than one newsletter to Clubs and Newsletters, BYTE Publications, POB 372, Hancock, NH 03449. Overseas groups are encouraged to participate. Please allow at least three months for your announcement to appear.
Anyone can sell you a box full of hardware. But is it too much computer? Too little? Will it run the appropriate software? What about service? If you need the right answers before and after the sale, call your nearest Full Service CompuPro System Center. For product information, see pgs. 119 & 410.
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Capital Strategy for Investors, an investment-planning program. By performing mathematical calculations, this program not only lets you decide what to invest in, but how much to invest. The computer will provide information for optimal capital growth without financial strain, show the effects of the growth rate, and test the results of varied investment decisions. For II Plus, Ile, and III; floppy disk, $69. Ventura Data Systems, 1061 Sage View, Chula Vista, CA 92010.

Family Medical Advisor, a medical-diagnostic program. This program is designed to analyze health symptoms and identify probable causes of medical conditions, including drug abuse and poisoning. Using almost 10,000 combinations of symptoms, the program helps to diagnose common ailments, obscure diseases, or childhood illnesses. You reply with yes and no answers to a series of questions. For informational purposes only. For the II; floppy disk, $37.50. Navic Corp., Box 14727, North Palm Beach, FL 33408.

Gene Machine, an educational program for use by high school biology students. This program explores the basic ideas concerning the structure and function of the two nucleic acids, DNA and RNA. Also useful for chemistry courses that include aspects of the chemical basis of heredity. For II, II Plus, and III; floppy disk, $65. HRM Software, 175 Tompkins Ave., Pleasantville, NY 10570.

The Graphics Department, an integrated graphics system for use in business presentations. This program combines the graphics functions of plotting, chart generation, lettering, a graphics editor, and a slide projector to quickly create and enhance your own business presentations. For II, Ile, and III; floppy disks, $124.95. Sensible Software Inc., 6619 Perham Dr., West Bloomfield, MI 48033.

Health Awareness Games, five interactive software programs suitable for school or home use. A variety of age groups can increase their health awareness with programs entitled Coronary Risk, Why Do You Smoke?, Exercise Weight, Life Expectancy, and Life Style. For II, II Plus, and Ile; floppy disk, $99. HRM Software (see address above).

Hereditary Dog, an interactive, educational genetic simulation. High school students combine genetic differences in dogs as an introductory study of basic genetics. The computer shows potential outcomes in litters of pups. For II, II Plus, and Ile; floppy disk, $49. HRM Software (see address above).

Homework, a personal word-processing program that leads you through each step. You can write letters, school assignments, shopping lists, and memos. Text combined with pictures (icons) show you text commands and your formatted page. For II, II Plus, and Ile; cassette and floppy disk, $49.95. Sierra On-Line, Sierra On-Line Building, Coarsegold, CA 93614.

Mad Rat, an arcade-type game. Three mice are trapped in a department store. You must get them to eat the cheese while also keeping them away from the cat and the holes under the escalators. If the cheese drops through the escalator holes, it turns into more cats. Various skill levels. For II, II Plus, and Ile; floppy disk, $24.95. Phoenix Software Inc., 64 Lake Zurich Dr., Lake Zurich, IL 60047.

Mastering the College Board Achievement Tests: English Composition, a comprehensive program for individuals preparing to take College Boards. This self-paced program has more than 1000 problems to give you practice in rewriting sentences, phrasing, identification of grammatical errors, and pointers on sentence structure. It provides scores and error analysis for further study. For II Plus and Ile; floppy disks, $175. CBS Software, 1 Fawcett Place, Greenwich, CT 06836.

Murdar by the Dozen, a whodunit-simulation series. This is a game containing 12 murder mysteries and their case histories. You are the top detective and must solve each case within a limited amount of time using clues and a map of the city. Up to four people can play individually or as a team. For II Plus and Ile; floppy disk, $34.95. CBS Software (see address above).

Penwrite II, a data-transferral system. Data, text, and code files can be transferred between DOS 3.3 and Apple Pascal format disks. You can use BASIC data or text files with Pascal programs; Pascal text or data files with BASIC programs; and code files from the Pascal 6502 assembler as DOS binary files. For II, II Plus, and Ile; floppy disk, $34.95. DESC Software, P0B 7212, Stanford, CA 94305.

Picture Writer, an artistic educational program. Children ages 4 through 12 can easily draw lines, shapes, and pictures. A tutorial teaches the child to draw original pictures using the keyboard, use the artwork on disk, alter or store pictures, and add color. This teaches spatial and color relationships and the basics of early programming skills. For II, II Plus, Ile, and III; floppy disk, $39.95. Scarborough Systems Inc., 25 North Broadway, Tarrytown, NY 10591.

Project for an Energy Enriched Curriculum (PEEC), a collection of six independent, integrated programs on energy-conservation issues. Technical Education Research Centers (TERC) and the National Science Teachers Association (NSTA) aided in the development of these six programs that include Electric Bill, Energy Conversions, Home Energy Savings, Personal Energy Inventory, Power Grid, and Temperature Grapher. For II, II Plus, and Ile; floppy disk, $225 for all six programs; also available individually. HRM Software (see address above).

Songwriter, a music-composing system for ages four through adult. Compose or learn theory with music and a metronome already on disk. Manipulate tempo or scale by touching a key; print out your composition; or hear it on a computer or stereo. Includes a cable that connects the stereo to the computer. For II, II Plus, Ile, and III; floppy disk, $39.95. Scarborough Systems Inc. (see address above).

Super Quiz II, a multiple-choice test-generation system. This educational tool enables teachers and ad-
Termexx, a comprehensive communications package. You can log in via modem to a remote host computer, electronic bulletin-board system, or an information, news, or stock-market service. Features include expanded character set, long-file handling, scrolling, macro commands, exec files, full-screen editor, and more. A hotline is available for technical support. For II Plus and Ile; floppy disk, $79.95. Exec Software Inc., 201 Waltham St., Lexington, MA 02173.

Atari

Cosmic Tunnels, an arcade-type game. Save your planet Sirref from energy starvation the Jibs have imposed by destroying their space mines and missile launchers. Then retrieve as many glowing energy bars from four aster-oids as you can while avoiding dynobots and quicksand. For 800 and 1200; floppy disk, $34.95. Datamost Inc., 8943 Fullbright Ave., Chatsworth, CA 91311-2750.

FDOS, a disk operating system for FORTH users. In addition to performing normal DOS 2.05 file manipulations, this program also converts DOS files to FDOS files that are saved on your FORTH disk. You can create data files with existing BASIC programs operating under DOS 2.05, and then convert them for use in a FORTH program. For 400/800 and 1200; floppy disk, $39.95. Superware, 2028 Kingshouse Rd., Silver Spring, MD 20904.

Hellcat Ace, a flying-combat simulation. The three-dimensional scene is in the Pacific during WWII. You confront 14 scenes in time ranging from 1940 to defending the fleet from Kamikaze attacks during the invasion of Iwo Jima in March 1945. Become an ace by maneuvering your aircraft through aileron rolls, loops, split Ss, and Immelmann turns. For 400/800; floppy disk, $29.95. Microprose Software, 10616 Beaver Dam Rd., Hunt Valley, MD 21030.

Major League Hockey, a hockey-simulation game. Use your maneuvering ability to score goals and beat the other team. Features include a scrolling display of the rink and a game timer. Because the ice rink is triple the screen size, your view of the rink changes according to where the puck is. For 400/800 and 1200; cartridge, $44.95. Thorin Eme Home Video, 1370 Avenue of the Americas, New York, NY 10019.

Monster Smash, an arcade-type game. You are the master of the local graveyard. The monsters who have moved in have destroyed the peace and quiet and are trying to escape through the gates. You must smash as many monsters as possible but let all the visitors and children pass through the gates unharmed. For 400/800 and 1200; floppy disk, $29.95. Datamost Inc. (see address above).

Mountain King, an arcade-type game. Armed only with a flashlight and a thirst for adventure, you delve into the heart of a secret mountain and try to capture the crown. Carry it safely to the top of the mountain before your time expires and you will become Mountain King; if not, you will be destroyed. Requires a joystick. For 400/800; cartridge, $25. CBS Software, 1 Fawcett Place, Greenwich, CT 06836.

Party Mix, a collection of five arcade-type games. In Bop a Buggy, you drive a two-wheeled buggy through various screens to cross the finish line. In Tug of War, your team tries to pull the opposing team across the line. In Wizard's Keep, you control a wizard who releases his fireball to hit chickens or ships. In Down on the Line, workers must move packages around on colorful conveyor belts. In Handcar, you race on railroad tracks across the desert. For the 2600; cartridge, $9.95. Epyx/Automated Simulations, 1043 Kiel Court, Sunnyvale, CA 94089.

Poozan, a high-resolution arcade-type game. Battle a pack of vicious wolves to protect your helpless piglets. You shoot arrows at wolves that float in the air by holding onto balloons. For 400/800 and 1200; floppy disk, $29.95. Datasoft, 9421 Winnetka Ave., Chatsworth, CA 91311.

Scroll It, a machine-language program. You can implement variable-speed fine scrolling in a BASIC program. The fine scrolling can be continuous horizontal, vertical, or diagonal; the ANTIC character mode can be changed; and the screen can be coarse scrolled to any x,y location. For 400/800; floppy disk, $19.95. Superware (see address above).

Solar Fox, an arcade-type space-adventure game for one or two players. As Earth runs out of energy, you must navigate your starship through a complex matrix of solar cells guarded by fireball-shooting Sentinels. The faster your speed, the greater your reward. See if you can unlock the secret of the Solar Fox. For the 2600; cartridge, $25. CBS Electronics, 41 Madison Ave., New York, NY 10010.


CP/M

Datacure, an error-detecting and backup/restore utility program for CP/M version 2.2 operating systems. Using proprietary error-detection and correction techniques, you can reconstruct the original contents of disk sectors that have gone bad. Rebuild the original file and regenerate all the information for a complete track or for sectors damaged by a multitrack scratch. Floppy disk, $99. Colorado Online Systems Inc., 40 Balfour Lane, Ramseay, NY 07446.

FORTRAN Relabel, a label-renumbering program. All the numeric labels in FORTRAN programs containing statements and all labeled line references can be renumbered using this program. Subroutines, function subprograms, and Microsoft EDIT80 line numbers are processed automatically. You specify ASCII code and the numeric value of desired
Software Received

label and increment. Floppy disk, $29.95. Cleydale Engineering, POB 784, Dahlgren, VA 22448.

Magicbind, a word-processing program. Upgrade your word-processing equipment with automatic numbering of chapters, paragraphs, and articles; automatic printing of personalized letters for mass mailing; print-time selection of records; automatic verification of data-file accuracy; flexible page heading and footing; and other capabilities. Floppy disk, $250. Computer Editype Systems, 509 Cathedral Parkway IIIA, New York, NY 10025.

Printman, a print-spooler system. An alternative to the standard DESPOOL and SPOOL programs. Minicomputer capabilities: such as add, change, delete, list, and others give you increased system use. Perform more functions on files with special features and enter any number of items to the list. Floppy disk, $195. Data Base Administrators Inc., W305 S4553 Brookhill Rd., Waukesha, WI 53186.

The Word Machine, a word-processing/text-editing program. Transform your computer into an automatic typewriter letting you create, edit, store, and print letters, forms, manuscripts, and personalized form letters. Detailed help instructions are included. Floppy disk, $37. GB Associates, POB 3322, Granada Hills, CA 91344.

Commodore

The Complete Personal Accountant, five personal financial programs. This package transforms your computer into a financial manager with

a checkbook-maintenance program, a detailed summary budget, an appointments and payments calendar, a “what if” spreadsheet, and a tax-handling format. For the 64; floppy disk, $29.95. Microprose Software, 10616 Beaver Dam Rd., Hunt Valley, MD 21030.

Squish 'Em, an arcade-type game. As you climb to the top of a 48-story building to collect a suitcase of money, you try to avoid being knocked off the building by a variety of Creepy Creatures or falling objects. For the VIC-20; cassette, $19.95. Sirius Software Inc. (see address above).

3-D Othello, a three-dimensional board-game simulation of Othello in machine-language programming. Two players can compete in four skill levels with colorful graphics and sound effects for younger players. Helps to develop spatial perspective and strategic skills. Requires a joystick. For the VIC-20; cassette, $15. Ojai Software, POB 1860, Ojai, CA 93023.

IBM Personal Computer

Aura, an integrated information-management system containing word-processing, electronic-spreadsheet, business-graphics, and communications programs with an optional micro-mainframe communications link. You can create business reports of customers with outstanding balances, weed inactive accounts from mailing lists, track sales by product and region, and create reorder lists of low inventory. Floppy disks, $495; with communications-link capacity, $995. Softrend, 87 Indian Rock Rd., Windham, NH 03087.

BASLIN, a BASIC line number/page program. This utility is designed to let BASIC use programs that were previously created as a program library. You can combine programs, renumber the listing, and create a new, enhanced program. Floppy disk, $35. Orion Co., 524 North 2nd St., Weatherford, OK 73096.

Burgertime, an arcade-type game. Your chef is in a maze surrounded by pickles, hot dogs, and eggs that are trying to get him. If they catch him, his fast-food career is over. Try to sprinkle pepper on a pickle and dodge down a ladder. Floppy disk, $25. Mattel Electronics, 5900 Wilshire Blvd., Los Angeles, CA 90036.

Chartmaster, a commodity- and stock-charting program. You can examine, analyze, display, and print a variety of price charts. You can also generate high, low, close bar, and moving averages. The database can be updated by retrieving stock or commodity price information via data communications. Floppy disks, $275. Professional Farm Software, 219 Parkade, Cedar Falls, IA 50613.

Conquest, a prehistoric-simulation game. As King of the Falcons, you use your strength and endurance against pterodactyl warriors. You must swoop down to destroy them while encountering hurricanes, tornados, and dragons trying to deter you. Floppy disk, $39.95. Windmill Software Inc., 2209 Leominster Dr., POB 1008, Burlington, Ontario L7P 3W8, Canada.

CP+, a collection of training and productivity programs for your computer. It is a user-friendly interface between you and the command interface of the operating system and provides extended utility features. Designed for nontechnical users. Floppy disk, $79.95. Taurus Software Corp., Suite 170, 3155 Kearney, Fremont, CA 94538.

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EMSearch Bioscience Software, a database-retrieval system. You can store, cross-index, and retrieve electron-micrograph records. For use in biological and materials science, this program uses 14 search categories (specimen, fixative, and user-defined) for 4200 to 8500 electron micrographs on one disk. No computer experience is necessary. Floppy disk, $99. New Leaf Enterprises Inc., 1901 C Waters Edge, Ft. Collins, CO 80526.


Financial Planning for Lotus 1-2-3, an electronic-spreadsheet template program. You can calculate 16 financial planning and forecasting problems contained on disk. Each program, called a worksheet, is a complete and ready-to-use program that solves several related financial problems with Lotus 1-2-3. Floppy disk, $89.95. Howard W. Sams & Co. Inc., 4300 West 62nd St., Indianapolis, IN 46268.

Fontastic, a document-enhancing printer program. Designed to work with a word processor, this program lets you print diagrams, drawings, and foreign language characters with 20 fonts supporting sub- and superscripts, italics, underline, bold, and more. You can also create your own character set. Floppy disks, $125. IHS Systems, Suite 211, 4718 Meridian Ave., San Jose, CA 95138.

4-Point Graphics, a color-graphics program that features a four-part cursor for versatility in creating, manipulating, storing, and retrieving images from all or part of the screen. Dual memory buffers allow access to images for comparison, overlays, and creation of animation. Floppy disk, $195. International Microcomputer Software Inc., 633 Fifth Ave., San Rafael, CA 94901.

The Idea Processor, an integrated word-processing system and textual data-management system that run simultaneously. This program lets you save spreadsheets and graphics in a database, cross-index them using 10 keywords, use graphics from DOS-based programs in its printed documents, and put on a slide-show presentation with a graphics program. Floppy disk, $295. Idea Ware, 225 Lafayette St., New York, NY 10012.

Knoware, an educational program for business professionals that teaches business applications. By playing games, you learn about spreadsheet applications, database management, text editing, financial decision-making, simple graphics, and programming techniques. Floppy disk, $95. Knoware Inc., 301 Vassar St., Cambridge, MA 02139.

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can also create and program your own categories. Floppy disk, $29.95. CBS Software, 1 Fawcett Place, Greenwich, CT 06836.

**Night Stalker**, an arcade-type game. Your man is trapped in a maze with robots, spiders, and bats trying to track him down. Destroy them with your gun before they get him. Floppy disk, $24. Mattel Electronics (see address above).

**PC Write**, a word-processor and text-editor program. This program helps you write and format any text. Features include insert, replace, delete, wordwrap, search, move and copy blocks, a split-screen mode, and functions for more advanced users. Floppy disk and manual, $35. User registration fee, $75. Quicksoft, 219 First North #224, Seattle, WA 98109.

**Pits & Stones**, an artificial-intelligence strategy game for all ages. Try to collect the most stones in your home pit by taking turns distributing them. Plan each move ahead while anticipating your opponent's strategies. Floppy disk, $36.95. Orion Software, POB 2488, Auburn, AL 36831.

**Realpac**, a collection of real estate analyses programs. Features include files that let you calculate fixed rate, fixed principal reduction, graduated payment and equity, re-negotiable/variable rate amortization schedules, internal rate of return calculator, and other programs related to real estate purchasing and sales. Floppy disks, $275. Creative Business Computer Systems Inc., 6731 Red Rd., Coral Gables, FL 33143.

**Rogue**, a fantasy-adventure game. You are on a quest for the amulet of Yendor in the Dungeons of Doom. Discover magical objects, food, and weapons, but beware of the monsters lurking in the darkness. Floppy disk, $44.95. Artificial Intelligence Design Systems, POB 3685, Santa Clara, CA 95055.

**SR-LIB**, a library-manager program. You can create and modify library files that are compatible with the PC-DOS linker. Add object files, delete and replace modules in a library, and list the names of the modules in a library. Floppy disk, $29.95. Software Research, POB 10004, Austin, TX 78766.

**Scientific Mathematical Function Library**, a mathematical-applications system. This Microsoft package is for C programmers in engineering and graphics who need more mathematical sophistication than C provides. Features include 20 functions, fatal errors, warning errors, and a math library of three files. Floppy disk, $45. Soft C, 14350 Southwest Derby St., Beaverton, OR 97005.


**Tiao Chi**, a Chinese-checkers simulation game. Played on a six-pointed star, two to six players take turns consecutively moving men from their star point to the opposite star point. Whoever makes it in the least number of moves is the winner. Floppy disk, $24.95. Microclassics, 315 Fawcett Place, Greenwich, CT 06836.

**Optimizing C86** to control the IBM PC and other MS-DOS/PC-DOS computers. Features include:

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Cost Estimating With Risk Analysis (CEWRA), a spreadsheet-template business program designed to let you estimate project costs using fundamental risk-analysis techniques. It includes three types of estimates: constant, uniform, and triangular for project-cost elements such as labor, materials, and capital. For use with Supercalc. Floppy disk, $39. CPG Inc., POB 1057, Chester, VA 23831.

Multi-Factor Productivity Measurement Model for Small Business (MFPMM-SB), a spreadsheet-template small-business program. Enter the price and quantity data for input and output factors and you receive calculated desired productivity indexes, ratios, and their impact on profits. For use with Supercalc. Floppy disk, $79. CPG Inc. (see address above).

TRS-80

Accounts Receivable, an accounting program that monitors sales and incoming funds. Features include a balance-forward system, a capacity of up to 2000 transactions per month with 150 customers on file, optional late-charge processing, mailing labels, and printing of general-ledger reports. For the Model 4; floppy disks, $199.95. Radio Shack, 300 One Tandy Center, Ft. Worth, TX 76102.

COBOL for the TRS-80, Volume One, an instructional package designed to teach the fundamentals of COBOL programming to secondary and college-level students. Each chapter of the manual includes an overview, objectives, hands-on experience, flowcharts and diagrams where applicable, programs, discussion, a summary, and review. For Models II, 12, and 16; floppy disk, $49.95. Radio Shack (see address above).

Corplan, a business-simulation program. This educational package is designed to supplement business instruction at the college or advanced secondary levels by simulating corporate operations. This program puts a player or a team in control of a theoretical corporation, planning overall business policy and applying the decisions needed for success. No computer experience is needed. For Models III and 4; floppy disk, $49.95. Microsoft Services, POB 776, Harrisonburg, VA 22801.

Guardian, an arcade-type game. Protect ten energy modules that enemy ships are trying to steal from your planet's force field. Catch, but do not destroy, the enemy with a stolen module or else the energy will be lost and the enemy will transform to a higher energy state. For the Color Computer; floppy disk, $29.95; cassette, $27.95. Quasar Animations, 1520 Pacific Beach Dr., San Diego, CA 92109.

Investment Analysis, a portable three-program package. Fixed Income Security Evaluator calculates data useful for buying or selling fixed-income securities. Commission Calculator calculates commission charges for stock and option transactions. Option Strategy Evaluator calculates the results of option transactions involving vari-
ous combinations of put and call purchases and sales. For the Model 100; cassette, $69.95. Radio Shack (see address above).

LS-HOST/Term, a telecommunications package. This set of seven programs lets the Model 4 emulate an ADDS 25 terminal with video effects. The computer can also be remotely controlled by another computer or terminal. Package includes a binary-to-ASCII conversion utility and a file-transfer program using Christiansen protocol. For the Model 4; floppy disk, $199. Logical Systems Inc. (see address above).

MLIB, a program that aids in the construction of Microsoft-compatible relocatable object-file libraries. Commands let you add, replace, copy, or delete modules from existing libraries or you can create new libraries from individual modules. For Models I and III; floppy disk, $50. Misosys, POB 4848, Alexandria, VA 22303-0848.

Real Estate Investment Analysis, five financial-planning programs. Mortgage Analysis calculates percentages of loans, mortgages, amortization, and more. Mortgage Equity Analysis calculates values, resale prices, ratios, and yields. Present Worth Analysis calculates the present value and worth of steady and uneven income. Utility Routine Analysis calculates interest, expenses, budgets, capitalization rate, and more. Statistical Analysis performs tests using decision-tree and time-trend analysis to forecast net-operating income. For the Model III; floppy disk, $99.95. Radio Shack (see address above).

The Traveling Appointment Manager, a portable appointment-reminder program. Keep track of personal and professional appointments. Enter dates up until the turn of the century. Old appointments are erased unless you reschedule them. You can also list things-to-do and print your calendar. For the Model 100; cassette, $59.95. Traveling Software Inc., 11050 Fifth Ave. NE, Seattle, WA 98125.

The Traveling Time Manager, a portable time-keeping program. You can keep track of billable and nonbillable work hours. Other applications include keeping track of expenses, recording and listing student grades, managing equipment and machinery usage, tracking a runner's miles, and averaging time per mile. For the Model 100; cassette, $59.95. Traveling Software Inc. (see address above).

TRS-80 Wordstar, an adapted version of the word-processing program by Micropro. Features include automatic line wrap, margin set, and various other text adjustments. On-screen help and prompts let you design and lay out your pages. The documentation describes the differences between the two versions. Includes smallLDOS, an enhanced operating system. For the Model III; floppy disk, $395. Logical Systems Inc. (see address above).

Other Computers

Picture Perfect, a business-graphics system. With this program you can transform your data into pies and exploded pies, vertical and horizontal bar charts, or line charts. Features include numerous bar and pie shading patterns. For the Hewlett-Packard HP 150; floppy disk, $295. Computer Support Corp., 4215 Beltwood Parkway, Dallas, TX 75234.

Stock Control, a stock-control system. You can keep 500 items per file with a two-second access time. Features include an audit trail, item/supplier search facilities, reorder levels, nine menu options, and unlimited entries. For the Timex/Sinclair 2000 (Spectrum); cassette, £14.95. Kemp Limited, 43 Muswell Hill, London N10 3PN, England.


Machine Code and Better Basic, Ian Stewart and Robbin
Books Received


This is a list of books received at BYTE Publications during this past month. Although the list is not meant to be exhaustive, its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.

BYTE's Bits

Color Computer On-Line

A computerized BBS (bulletin-board system) for users of the Radio Shack TRS-80 Color Computer is up and running 24 hours a day in Santa Barbara, California. A 300- or 1200-bit-per-second modem is required, and the system permits both up- and downloading. For more information, call the CoCo Corner BBS at (805) 687-9400.

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Discover FORTH
Thom Hogan
Osborne/McGraw-Hill
Berkeley, CA: 1982
140 pages, softcover, $14.95

Reviewed by
Paul E. Hoffman

Although the microcomputer industry has adopted BASIC as a standard language, it is by no means the final word on languages. More than five other languages are becoming popular, and FORTH is among the most recent.

Thom Hogan's Discover FORTH is not simply another language book because FORTH is not at all just another language. The concepts in FORTH programming are very different from those used in BASIC programming, and Hogan introduces FORTH programming innovatively in a non-technical fashion. Hogan has previously authored Osborne CPIM User Guide.

To a BASIC programmer, FORTH programs resemble a long list of subroutine calls with few procedural steps. Once a procedure is defined in FORTH, it can be used anywhere else, so that a procedure can call any other procedure or even call itself. This is quite a different technique than programming in BASIC, and Discover FORTH holds the reader's hand, so to speak, throughout this learning process.

Why FORTH?
Although the FORTH language has been available in the microcomputer market for a few years, this is the first book to answer the question, Why should I be interested in another language, and why should it be FORTH? Hogan points out the uniqueness of FORTH programming, such as relying on a memory stack and the absence of GOTO statements. He describes how FORTH is better suited to programming than other languages.

Several books on the market are introductions to FORTH, but Discover FORTH has more for the novice FORTH user. Hogan has kept in mind the fact that microcomputer users are not always oriented to bits and bytes, and many have programmed only in BASIC. The book thus has a friendly tone without talking down to people who know other languages but want a flavor of FORTH.

Hogan also realizes the advantages of humor in teaching. Without trying to be a laugh a minute, he succeeds in making an otherwise dry and sometimes complex language interesting. A few section headings are puns, as in "It's His FORTH Operation, Doctor" for the section discussing arithmetic operators, and "I/O You An Explanation?" for the section describing how to use input/output operations.

Using FORTH
Hogan suggests that the FORTH language is one that should be learned by doing. The author gives short examples of programs that include the operations being described. Each example is shown in its environment so that the reader can easily follow the sequence. Since FORTH is an interactive language, results can be viewed at any time throughout the entire programming process. Because FORTH programs look very different from BASIC, Hogan recommends that the reader verify the results of steps explained in the book.

Two of the most difficult FORTH concepts to teach are the use of the stack and the greatly reduced use of variables. Most programmers familiar with procedural languages such as BASIC have never used stacks and frequently use variables in their programs. Thus, FORTH's techniques for storing information during program execution need special attention.

Discover FORTH devotes chapters to each of these concepts early in the book to give the reader a clearer idea of why FORTH might seem strange. While many authors cover these basic FORTH structures only briefly, Hogan emphasizes them early enough so that you can be sure you understand them before reading on. He succeeds in explaining the concepts through the use of illustrations and real-world analogies.

Examples in FORTH
One problem with Discover FORTH is the rarity of examples. Although Hogan fully explains each FORTH word (which is the equivalent of a BASIC command), he offers only three or four small programs to show how to actually develop something with the language. This makes it harder to decide if you're interested enough in the language to buy the book. However, the examples he does provide are clear and explained fully in the text.

Regardless of Hogan's underuse of example programs, you will certainly know what each part of FORTH does by the time you finish reading the book. Since FORTH rarely uses variables (at least, not in the way they are used in BASIC), it is a major task to describe the structure of the language and diagram the actions of particular FORTH words.

The Book's Structure
The book is broken into three areas: the low-level concepts and history of FORTH, how words in FORTH make things happen, and how to make your computer run your FORTH programs. Because each area is covered thoroughly, the reader is left with the impression that the author said everything he wanted to in a small amount of space. The book demonstrates how FORTH can be taken out of its current jargon-riddled state and be tailored to the individual programmer. Hogan stresses this throughout the book and takes some of the edge off the strange words chosen for some FORTH concepts.

In essence, Discover FORTH is a practical book for anyone who is interested in a new and very different language for his microcomputer. It is written on a level that anyone can appreciate, and it shows FORTH's strengths as well as its weaknesses. As the title implies, the purpose of the book is to exhort you to become involved in FORTH, and it does so in a way not found in other FORTH manuals.

Paul E. Hoffman, president of Proper Software (Suite 1024, 2000 Center St., Berkeley, CA 94704), writes manuals for microcomputer companies in the San Francisco area.

Electronic Bookshelf on Air
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MAGICAL Programming Language

MAGIC from Data Management Associates is a medium-level, portable programming language that creates applications programs without requiring a run-time package. The instruction set permits the creation and maintenance of machine-executable programs, and its file I/O capabilities support random, sequential, and ISAM file types. MAGIC has internal data areas that are said to be completely variable with buffers that are dynamically allocated for hardware and software efficiency. Other features include BCD arithmetic with up to 36 digits, simplified screen formatting and data editing, the ability to mix assembly language anywhere in source code, and total string-manipulation capability. MAGIC is available for CP/M; 8086; and 8088-based systems. It costs $795, which includes a cross-referenced manual. For details, contact Data Management Associates Inc., POB 4340, Wilmington, DE 19807, (302) 655-8986. Circle 510 on inquiry card.

Simulation Environment is Interactive

GPSS/PC is a simulation environment designed for interactive use on the IBM Personal Computer. Using GPSS/PC, you can predict the effects of managerial or engineering decisions on complex real-world systems. The software features more than 70 blocks and commands, 45 SNAs (system numerical attributes), clock and internal precisions limited only by the amount of computer memory, full-period 32-bit random-number generators, and the ability to include exponents, cosines, tangents, and logarithms in complex expressions. All blocks and SNAs can be accessed from within the program or entered interactively through the keyboard during simulation. You can mix SNAs into complex expressions and construct accurate probability distributions without using GPSS functions.

GPSS/PC will expand beyond a megabyte of memory if your DOS permits. Models typically require approximately 0.003 second per block entry on the IBM PC's 4.77-MHz 8088 processor. Dynamic allocation of individual entry types and indirect addressing through transaction parameters are supported. The following are limited solely by the amount of memory in your computer: parameters per transaction, random-number generators, chains occupied by a transaction, and internal accumulators. Operator conveniences include on-line help, command recognition, keystroke error correction, assignable function keys, automatic spacing, cursor prompting, and a built-in line editor.

Production quantities of GPSS/PC will be available in May. For information on licensing fees, contact Minute-Man Software, POB 171, Stow, MA 01775, (617) 897-5662. Circle 504 on inquiry card.

Utility Lets You Edit Any Byte

Media Magician is a full disk-editing utility that lets you view, change, and save any byte, string, or sector anywhere on a floppy or hard disk. It provides simultaneous screen displays of the hexadecimal and ASCII representations of each byte. Editing can be done on either window, and all changes in one window are immediately made in the corresponding display. Media Magician uses single-character commands for such functions as printing out a sector, searching for a specific string, comparing two sectors, and moving sectors. Other features include help screens and the ability to use IBM PC color or monochrome graphics.


Pro-Accountant for DEC Professional

Deccomp's Pro-Accountant General Ledger accounting software operates on the DEC Professional 350 microcomputer. A novel feature of this system is its multitasking capability, which lets you set up posting of journals or generate and print reports in the background while continuing to use the keyboard for other tasks. Pro-Accountant can handle multiple companies and divisions on the same disk, and two years of detail is maintained with one year of budget amounts. When a report is generated, the profit account is automatically computed, which allows contribution income to be shown by individual or all departments. Pro-Accountant is menu-driven, and it fully supports all the Professional 350's special function keys.

Pro-Accountant costs $1500. For complete details, contact Deccomp Inc., 14752 Sinclair Circle, Tustin, CA 92680, (714) 730-5116. Circle 500 on inquiry card.

Sophisticated Word Processor for PC

Volkswriter Deluxe is a sophisticated word processor for business and professional users of the IBM Personal Computer and its compatibles. When used with a database manager, such as dBASE II, Volkswriter lets you compile a mailing list, send personalized form letters, and print labels. Through the use of virtual memory, document sizes can be as large as 1 megabyte. Page endings, underlining, boldface, double strike, and strike-throughs are shown on screen. Special features include horizontal scrolling up to 250 characters, chapter-end footnotes, and proportional spacing.
What's New?

This program comes preconfigured for 16 printers. Multiple fonts and color monitors are supported. It can handle multilingual keyboards and printer character sets, and it may contain a variety of spelling checkers. Among the additional word-processing functions provided with Volkswriter are single-keystroke editing, on-screen reference guide, variable margins, superscripts, and subscripts.


Circle 501 on inquiry card.

Sort/Merge Co-routine Operates Interactively

Co-Sort from Information Resources is a general-purpose sort/merge-co-routine for online report generators, database managers, mailing lists, and compilers. Co-Sort operates interactively with a calling program or off-line for utility sorting and merging. Its time-sorting algorithm is accessed interactively by programs in ASMD, CBASIC, MBASIC, Pascal, and other languages that can call a machine-language routine. Any number and type of files, inputs, keys, and outputs are permitted with Co-Sort, including exception processing. I/O records can be transferred in files or directly in memory without physical I/O.

Co-sort runs under CP/M-80, CP/M-86, or MS-DOS. It costs $200, which includes programs and documentation in ASMD and BASIC. For more information, contact Information Resources, POB W, Manhasset, NY 11030, (516) 365-7629.

Circle 507 on inquiry card.

Family Medical Program

Navic Corporation's Family Medical Advisor is an information and educational program that analyzes overt symptoms and identifies the probable cause of a medical condition. This program prompts you with a series of yes-or-no questions to establish a pattern. It then analyzes your responses and lists related disorders in descending order of probability. In the database are details on nearly 200 common illnesses.

Family Medical Advisor runs on an Apple II Plus with 48K bytes of memory and a disk drive. For more information, contact Navic Corp., POB 14727, North Palm Beach, FL 33408, (305) 627-4132.

Circle 508 on inquiry card.

LISP System for IBM PC

Gold Hill Computers has announced the availability of Golden Common LISP [GCLISP] for the IBM Personal Computer. GCLISP offers a full range of data types, including infinite-precision integers, floating-point numbers, arrays, character strings, lists, structures, and symbols. It supports object-oriented programming. GCLISP has been enhanced with such programming development aids and operating extensions as a full-screen intelligent editor, multitasking capabilities, macro instructions, memory allocation, garbage collection, and stream-oriented I/O.

Gold Hill Computers plans to support the IAPX286 and to release a GCLISP compiler. GCLISP requires PC-DOS 2.0 or greater and 256K bytes of memory. The suggested price is $375, which includes comprehensive documentation. Dealer inquiries are invited. For further information, contact Gold Hill Computers Inc., 163 Harvard St., Cambridge, MA 02139, (617) 492-2071.

Circle 505 on inquiry card.

Accounting Software

The Certified Accounting System is an integrated accounting package for micro-computers running under CP/M-80, CP/M-86, MS-DOS, and PC-DOS. A key feature of this software is that it supports end-user customization of input screens, files, and report formats. Certified Software lets you tailor input screens to your business documents and forms, change numeric and alphanumeric field lengths and types, design new printed reports to replace or supplement standard reports, modify program print positions to match print positions on existing forms, and create vertical accounting packages targeted at specific needs. This package has received independent third-party review and certification from Touche Ross & Co., an international accounting firm.

The Certified Software package comprises five basic accounting modules: general ledger, accounts payable, accounts receivable, inventory, and payroll. In addition, a customizing kit is offered. All the modules are available with or without the ability to automatically update the general ledger whenever new data are entered into any module. Without the automatic general-ledger update, the suggested retail price for each module is $195. Individual modules with the update feature are $295. A required system guide is $45. The customizing kit is $145. Dealer inquiries are welcome. For the name of your nearest dealer, contact Certified Software Inc., 9000 Southwest 1st St., Portland, OR 97225, (503) 297-8666.

Circle 503 on inquiry card.

Integrated Package for Business

An integrated software package for business people using the DEC Professional 350, Propel is distributed by Pro Computing. Propel's applications are divided into three categories: telephone communications, written communications, and number processing. Its telephone communications capabilities are made up of a telephone directory with an automatic directory function, a telephone-call notebook, and an answering and message service. For writ-
ten communications. Propel offers word processing, electronic mail, and meeting and reading notebooks. A spreadsheet and graphics constitute its number-processing abilities. In addition, Propel enables the Professional 350 to emulate DEC and IBM terminals for communicating with mainframe computers.

Propel can operate at four different levels of sophistication. Each level offers additional features for customizing applications. The software uses dedicated function keys, simple menu hierarchies, single-key-stroke commands, and a consistent set of commands across all applications. Data transfers between applications are said to be simple. On-screen prompts for each menu option and help screens assist users.

Propel is available with or without the telephone functions for $1195 or $950, respectively. A toll-free hot-line number supports users. For full details, write to Pro Computing Inc., Suite 3314, One Penn Plaza, New York, NY 10119.

Circle 509 on inquiry card.

Mass Storage

Fluid Dynamics Boosts Storage Capacities

Iomega's engineers have adapted eighteenth-century Swiss mathematician Daniel Bernoulli's principle of fluid dynamics to flexible-disk subsystems. Called the Bernoulli Box, the unit controls the movement of air around a flexible disk as it spins under the read/write heads, creating a soft interface that permits high media density and rapid access. The average access speed is 30 milliseconds, and the transfer rate is 1 megabyte per second. The removable flexible-disk cartridge can handle 10 megabytes of formatted data. Cabinet dimensions are 5½ by 19½ by 18 ¾ inches.

The Bernoulli Box is available in 10- and 20-megabyte versions for the IBM PC XT and the Texas Instruments Professional Computer. The 10-megabyte unit, which is upgradeable to 20 megabytes, has a $2695 suggested retail price. The 20-megabyte unit lists for $3695. The 10-megabyte upgrade kit is $1000. The disk cartridges cost approximately $60. Iomega also produces 5½- and 8-inch cartridge drives capable of holding 5.2 megabytes of data. For complete details, contact Iomega Corp., 4646 South 1500 W., Ogden, UT 84403, (801) 399-2117.

Circle 514 on inquiry card.

5½- and 3½-Inch Winchesters Unveiled

Microcomputer Memories has unveiled a line of Winchester-disk drives aimed at the OEM and systems integrators market. The drives have ST-506 interfaces and offer 6.38 and 12.75 megabytes of storage and are available in half-height 5½- and 3½-inch formats. These devices are engineered with such safety features as head-landing zones for recorded-data protection. The 12-megabyte unit features two oxide platters and manganese/zinc read/write heads, permitting less critical densities and enhancing reliability.

The single-unit price of the 12-megabyte Winchester drive in a 5½-inch enclosure is $1300. OEM pricing can be less than $700. Address inquiries to Microcomputer Memories Inc., 7444 Valjean Ave., Van Nuys, CA 91406. (213) 782-2222.

Circle 512 on inquiry card.

Microfloppies Designed for Atari

A pair of 3-inch microfloppy-disk drives, the single-drive AMDC-I and the dual-drive AMDC-II, are compatible with Atari 400/800 and XL Series computers. Both units have an integral intelligent controller and DOS/DOS operating system software. They can control up to four drives, each programmable for single- or double-density operation, and can be used in conjunction with 5½-inch drives to boot Atari software. The media are Amdek's 3-inch cartridges, which feature an automatic shutter mechanism to protect against dust and fingerprints.

The AMDC-I provides 180K bytes of formatted storage. The AMDC-II gives you 180K bytes of double-density storage per side for a total of 360K bytes.

(Note that you must manually flip the cartridge.) The suggested retail price is $599 for the former and $850 for the latter. The 3-inch cartridge media are $6.99 each. For full information, contact Amdek Corp., 2201 Lively Blvd., Elk Grove Village, IL 60007, (312) 364-1180.

Circle 511 on inquiry card.

Turbo-Disk Unveiled

The Turbo-Disk from New World Computer Company is a 5½-inch Winchester-disk drive with a dozen read/write heads on each side of the disk. Its head slider assembly is mounted on a parallelogram that moves the read/write heads across a rotating disk in a purported 1/12th the time and distance of a single head. The Turbo-Disk provides an 8-millisecond access time for data under the heads and a 16-millisecond average access for remaining data. When not in use, the heads are locked above the disk surface, protecting data.

Turbo-Disk comes in configurations for the OEM and high-performance end-user markets. The first OEM model is a half-height 5-megabyte fixed-disk drive priced at $1800. A 5-megabyte half-height fixed disk drive enhanced with 5 megabytes of removable storage is available for $2325. For end-users, the Turbo-Disk can be purchased as a 20-megabyte subsystem. This system features 5 megabytes fixed and 5 megabytes removable storage, plus 10 megabytes of additional storage in the form of two removable cartridges. It's provided with a power supply, disk controller, connecting cables, utility software, and a host interface that's compatible with IBM, Apple, DEC, S-100 bus, and Multibus systems. It lists for $4950, with
volume discounts available. Additional cartridges and an ST505/412 interface are optional. New World Computer Co. Inc., 6624 Owens Dr., POB 1479, Pleasanton, CA 94566, (415) 463-0330. Circle 515 on inquiry card.

Drive Stores 3.2 Megabytes at 170 TPI

MPI has announced MegaDrive, a 5¼-inch floppy-disk drive with an unformatted storage capacity of 3.2 megabytes at 170 tpi. Standard features include back-up and program-load capabilities. 3-millisecond track-to-track access time, and a closed-loop positioning system designed to adjust the drive to media distortions caused by heat or humidity. MegaDrive has a microprocessor coupled with a stationary quad sensor and a mylar reference scale that enables it to sense track locations and guide the head to the intended track, eliminating the risks associated with higher tpi densities. It's plug-compatible with existing 8-inch controllers with ST 850 interfaces, and it can read 48-and 96-tpi floppy disks. Mean time between failures is 8000 hours under typical usage. OEM evaluation units are priced at $500. Contact MPI, 9754 Deering Ave., Chatsworth, CA 91311, (213) 709-4102. Circle 516 on inquiry card.

Subsystem Upgrades PC to XT Storage Capacity

Piceon's WHAMS-I-XT is a 10-megabyte Winchester-disk subsystem that upgrades the IBM PC to the storage capacity of a PC XT. The complete subsystem comprises a multifunction board equipped with an RS-232C asynchronous serial port and room for up to 256K bytes of RAM, a half-height drive, and a drive connector cable. It's hardware- and software-compatible with the IBM PC and PC XT and runs all versions of PC-DOS, including DOS 2.0, as well as utilities.

WHAMS fits into the IBM's second floppy-disk slot and requires two cable connections. It operates with the PC's power supply. Without RAM, WHAMS costs $2375. Each 64K-byte RAM is $50. For additional information, contact Piceon Inc., 2045 Lundy, San Jose, CA 95131, (408) 998-4016. Circle 513 on inquiry card.

### PRINTERS

Qantex Compatible with Epson and Anadex ESC Codes

The Qantex Model 7065 serial dot-matrix printer is fully compatible with Epson and Anadex escape codes. Its operating speeds are 300 cps for draft copy; 250 cps, compose; 125 cps, near letter quality; and 65 cps, letter quality. In its dot graphics mode, this printer provides 144 by 144 bit-mapped dots per square inch at a repetition rate of 1500 dots per second per activated needle. Prominent print attributes include proportional spacing, right-hand margin justification, automatic underlining, overprint and boldface, and downloadable fonts. The 7065 will store three letter-quality fonts on line before requiring a change of print wheels. Standard word-processing fonts are Trend and Courier; Emphasis, Cubic, Scientific, APL, Script, and italics are offered as options.

The Model 7065 is controlled by a Z80A microprocessor. The built-in 4.7K-byte buffer is expandable. The printer's single-sheet feeder incorporates a combination roller-tractor that lets you use continuous or cut-sheet forms. DIP-switch activated Centronics parallel or RS-232C serial interfaces are provided. Data-rate capabilities range from 110 to 19,200 bps.

Diablo compatibility is optional. In single units, the Model 7065 is $1995. Purchasing information is available from North Atlantic Industries Inc., Qantex Division, 60 Plant Ave., Hauppauge, NY 11788. (800) 645-5292; in New York, (516) 582-6060. Circle 517 on inquiry card.

Canon Unveils Three Printers

Canon U.S.A. recently introduced two near letter quality printers and a color inkjet printer. The PW-1080A and the PW-1156A printers give you single-sheet insertion with roll, fan-fold, single-sheet, and multipart copy paper. They have a built-in, adjustable tractor feed, removable cartridge ribbon, and the ability to print four character styles on the same line. For high-resolution graphics, they provide N-by-16-dot matrix printing. Both operate at 160 cps. The PW-1080A prints 80 characters per line, and the PW-1156A can print 156 characters per line. Superscript, subscript, and international character sets are optional.

The PJ-1080A inkjet printer can produce seven colors on paper and overhead transparencies. It has four character styles that it prints at 37 cps. The PJ-1080A has separate black and tri-color ink cartridges, high-resolution color-graphic printing of 640 dots per line, and automatic vertical and horizontal tabulation with page-length-per-inch setting. International character sets are available.

The suggested price for the PW-1080A is $575. The PW-1156A is $589, and the PJ-1080A is $795. For more specifications, contact Canon U.S.A., 1 Canon Plaza, Lake Success, NY 11042, (516) 488-6700. Circle 518 on inquiry card.

Color Printer for Atari

Axiom Corporation has introduced a multifunction, full-color printer that's compatible with Atari computers. The GP-700AT plugs directly into the Atari's serial port, eliminating the need for an 850 interface. It also permits daisy-chaining of cassettes and other
Thermal Printer Complements Portables

The TTX 1280 Portaprint, a three-pound battery- and AC-powered thermal-matrix printer, complements your portable or hand-held computer. This bidirectional printer operates at 40 cps (batteries) and 80 cps (AC). Portaprint uses a 5- by 7-dot nonimpact print head to produce a variety of character sizes and densities, specialized letters, and line and dot-by-dot placements. It offers graphics capabilities, bold and shadow printing, and oversized characters. Portaprint has a condensed-printing mode that lets you expand its normal 80-column line so that 132-column spreadsheets can be printed on standard 8½- by 11-inch paper. Six-volt batteries provide 4000 to 5000 lines of print or approximately 2½ hours of operation.

The TTX 1280 Portaprint costs $199. An AC adapter is supplied. Production quantities will be available in the spring. For full details, contact Teletex Communication Corp., 3420 East Third Ave., Foster City, CA 94404. (415) 341-1300.

Circle 521 on inquiry card.

Multifunction Printer from Epson

Epson's LQ-1500, a multifunction serial dot-matrix printer, can run at speeds from 60 to 200 cps. This 136-column unit has built-in character sets that provide the 96 ASCII characters, 13 international sets, and 128 downloadable characters. Its 45 standard fonts implement Pica and Elite spacing in regular, enlarged, emphasized, and condensed formats. Proportional spacing in regular and enlarged formats and regular and enlarged superscript and subscripts are provided. A 24-pin print head forms characters with matrices spanning 9 by 17 to 37 by 17 dots. For graphics printing, variable resolution from 60 to 240 dots per inch can be achieved using 8- and 24-pin head configurations. Also supplied are a 15K-byte print line image buffer, bidirectional printing with logic seeking, automatic sheet loading, and software control over intercharacter spacing, print size, and vertical and horizontal tabs.

Centronics 8-bit parallel, RS-232C, and IEEE-488/GPIB interfaces are available. The LQ-150000 retails in the $1200 to $1500 range. OEM discounts are offered. Contact Epson OEM Products Division, 3415 Kashiwa St., Torrance, CA 90505, (213) 533-8277.

Circle 523 on inquiry card.

Dot-Matrix Printer Supports Hi-Res Graphics

Apple's Imagewriter dot-matrix printer reproduces high-resolution graphics at speeds approaching 180 cps. The Imagewriter prints in a 7- by 9-dot matrix and provides variable resolution of 72 to 160 dots per inch. Such print features as variable pitch from 10 to 17 characters per inch, eight fonts, variable line spacing from 1/6 to 1/44 inch, and proportional font and line spacing are furnished. Fonts, underscoring, superscripts, and subscripts can be mixed on the same line. Its bit-mapped graphics technology supports the Lisa's graphics capabilities.
What's New?

The imagewriter uses either friction-feed or adjustable-width pin-feed tractors. Paper sizes range from 3 to 10 inches wide. Single sheets, fan-fold continuous forms, roll stock, and precut labels are all acceptable. Four copies can be printed simultaneously.

The imagewriter uses a standard RS-232C interface to connect directly with the super Serial Interface card is required for the Apple II Plus and IIe. The suggested price is $675, which includes cables, applications manual, user guide, and software for printing high-resolution graphics. Contact Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014; (800) 538-9696; in California, (408) 996-1010. Circle 520 on inquiry card.

Senior Partner for Portable Computing

Panasonic's portable Senior Partner uses MS-DOS 2.0 and is compatible with IBM PC hardware and software. It incorporates a built-in thermal printer, a double-sided double-density 320K-byte floppy-disk drive, and a 9-inch display in a single 28.7-pound case. It has 128K bytes of RAM (expandable to 512K bytes) and is based on the 16-bit 8088 chip. For mathematics processing, the Senior Partner has a spare socket for an 8087 processor.

The thermal printer has graphics capabilities and can be switched from 80 to 132 characters per line. The video display has a green background and an 80 by 25 format. The format is adjustable to 40 characters per line. Senior Partner carries an RGB monitor port and Centronics parallel and RS-232C interfaces. The Senior Partner measures 18 1/4 by 13 3/4 by 8 1/4 inches. It costs $2495, which includes six software packages. Contact Panasonic Co., One Panasonic Way, Secaucus, NJ 07094. Circle 525 on inquiry card.

128K Standard with Leading Edge PC

The Leading Edge Personal Computer is an IBM PC-compatible offering 128K bytes of memory and an integrated RS-232C serial port. Salient features include a 7.16-MHz processing speed, seven IBM bus-compatible expansion slots, a digital time-of-day clock with battery backup, an 83-key IBM-format keyboard, and twin 514-inch 320K-byte floppy-disk drives. A 12-inch green-screen monitor with an 80 by 25 display format is standard. Microsoft DOS 1.25, Microsoft GW BASIC, and the Leading Edge Word Processor are bundled with the system.

The Leading Edge Personal Computer has a suggested retail price of $2895. For further details, contact Leading Edge Products Inc., 225 Turnpike St., Canton, MA 02021, (800) 343-6833; in Massachusetts, (617) 828-8150. Circle 529 on inquiry card.

Single-Board Computer Controller

The Model 83-230 single-board computer from John Bell Engineering is designed for use as a print spooler or as a controller in security systems or robots. This 6502-based board has 55K bytes of dynamic RAM, 8K bytes of EPROM, four parallel ports, one serial RS-232C port, and four timers. It measures 4 1/2 by 6 1/2 inches and uses the 44-pin AIM bus. A 2716 monitor EPROM is available as a $19.95 option. The bare board is $49.95. The assembled and tested version is $299.95. Full documentation is supplied.

A universal interface suitable for laboratory experiments and industrial-control applications is also available from John Bell Engineering. Designed for the IBM Personal Computer, the Model 83-064 has nine parallel 8-bit ports, 16 analog input ports, a timer, interrupt circuitry, and a prototyping area. It uses three 8255 programmable pe-
r peripheral-interface chips and an ADC-0817 analog input device. Analog inputs are 0 to 5 volts; the conversion time is approximately 200 microseconds per channel. The timer-oscillator runs at 32768 Hz and provides a total of 25 different frequencies. All I/O ports attach through 16-pin ribbon cables with DIP connectors. With documentation, the 83-064 costs $299.95, assembled and tested. Contact John Bell Engineering Inc., 1014 Center St., San Carlos, CA 94070, (415) 592-8411. Circle 530 on inquiry card.

Headstart Offers Up to 1 Megabyte RAM

Intertec's Headstart can be equipped with 1 megabyte of memory. Headstart comes with dual 8/16-bit microprocessors, 3½-inch 500K-byte [unformatted] floppy-disk drives, and built-in multituser networking capabilities. System interfaces comprise coaxial communications, RS-449/RS-232C, serial communications port, and a Centronics-type parallel port. A detached keyboard, a 12-inch nonglare screen, IBM PC compatibility, and RAM disk emulation capabilities are some of Headstart's highlights. It employs the 16-bit Intel 8088 and Zilog's 8-bit Z80A, respectively running MS-DOS and CP/M-80.

Up to 255 Headsarts can be linked with Intertec's high-speed coaxial interface. Networking capabilities include electronic mail and software file protection. A 3½-inch 20-megabyte Winchester unit and an 8-inch Winchester with 25 megabytes of fixed storage and 25 megabytes of removable storage are offered as network enhancements.

Headstart can be obtained in 128K-, 500K-, and 1-megabyte versions. In ascending order, base prices are $1895, $3495, and $4495. Software utilities and 5¼-inch floppy-disk drives are optional. For details, contact Intertec, 2300 Broad River Rd., Columbia, SC 29210, (803) 798-9100. Circle 524 on inquiry card.

PUBLICATIONS

Computers for Everybody 1984 Buyer's Guide
Computers for Everybody 1984 Buyer's Guide by Jerry Willis and Merl Miller carries up-to-date information on microcomputers. It describes 143 computers in detail ranging from keyboard design to available software. Topics covered include an introduction and guide to hardware and software, steps in selecting a computer, and portable computers.

Computers for Everybody is available in paperback for $19.95. Contact Diliithum Press, Suite 151, 8285 Southwest Nimbus, Beaverton, OR 97005, (800) 547-1184, in Oregon, (503) 646-2713. Circle 533 on inquiry card.

Statistics Program Directory
An Annotated Directory of Statistical and Related Microcomputer Software for Socio-

Economic Data Analysis by Kelly, Stevens, Stilwell, and Weber is available from Michigan State University. This directory describes more than 260 programs and places a special emphasis on those packages written for Apple, IBM, and CP/M systems. It also identifies and provides information on 30 generalized statistical packages.

The 165-page directory costs $7. Copies can be obtained from the Department of Agriculture, Agriculture Hall, Michigan State University, East Lansing, MI 48824. Circle 532 on inquiry card.

Independent Maintenance Service Guide Offered
C/ESN Publications has introduced its first annual Guide to Independent Service, a directory of companies offering third-party on-site maintenance and depot repair to OEMs and end users. The directory contains a geographical index of service companies and provides such information as number of employees, service revenues, years in business, and hardware and software maintained. Services offered include depot and on-site repairs, remote diagnostics, repair of communications equipment, and operating-system and applications-software troubleshooting. Such management innovations as centralized dispatch, telephone support, and automated parts inventory are noted. Also included in the directory are details of each company's service contracts and feature articles of interest.

The cover price for the Guide to Independent Service is $19.95. For more information, contact C/ESN Publications, POB 428, Peterborough, NH 03458, (603) 924-9457. Circle 536 on inquiry card.

100 Plus Public-Domain IBM Programs
A catalog listing more than 100 public domain and user-supported programs for the IBM Personal Computer has been published by the Public Software Interest Group. Programs listed include financial and stock market analysis, word processing, communications, databases, BASIC utilities, graphics, spreadsheets, and print spoolers.

Copies of the book are available for $2.95 plus $1 for shipping. A set of the 10 most popular programs on disk costs $59. The complete set of 75 programs on disk is $439. Contact PC Software Interest Group, Suite 130K, 1556 Hayward Ave., Santa Clara, CA 95051, (408) 247-6303. Circle 534 on inquiry card.

Graphics Market Subject of Directory
You can locate information on the computer graphics industry in Computer Graphics Marketplace 1983-84. Edited
by John Cosentino, this book provides a listing of manufacturers, consultants, services, professional organizations, educational programs, conferences and conventions, and publications geared toward the graphics industry. Each entry includes names, addresses, telephone numbers, titles, and descriptions of each company's products or services. Product and geographical indexes augment the presentation.

This 102-page paperback costs $32.50. It's available directly from the Oryx Press, 2214 North Central, Phoenix, AZ 85004, (602) 254-6156. Circle 535 on inquiry card.

Manual Experiments with Hero

Heath's Robot "HERO"; 68 Experiments: Fundamentals and Applications by Howard Boyett covers the basics behind controlling all of the Hero I's inputs, outputs, and applications. This 160-page book covers the Hero's use in such areas as industrial manufacturing, security systems, and home education. Its objective is to teach you how to become a robot innovator, capable of conceiving and implementing programs to control the Hero in a variety of applications. Topics addressed include machine-language control of inputs/outputs, user-dedicated keys, how to write an interpreter behind its cartridge slot, and an expansion connector is furnished. Enterpris is equipped with a network scheme that permits up to 32 computers to communicate and share resources. Cassette or 3½-inch micro-floppy-disk drives serve as mass-storage devices.

A fully structured programming language based on BASIC and enhanced with special operation commands and graphic- and sound-control facilities is supplied. Video and strategy games, educational programs, and programming aids are available. For complete details, contact Elan Computers Ltd., 31-37 Hoxton St., London N1, England; tel: 011441 739 4282; Telex: 22717 ELCOM G. Circle 540 on inquiry card.

Ball-Bearing Carriage Eliminates Noise

The Edcom slim-line floppy-disk drive uses a ball-bearing carriage to eliminate the noise and friction generated from a sliding read/write head. Edcom features a direct-drive brushless spindle motor, an automatic disk-ejection mechanism, a continuous band positioner, and ceramic heads. Memory capacity is 250K bytes double density and 125K bytes single density. The double-density transfer rate is 250K bits per second, and the single-density rate is 125K bits. Track density is 48 tpi, and track-to-track access averages 6 milliseconds. It works with Apple DOS, CP/M, and Pascal. Edcom measures 7.5 by 16 by 81 inches. For complete details, contact EDP Resources Co. Ltd., Number 5, 2/F., Newport Centre Phase 2, 116 Ma Tau Kok Rd., Tokwawan, Kowloon, Hong Kong; tel: 3-342405-6; Telex: 37449 ACTEL HX. Circle 539 on inquiry card.

Commodore Speech Unit

The Commtalk speaker synthesizer for the Commodore 64 and VIC-20 has a virtually unlimited vocabulary. It operates independently, affecting neither your computer's normal sound functions nor its BASIC language. Commtalk uses allographs, which are the variants of individual phonemes, to construct words. You can access speech directly through BASIC commands and create a library of words with strings. The synthesizer has the ability to talk with the continuous execution of a BASIC program. Speech is output through your monitor. Commtalk connects directly to the Commodore, leaving free its cartridge slot.

Drafting System Introduced

Datagraph has introduced a computer-aided design and drafting system that's built around an IBM PC or IBM PC XT and designed to serve as a tool for creating technical drawings, circuit diagrams, building plans, sketches, and illustrations. It features a 20-inch high-resolution graphics monitor, a video controller with 512K bytes of RAM, 1024- by 1024- by 4-pixel graphics, a mouse or digitizer tablet, and a drum or flatbed plotter. Elements such as lines, circles, arcs, rectangles, polygons, and text can be entered from a graphics tablet. Users can create and store elements. Drawings can be saved for manipulation or hard-copy printouts. Including the IBM, prices for the system range between DM 40,000 and DM 55,000, depending on configurations. Contact Datagraph GmbH, Giessener Str. 27, D-6302 Lich 1, West Germany; tel: 0 64 04120 71; Telex: 48 2890 video d. Circle 537 on inquiry card.

 FOREIGN

Home Computers With Stereophonic Sound

The Enterprise 64 and 128 Home Computers from Elan Computers Ltd. have stereo sound capabilities and 256 colors. Distributed in 64K- or 128K-byte versions, the Enterprise comes with a 69-key full-travel keyboard, a built-in joystick, color and black-and-white video outputs, a 56 by 84 display format, the ability to display text and graphics simultaneously, and an integral word processor with word-wrapping, justification, text centering, and paragraph paragraphing. Cassette, RS-423 serial, and Centronics-type parallel interfaces are standard, and a cartridge slot and an expansion interface are furnished. Enterprise is equipped with a network scheme that permits up to 32 computers to communicate and share resources. Cassette or 3½-inch micro-floppy-disk drives serve as mass-storage devices.

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What's New?

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**What's New?**

Commtalk comes with a program cassette and manual. It costs £39; the PET version is £45. Contact Andor Systems, 28 Hillside Dr., Rathfarnham, Dublin 14, Ireland; tel: 01-900107. Circle 538 on inquiry card.

**PERIPHERALS**

**Phone Replacement Allows High-Speed Dialing**

The Voice Oriented Auto Dialer, or VOAD, Keyboard Phone replaces standard rotary-dial or Touch Tone telephones and allows high-speed automatic dialing from a computer keyboard. VOAD permits detailed call recording, convenient access to such telecommunications systems as MCI or The Source, programming of call restrictions into a host computer, and, with the appropriate software, the selection of the most cost-effective call placement.

VOAD draws its power from the telephone line. It automatically selects Touch Tone or pulse modes and offers redialing capabilities. VOAD connects to an RS-232C port and comes with an RJ-11 jack for hook-up to a handset, headset, or speaker phone. It costs $199.50; quantity and OEM discounts are available. Contact VOAD Systems, Suite 227, 8570 Wilshire Blvd., Beverly Hills, CA 90211; (213) 550-0629. Circle 543 on inquiry card.

**Digital Transmits to Computers**

The Cybervision CV Series Digital-Camera detects an image and digitally transmits it to your computer for screening, printing, modification, transmission to another computer, or storage. A complete Digital-Camera includes an f/6 lens with adjustable focus and f-stop, digital detector, an interface board, connecting cable, a tripod, and supporting software. Camera resolution is 128 by 256 pixels. The crux of this device is Micron Technology's IS32 OpticRAM.

The Cybervision CV Series Digital-Camera is designed for direct coupling to Apple, Commodore 64, IBM PC and PC XT, or Radio Shack TRS-80 computers. A version that can communicate with most microcomputers through an RS-232C cable is offered. The Digital-Camera may be ordered in kit form or completely assembled and tested. Prices begin at less than $300. For full particulars, contact Cybergen Systems Corp., 2070 Walsh Ave., Santa Clara, CA 95050; (408) 727-6766. Circle 541 on inquiry card.

**Mouse and CAD System Introduced**

The Optomouse/AutoCAD package from USI Computer Products combines a digital mouse with a drafting and design software system. The Optomouse operates on a desktop grid and is accurate at speeds of up to 20 inches per second. It has four control buttons and is about the size of a deck of cards.

AutoCAD offers a variety of design and drafting applications ranging from architectural and landscaping drawings to drafting for mechanical, electrical, chemical, civil, and structural engineering. It lets you create and edit drawings of any size and scale. Drawings can be saved to disk, and complete drawings or combinations of design elements can be moved, copied, modified, erased, rotated, or rescaled through commands entered by the mouse or keyboard.

The Optomouse/AutoCAD works with the IBM Personal Computer and its compatibles. The retail price is $1200. For information, contact USI Computer Products Inc., 71 Park Lane, Brisbane, CA 94005; (415) 468-4900. Circle 544 on inquiry card.

**Single-Dot Editing with Light Pen**

Magellan Computer's Light Pen System for the Apple II Plus allows single-dot editing on the Apple II Plus or Ile's high-resolution screen. The Light Pen has push-button control over drawing operations. It comes with an electronic module that connects to the computer's game I/O port. This technique is transparent and allows game paddles, joysticks, and other peripherals to occupy the port as well.

Two programs are supplied: Quick-Draw lets you create and edit presentation-quality graphics; Amper-Pen lets you incorporate light-pen operations into Applesoft BASIC programs.

The Magellan Light Pen System costs $189.95, including software and documentation. It's available from Magellan Computer Inc., Suite D, 4371 East B2nd St., Indianapolis, IN 46250; (317) 842-9138. Circle 545 on inquiry card.

**Single-Dot Editing**

Magellan Computer's Light Pen System for the Apple II Plus allows single-dot editing on the Apple II Plus or Ile's high-resolution screen. The Light Pen has push-button control over drawing operations. It comes with an electronic module that connects to the computer's game I/O port. This technique is transparent and allows game paddles, joysticks, and other peripherals to occupy the port as well.

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Dual-Channel Chromatography for Apple
A full chromatography system for the Apple II is available from Anadata Inc. The Chromcard II, a 17-bit dual-channel A/D converter, comes with 128K bytes of RAM and necessary hardware and software. Data is acquired and displayed from two independent chromatographs and then analyzed at speeds of up to 40 points per second. A finished analytical report and graphic data can be output after peak detection and integration. If automatic selection is inappropriate, you can impose your own baseline. Methods and data can be stored on disk for retrieval and reprocessing.

Chromcard II costs $2450. For more information, contact Anadata Inc., 516 North Main St., Glen Ellyn, IL 60137, (312) 858-9606.
Circle 542 on inquiry card.

RS-232C Adapters
Ora Electronics designed the Data Spec ARS232AM adapter to convert a 25-pin RS-232C female connector to a male connector and the ARS232AF to perform the reverse function. These adapters are fully shielded to standards that are said to exceed FCC requirements. They incorporate a PVC molding to ensure maximum integrity and durability under adverse conditions. All 25 RS-232C pins are connected, making these adapters compatible with virtually all equipment. For more information, contact Ora Electronics, 18215 Parthenia St., Northridge, CA 91325, (213) 201-5848.
Circle 554 on inquiry card.

MISCELLANEOUS

Joystick Has ASCII Output
Turbo Stick is a high-pointing-speed joystick with full RS-232C ASCII output. Produced by the KA Design Group, Turbo Stick offers high resolution (i.e., one part in 4096) and dual fingertip-operated microswitches that let you alternate between an absolute mode with high pointing speed and a rate mode with high resolution. The switches can be redefined under software control to perform different functions.

Turbo Stick is suitable for graphics and instrumentation systems. It's priced at $395. OEM discounts are available. For details, contact KA Design Group, 6300 Telegraph Ave., Oakland, CA 94069, (415) 654-6300.
Circle 555 on inquiry card.

Cable Tester Has Remote Indicator
The Datacom RS-232C Cable Tester with remote indicator is a pocket-sized, battery-powered unit for testing and verifying cable configurations. Cables can be tested in either Step or Scan modes, and the Tester has 50 LEDs that indicate connections on each end of the cable. Three additional LEDs indicate Open, Short, or Continuity for each connection of the cable under test. Cable connectors are dual male/female 25-pin D-type, which allow any configuration of RS-232C cable connectors to be tested. The remote indicator lets you test and verify operations on installed cables. The Tester weighs 8 ounces, and the remote indicator is 3 ounces.

Circle 553 on inquiry card.

Datalife Detects Drive Problems
The Datalife Disk Drive Analyzer from Data Encore detects common disk-drive problems in Apple and IBM computers. Datalife runs four tests: disk alignment, disk clamping, write/read accuracy, and disk speed. It produces a display that indicates required adjustments and repair areas. System disassembly is not required. The entire test sequence takes only a few minutes.

The Datalife Disk Drive Analyzer comes on a 5 1/4-inch floppy disk. The suggested retail price is $39.95. For more information, contact Data Encore, 585 North Mary Ave., Sunnyvale, CA 94086, (408) 720-7400.
Circle 552 on inquiry card.
Introducing the Pika-Ink**, an incredible new device which extends the life of your fabric printer ribbons by a factor of TEN! Works with any fabric ribbon with 1/4" or narrower width. Automatically reinks your ribbons at the end or off the printer for consistent dark black print. Pays for itself on the first ribbon purchased.

The Pika-Ink is a kit which includes:
1. Stainless steel ink reservoir
2. Ball bearing assembly
3. Transfer felts
4. 1/5-28 60Hz electric motor
5. Power supply

Includes all necessary assembly and fabrication with hand tools.

The Pika-Box is the most advanced break out box on the market today. An absolute necessity for anyone who uses or works with RS-232 peripherals, interfaces, or data lines. Serves hours of aggravation. Available in standard or deluxe tri-state models. Lifetime warranty!

- 25-pin male DCE and female DTE connectors
- Individual LED's for monitor pins, 2, 3, 4, 5, 6, 8, 10, 11, 17, 20, 21, 22, 25, plus MARK and SPACE.
- 24 DIP switches allow signal lines to be individually interrupted.
- 25 test pins for monitoring or cross patching with included jumpers.
- Tri-State model displays signals as high, low, or invalid.
- Fits in shirt pocket. 2.9"x5.5"x1.5", wt. 8 oz.
- Fully assembled, ready to use.

The Pika-Box fits any standard Shugart compatible 51/4" floppy disk drive. Does not read 1/2 track.

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- Attractive case
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Compatible With: IBM, IBM PC, Apple II, Apple IIe, Commodore, CPC, Apple IIc, PLUS4, Radio Shack, Sinclair Timex, and more.

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- Qume QVT-102 $675

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Software

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<td>SONY Type Writer</td>
<td>$89.00</td>
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<td>TAL'S™</td>
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<tr>
<td>THE CHANNEL Connecting You And Computers</td>
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### exemple

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**ORDER HOURS:** M-F 8-6pm, Sat. 8-5pm  
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BYTE March 1984 489

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### MODEMS
- Anchor Mark I: $79.00
- Anchor Mark II: $79.00
- Hayes Smart: $299.00
- Hayes Micro II: $309.00
- Micro Bit: $299.00
- Apple Cat II: $589.00
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<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
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<tr>
<td>200 General Terminals CTC RS232</td>
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<tr>
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<td>CODEX IBM PC Extender Card</td>
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<td>IBM PC Prodigy Card</td>
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<td>PC Master (12 okin)</td>
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<tr>
<td>Distiller (Polyphonic)</td>
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**SOFTWARE**

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**DISKETTES**

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**MODEMS**

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<td>NOVATION Access 1-2-3</td>
<td>Call</td>
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<td>SYSTEM 816/10*</td>
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<td>THE ABOVE FULLY ASSEMBLED, TESTED &amp; BURNED-IN</td>
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<td>*Includes on-site Xerox service</td>
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<td>CPU 8086 A&amp;T</td>
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<td>RAM 16 64K STATIC, 8 OR 16, A&amp;T</td>
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<td>FREEDOM 100 TERMINAL CALL</td>
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<td>(EMUL TELEVIDEO 950 &amp; ADM 31</td>
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<td>TAXAN RGB 420 (IBM LOOK-ALIKE)</td>
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<td>USI PI 3 12” AMBER MON.</td>
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<td>PE-14 Erases 6 Eproms</td>
<td>$66</td>
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<td>PE-14T Same as PE-14 w/Timer</td>
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<td>PE-24T Erases 9 Eproms in 1 Min. W/Timer</td>
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<td>SUPERSIX W/128K RAM</td>
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<td>SUPERSLAVE, 6 MHz, 128K RAM</td>
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<td>HDC-1001 H.D. CONTROLLER</td>
<td>$398</td>
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<tr>
<td>CP/M 3.0</td>
<td>$350</td>
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<td>TURBODOS MULTI-USER</td>
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<td>DMA MICRO-MAGNUM</td>
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<td>5Mb FIX + 5Mb REMOV H.D.</td>
<td>$2,289</td>
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<td>S-100 SUBSYSTEM</td>
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<td>MBS-16/32K SERIAL</td>
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<td>MBS-64K PARALLEL</td>
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<td>MICROBUFFER IN-LINE™ STAND ALONE</td>
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<td>CAPTAIN w/384K, Clock/Cal w/Battery, Serial, Para, RamDisk, Spooler</td>
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<td>IEEE 488 BD. W/Software</td>
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<td>S-100 BOARD MODEM</td>
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<td>W/2 QUME 142 5½” DDSDD</td>
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<tr>
<th>Drive Type</th>
<th>Manufacturer</th>
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<td>320K Drive Slimline</td>
<td>TANDON TM100-2</td>
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<td>256K Memory</td>
<td>MBC 555</td>
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<td>Mark VII, 300 Baud</td>
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<td>Mark XII, 1200 Baud</td>
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### PRINTERS

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<td>RX80, 120 cps</td>
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<td>TX80, 150 cps</td>
<td>OKIDATA</td>
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### MONITORS

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<td>300, 12&quot; Green</td>
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<td>300A, 12&quot; amber</td>
<td>AMDEK</td>
<td>$139</td>
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### MORE ACCESSORIES

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<th>Item</th>
<th>Price</th>
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<tbody>
<tr>
<td>Koala Graphics Tablet</td>
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<td>8087 Co-Processor</td>
<td>$109</td>
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<td>Kraft Joystick</td>
<td>$39</td>
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<td>Sigma Controller Card</td>
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<td>Cable for Printer</td>
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<td>AMDEK MAI Card</td>
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**IBM & COMPATIBLE COMPUTERS**

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<th>Model</th>
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<td>PCw/64K, 2-Drives</td>
<td>EAGLE</td>
<td>$5295</td>
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<td>XTw/Hardisk, 128K</td>
<td>SANYO</td>
<td>$4695</td>
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<td>MBC-555, 1-Drive</td>
<td>TOSHIBA</td>
<td>$1199</td>
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<td>MBC-555, 2-Drives, more software</td>
<td>TOSHIBA</td>
<td>$5295</td>
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<th><strong>FRANKLIN SYSTEMS!</strong></th>
<th><strong>SOFTWARE</strong></th>
<th><strong>FOR IBM/PC</strong></th>
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<tr>
<td>1000 Pro Pack Plus: Feature:</td>
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<td>IBM</td>
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<tr>
<td>• 1000 CPU</td>
<td>Supercalc 3</td>
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<tr>
<td>• Franklin Monitor</td>
<td>Visual Calc IV</td>
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<tr>
<td>• 80 Column Card</td>
<td>Home Accountant</td>
<td>$274.95</td>
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<tr>
<td>• Ace 10 Disk Drive + Controller</td>
<td>Dollars And Sense</td>
<td>$124.95</td>
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<td>• Ace Calculator</td>
<td>Micro Cookbook</td>
<td>$134.95</td>
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<td>• Ace Writer</td>
<td>Bank Street Writer</td>
<td>$44.95</td>
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<tr>
<td>• Data Perfect</td>
<td>Tax Advantage</td>
<td>$41.95</td>
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<td>• Welcome Package</td>
<td>Multilink</td>
<td>$184.95</td>
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<td><strong>TOO LOW TO PUBLISH</strong></td>
<td>The General Manager</td>
<td>$154.95</td>
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<td>1200 OMS Package: Feature:</td>
<td>TK Solver</td>
<td>—</td>
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<tr>
<td>• 5000 CPU</td>
<td>BPI-GEN Acct/Inv/Payroll</td>
<td>$274.95</td>
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<tr>
<td>• 80 Column Card</td>
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<tr>
<td>• 2 Disk Drives + Controller</td>
<td>Wordstar Professional</td>
<td>$434.95</td>
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<tr>
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<tr>
<td>• Parallel &amp; Serial interfaces</td>
<td>Sensible Speller</td>
<td>$84.95</td>
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<td>• Wordstar</td>
<td>PFS: Write/File/Report</td>
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<td>• Mailmerge</td>
<td>Peachliv 3000</td>
<td>$264.95</td>
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<td>• Ace Calc.</td>
<td>Lotus 1-2-3</td>
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<tr>
<td>• Welcome Package</td>
<td>DB Master (Version 4)</td>
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<td>DBASE II</td>
<td>$444.95</td>
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<tr>
<th>Product Description</th>
<th>Price</th>
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<td>OYSAN 5&quot; SS/DO (10)</td>
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<td>OYSAN 5&quot; SD/DD (10)</td>
<td>39.99</td>
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<tr>
<th>Product Description</th>
<th>Price</th>
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<td>VISI-ON MAXELL 5&quot; SS/DD (10)</td>
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**MICROSOFT**

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<td>ALDO</td>
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<td>APPLET EDUCATOR</td>
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<td>BASIC COMPILER</td>
<td>239.99</td>
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<td>CASIO COMPILER</td>
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<td>FLIGHT SIMULATOR (IBM)</td>
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<td>SOFTWARE</td>
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Full 1 year warranty—cable choice optional

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<th>Shugart (1 year war)</th>
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<th>2 @ 495 ea</th>
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<tbody>
<tr>
<td>SA-860 8&quot; double sided half high 8&quot;</td>
<td>2 bathrooms</td>
<td>250 ea</td>
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<tr>
<td>SA-465S 8&quot; 4 HD half height 5.25&quot;</td>
<td>350.00</td>
<td>2 @ 325 ea</td>
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<td>SA-300S 8&quot; 3.5&quot; inch</td>
<td>255.00</td>
<td>2 @ 230 ea</td>
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<td>SA-851 8&quot; full size</td>
<td>495.00</td>
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<td>W.S.F. (formerly SIEMENS)</td>
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<td>FDD-100-564 floppy 5.25&quot;</td>
<td>225.00</td>
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<td>FDD-221-5 DS 96tpi for PC</td>
<td>265.00</td>
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<td>FDD-221-5 DS 96tpi full size</td>
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<tr>
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<tr>
<td>Heath H-89 TWINET kit</td>
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</tr>
<tr>
<td>put 2 half height floppy drives internal to the H-89 with our exclusive mounting kit, call for details!</td>
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<td>Maynard Electronics for the IBM-PC</td>
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<td>Memory module (bare)</td>
<td>210.00</td>
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<td>64K</td>
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<td>128K</td>
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<td>49K</td>
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<tr>
<td>256K</td>
<td>615.00</td>
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</tr>
<tr>
<td>With serial port add</td>
<td>100.00</td>
<td></td>
</tr>
<tr>
<td>With 2 serial ports</td>
<td>150.00</td>
<td></td>
</tr>
<tr>
<td>Controller w/ mod ports</td>
<td>265.00</td>
<td></td>
</tr>
<tr>
<td>FDC8 8&quot; controller</td>
<td>245.00</td>
<td></td>
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</tbody>
</table>

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**CCS CALSTAR SYSTEM**

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- One parallel and two serial ports

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**B**

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<thead>
<tr>
<th>Brand</th>
<th>Model</th>
<th>Price</th>
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<tr>
<td>Amdek</td>
<td>Color 1 + Composite</td>
<td>$299</td>
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<td>Color 1 + RGB Video</td>
<td>$419</td>
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<td></td>
<td>300G, 12&quot; Green</td>
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<td></td>
<td>300A, 12&quot; Amber</td>
<td>$149</td>
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<td>310A, Monochrome Amber</td>
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<tr>
<td>BMC</td>
<td>12 AUW, 80 column</td>
<td>$84</td>
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<td></td>
<td>12 EUN Hi-Res Green</td>
<td>$109</td>
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<td>9191 Color New Version</td>
<td>$259</td>
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<td>IBM</td>
<td>Monochrome Hi-Res Green</td>
<td>$319</td>
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<td>RGB Color</td>
<td>$699</td>
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<td>Princton Graphics</td>
<td>PGS-HX12, IBM Copy</td>
<td>$499</td>
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<td>PGSXR-12, Hi-Res Color</td>
<td>$489</td>
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<td>PGS MAX-12, 12&quot; Monochrome</td>
<td>$199</td>
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<td>USI</td>
<td>P1, 9&quot; Green, Hi-Res, 20MHz</td>
<td>$119</td>
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<td>P2, 12&quot; Green, Hi-Res, 20MHz</td>
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<td>P3, 12&quot; Amber, Hi-Res, 20MHz</td>
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<td>P4, 9&quot; Amber, Hi-Res, 20MHz</td>
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<td>Zenith</td>
<td>ZVM122, Hi-Res Green</td>
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<td>ZVM123, Hi-Res Amber</td>
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### COMPUTER SYSTEMS

<table>
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<tr>
<th>Brand</th>
<th>Model</th>
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<tr>
<td>Apple</td>
<td>IIE Starter System</td>
<td>$1326</td>
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<td></td>
<td>CPU Only</td>
<td>$999</td>
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<td></td>
<td>Compaq Portable (PC Compatible)</td>
<td>$2795</td>
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<td></td>
<td>Franklin</td>
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<td>Kaypro</td>
<td>Kaypro II</td>
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<td>Kaypro 4</td>
<td>$1695</td>
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<td>Kaypro 10</td>
<td>$2495</td>
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<td>IBM</td>
<td>PC64K, 2-Drives</td>
<td>$2295</td>
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<td>XT Hard Disk Drive, 128k</td>
<td>$2695</td>
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<td>SANYO</td>
<td>MBC-550 PC Compatible</td>
<td>$849</td>
</tr>
<tr>
<td></td>
<td>MBC-555 2-Drives, more software</td>
<td>$129</td>
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### 5 1/4" DISKETTES

<table>
<thead>
<tr>
<th>Brand</th>
<th>Type</th>
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<tr>
<td>CCU</td>
<td>Sgl/Dbl reinforced hub</td>
<td>$18</td>
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<tr>
<td></td>
<td>Dbl/Dbl reinforced hub</td>
<td>$22</td>
</tr>
<tr>
<td></td>
<td>Not Bulk Packed</td>
<td>$100</td>
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<tr>
<td>Dysan</td>
<td>Sgl/Dbl</td>
<td>$33</td>
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<td></td>
<td>Dbl/Dbl</td>
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<tr>
<td>Maxell</td>
<td>Sgl/Dbl</td>
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<td>Dbl/Dbl</td>
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<td>Memorex</td>
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<td></td>
<td>Dbl/Dbl</td>
<td>$35</td>
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<td>Verbatim</td>
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<td>$26</td>
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<tr>
<td></td>
<td>Dbl/Dbl</td>
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<td>Wabash</td>
<td>Sgl/Dbl</td>
<td>$22</td>
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<tr>
<td></td>
<td>Dbl/Dbl</td>
<td>$29</td>
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<tr>
<td></td>
<td>100 for 150</td>
<td>$100</td>
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<tr>
<td></td>
<td>100 for 200</td>
<td>$100</td>
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### 8" DISKETTES

<table>
<thead>
<tr>
<th>Brand</th>
<th>Type</th>
<th>Price</th>
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<tbody>
<tr>
<td>Dysan</td>
<td>Sgl/Sgl</td>
<td>$54</td>
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<td>Dbl/Dbl</td>
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<td>Maxell</td>
<td>Sgl/Dbl</td>
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<td>Dbl/Dbl</td>
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<td>Memorex</td>
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<td>Dbl/Dbl</td>
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<td>Verbatim</td>
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<td>Dbl/Dbl</td>
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<td>Wabash</td>
<td>Sgl/Sgl</td>
<td>$24</td>
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<td>Dbl/Dbl</td>
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### DISK ACCESSORIES

<table>
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<th>Brand</th>
<th>Model</th>
<th>Price</th>
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<tr>
<td>Verbatim</td>
<td>8&quot; or 5 1/4&quot; Head Cleaning Kit</td>
<td>$11</td>
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<tr>
<td></td>
<td>Flip Tub</td>
<td>$17</td>
</tr>
<tr>
<td></td>
<td>5 1/4&quot; Holds 50 disks, plexiglass</td>
<td>$21</td>
</tr>
<tr>
<td></td>
<td>5 1/4&quot; Holds 70 disks, plexiglass</td>
<td>$21</td>
</tr>
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</table>

### APPLE DRIVES

<table>
<thead>
<tr>
<th>Brand</th>
<th>Model</th>
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<tbody>
<tr>
<td>Apple</td>
<td>Disk 2</td>
<td>$299</td>
</tr>
<tr>
<td></td>
<td>Disk 2 controller w/DOS 3.3</td>
<td>$89</td>
</tr>
<tr>
<td>Micro Sci</td>
<td>A-2 Fully compatible</td>
<td>$209</td>
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<td></td>
<td>Controller w/diagnostics</td>
<td>$79</td>
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<tr>
<td>Quentin Research</td>
<td>Applemate Controller</td>
<td>$209</td>
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<tr>
<td>Rana Systems</td>
<td>Elite I Quad Density Controller</td>
<td>$75</td>
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<td>Elite II Diol Sided</td>
<td>$379</td>
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<td></td>
<td>Elite III Quad Density Controller</td>
<td>$479</td>
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<tr>
<td></td>
<td>Super 5</td>
<td>$199</td>
</tr>
</tbody>
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- 851R DbI/DbI: $479

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- Kaypro to Printer: $25
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Send telegrams, Mailigrams and computer letters as easy as telephoning Western Union's toll free access line. Your personal computer and modem become your link to the World.

One time $35.00 installation fee includes EasyLink self teaching user manual, Telex directory and your EasyLink access password.

$995 SANYO IBM COMPATIBLE

Sanyo Electronics has just released the long awaited IBM/PC look-a-like, the MBC-550. This is a complete microcomputer that includes 128K/byte of memory, a 5¼ 160K/byte disk drive upgradeable to 320K/byte drives. Also included are color composites and RGB graphics interface, line profile keyboard, and parallel printer port. Extensive software such as Sanyo Basic, disk utilities, Wordstar word processing software, Calculator spread sheet & Easy Writer I. MS-DOS is supplied with the Sanyo computer. Most programs written for the IBM/PC will operate on the MBC-550.

Along with all this California Digital offers "FREE" your choice of either a second disk drive, or a high resolution green or amber screen monitor. All at the super low price of only $995.

$289 PRINTERS

Your Choice
Second Drive or Monitor

TERMINALS

Perkin Elmer 550

$339

$929 APPLE

$4995 256 KILOBYTE MEMORY BOARD

- 256 megabyte memory using 64K dynamic RAM.
- Over ten megabyte of memory using the new 256K dynamic RAM chip.
- 16 Mbyte capability.
- Individual 16K block can be located to any boundary with dynamic RAM.
- 24 bit addressability please recheck

$995 S-100 BOARDS

16 BIT MICROPROCESSORS

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- Godbout dual processor for $650.00
- Cabaloma Computer II microprocessor CCS-1810 $175.00
- Tarbell 100 word processor TAW-880 $339.00

8 BIT MICROPROCESSORS

- California Computer II microprocessor CCS-218 $175.00
- Tarbell I word processor TAW-Z80 $339.00

FLOPPY DISK CONTROLLERS

- Godbout DAC-10A $395.00
- California Computer ZX-2422 with CPM CCS-2422 $339.00
- MOS-OJ1 floppy disk controller MOS-OJ1 $350.00
- Fullerton OMA-101 $389.00

STATIC MEMORY BOARDS

- California Computer II 16-bit memory CCS-216 $299.00
- Godbout RAM/1 7.64 MB $850.00
- Godbout RAM/2 128Kbyte 811 Mbyte transfer $850.00
- Fulcrum OMA-300 8116 byte buffer bank $495.00

DYNAMIC MEMORY BOARDS

- California Computer II 2000 & 512K seletable CCS-2066 $295.00

$49 ASCII KEYBOARD

CP/M SOFTWARE

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- O-Basic II ASH-015C $499.00
- WordStar MPR-87C $499.00
- Multimagic MPR-39C $169.00
- Spelling MPR-429C $169.00
- Macro 80 MPR-87C $139.00

Additional Software available for Apple, IBM/PC and Atari. Please telephone for price and availability.

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Telex 753607 VISA

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(800) 848-8008

VISA MasterCard

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air pound, add $1 for UPS Blue
shipping and handling. California
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tax; Bay area and LA residents
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We are not responsible for typo-
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dise subject to prior sale.

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Saturdays 10:00 to 3:00

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Santa Clara, CA 95050
(408) 988-0697

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100% GUARANTEED

524 BYTE March 1984
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**5 1/4" DISKETTES**

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**DISKETTES**

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**BYTE March 1994**
APPLE ACCESSORIES

- 80 Column Apple II+ ........................................ 149.95
- 80 Column Apple II ......................................... 129.95
- 260 Apple II .................................................. 69.00
- 260 Apple II Kit .............................................. 59.00
- 260 Apple IIIE ................................................. 89.00
- 260 Apple IIIE Kit ........................................... 59.00
- 16K Card ....................................................... 59.05
- 16K Bare Board ............................................... 13.95
- Cooling Fan ................................................... 38.95
- Power Supply ................................................. 74.95
- Joystick ........................................................ 29.95
- RF Modulator ................................................ 13.95
- Disk Drive ..................................................... 199.00
- Controller Card .............................................. 59.95

micromax

VIEWMAX-80 149.95
- 80 Column card for Apple II+
- Video Soft Switch
- Inverse Video
- 2 Year Warranty

VIEWMAX-80e 129.95
- 80 Column card for Apple IIIE
- 64K RAM expandable to 128K
- 64K RAM Upgrade ........... 43.60

GRAPHMAX ....... 129.95
- Hi Resolution Graphics
- Printer Card
- Centronics Parallel Interface

Graphmax with COLOR and ZOOM Options .................. 139.95

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- Shugart mechanism, made in U.S.A.
- Directly replaces Apple Disk II
- Fully compatible with Apple Controller or other Apple compatible controllers.
- One Year Warranty

CONTROLLER CARD ............. 59.95

COOLING FAN

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APPLE COMPATIBLE POWER SUPPLY

74.95

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- +5V @ 5A  +12V @ 32A
- 5V @ .5A  -12V @ .5A
- Includes instructions

16K RAM Card Apple II+
- 2 Year Warranty

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The new Flip Sort™ has all the fine qualities of the original Flip Sort™, with some added benefits. Along with a new design, capacity has been increased 50% to hold 75 diskettes and the price is more reasonable than ever - $19.95

The Flip Sort PLUS™

The Flip Sort Plus™ adds new dimensions to storage. Designed with similar elegant lines as the original Flip Sort™ in a transparent smoked acrylic. Holds over 100 diskettes and has all the outstanding features you have come to expect from the Flip Sort Family.

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POWER SUPPLY

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MOUNTED on PC BOARD
Manufactured by CONVER

+5 VOLT, 4 AMP
±12 VOLT, 1 AMP

Dimensions: 8" x 4½" x 2¾" deep
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**Computer Savings Coming Just Over The Horizon!**

**DISK DRIVES**

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<td>5¼” 645L (40 TR) 320K HGT</td>
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<td>8” 8080/SS/DD 320K</td>
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<td>5¼” 142 (40 TR) 320K HGT</td>
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<td>8” DTB</td>
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**S’I<” B-S2 4DTR OS/DD 32DK (FOR IBM PC)**

**Sv.»” 4AD (3S TR) 16DK**

**Sv.” 94D9-DS/DD**

**Sv.” 84DDL (4D TR) 19DK**

**SV" 142 (4D TR) 32DK HGT**

**TM1 D1-4 (96 TPI Quad Den)**

**SW’ B-S1 4DTR SS/DD 1 BDK**

**SW’ DDCSV w/PS vertical-for 1 ea. Sv.’” drive**

**SW’ DDCSH w/PS horizontal-for 1 S’I<” drive**

**DDCBBV w/PS vertical-for 2 or 4” CABINETS**

**DDCBBT w/PS vertical-for 1-B” drive**

**DDCBBT-1 w/PS vertical-for 2 or 4” CABINETS**

**TV92S w/2nd page memory**

**TV97D**

**TV9SD w/2nd, 3rd, 4th page memory**

**TV91D**

**QVT-1D2**

**QVT-1DB**

**RG 162V/600 Graphics Upgrade for 295/650**

**QVT-1D2**

**RG 162V/600 Graphics Upgrade for 1,100.00**

**WTSE-100**

**WTSE-300**

**TERMINALS**

**ADDNS**

**Viewpoint-1 (White)**

**Viewpoint-2 (Green)**

**Viewpoint-3 (Green)**

**Viewpoint-60 Same as Televideo 925**

**QUIME**

**QVT-102 80 Col. Green (910 comp)**

**QVT-102 80 Col. Amber**

**QVT-110 80/120 Col. Green**

**QVT-110 80/120 Col. Amber**

**QVT-148 80/120 Col. Amber (925 comp)**

**TELEVIDEO**

**TV910**

**TV950**

**TV925 w/2nd page memory**

**TV650 w/2nd, 3rd, 4th page memory**

**TV670**

**RS 1020/TV60 Graphics Upgrade for 925/650**

**WYSE**

**WYSE-100**

**WYSE-300**

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- HR-1A 17 CPS Daisywheel 3K Buff 495.00
- HR-1A 17 CPS Daisywheel 3K Buff 589.00
- DATA-SOUTH
  - DS 180 180CPS Serial or Par/Tractor 1,400.00
- Daisywriter 2000-48K Buffer/20T040CPS LT/V/Par 1,095.00
- 620 (25CPS/Serial) 920.00
- 630 (40CPS/Multi-IF) 1,719.00

**DIABLO**

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- Diablo 630-Bi-Direct Tractor 275.00
- Diablo 630-DBL Sheet Feeder 1,395.00

**MITSUBISHI**

- 8” M-2894-63 Thinline 8” DS/DD 1.2 MG 419.00
- 8” M-2894-63 (110V) STD DS/DD 1.2 MG 425.00
- 5¼” Q9490/DS-DD 225.00
- 5¼” TM100-1S/DS/DD 150K 150.00
- 5¼” TM100-2A DS/DD (320K) FOR IBM-PC 225.00
- TM101-8 (96 TPI Quad Den) 1,2 MG 425.00
- 8” TM484-2 (DS/DD) 1.2 MG 355.00

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- Microline 62A (SER & PAR-120CPS 15”) 219.00
- Microline 62A (SER & PAR-120CPS 15”) CALL
- Microline 93 (PAR-160CPS-LTR-15”) CALL
- Microline 894 (SER-200CPS-LTR-15”) CALL
- Microline 894 (SER-200CPS-LTR-15”) CALL
- Microline 894 (SER-200CPS-LTR-15”) CALL
- Microline 894 (SER-200CPS-LTR-15”) CALL
- Microline 894 (SER-200CPS-LTR-15”) CALL

**ANCOR**

- Anchor Mark XII Totally Hayes 299.00
- Anchor Mark XII Totally Hayes 339.00
- Anchor Mark XII Totally Hayes 499.00

**ERASERS**

- E-PROM ERASERS
  - OUV-8/1H (Industrial) 120.00
  - OUV-8/1H (Industrial) 195.00
- OUV-8/2P (w/timer & safety switch) 97.50

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- Lemon (6AC outlets-3 prong) 50.00
- Peach (3 outlets) AC surge/emi filter 69.00
- Peach (3 outlets) AC surge/emi filter 89.00

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- Saturday 10 AM to 5 PM

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528 BYTE March 1984

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COMPUPRO S-100

COMPUPRO 816A 4,250.00
COMPUPRO 816B 5,595.00
COMPUPRO 816C 7,150.00
Call for specifications

APPLE/FRANKLIN

APPLE IIe Starter—Includes CPU 1 F.D. Monitor and 80 Col. Card 1,325.00
FRANKLINACE 1000 w/color 799.00
FRANKLIN ACE 1200 OMS includes CPU-2 F.D. and bundled software 1,699.00

KAYPRO

KAYPRO II w/bundled software 1,475.00
KAYPRO 4 w/bundled software 1,695.00
KAYPRO 10 w/bundled software 2,495.00
Call for specifications

KAYPRO II-IV ADD ONS

Sprinter K (5MHz Speed-up) 99.00
K-Clock (Batt Backup Clk/Cal) 99.50
Video Output BD (allows use of video monitor) 125.00

TOLL FREE 1-800-545-2633

1780 West 2300 South The Great Salt Lake Computer Co. Salt Lake City, Utah 84119

BYTE March 1984 529
## S-100 PRODUCTS

### QT PRODUCTS

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</thead>
<tbody>
<tr>
<td>PN-2044 Best Bar Code Board Set Available</td>
<td>$4,569.00</td>
</tr>
</tbody>
</table>

### MEMORY BOARDS

<table>
<thead>
<tr>
<th>Board Type</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAM 16</td>
<td>$1,675.00</td>
</tr>
<tr>
<td>RAM 17-64</td>
<td>$575.00</td>
</tr>
<tr>
<td>RAM 21</td>
<td>$450.00</td>
</tr>
<tr>
<td>RAM 22</td>
<td>$349.00</td>
</tr>
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</table>

### CPU BOARDS/MEMORY BOARDS/I/O

<table>
<thead>
<tr>
<th>Board Type</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU 8085/88 - 6/8 MHz</td>
<td>$369.00</td>
</tr>
<tr>
<td>CPU 8086 - 8 MHz</td>
<td>$650.00</td>
</tr>
<tr>
<td>8087 Support Board</td>
<td>$379.00</td>
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</table>

### SYSTEMS

<table>
<thead>
<tr>
<th>System Type</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>System 816A</td>
<td>$4,395.00</td>
</tr>
<tr>
<td>System 816A with RAM 21</td>
<td>$4,569.00</td>
</tr>
<tr>
<td>System 816B</td>
<td>$5,595.00</td>
</tr>
<tr>
<td>System 816B - H40</td>
<td>$8,349.00</td>
</tr>
<tr>
<td>System 816C</td>
<td>$7,695.00</td>
</tr>
<tr>
<td>System 816C - H40</td>
<td>$11,999.00</td>
</tr>
<tr>
<td>System 816D - H40</td>
<td>$13,995.00</td>
</tr>
<tr>
<td>System 816E (8K)</td>
<td>$7,150.00</td>
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<td>System 816E</td>
<td>$7,895.00</td>
</tr>
<tr>
<td>System 816Z</td>
<td>$3,999.00</td>
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### OPERATING SYSTEMS

<table>
<thead>
<tr>
<th>OS Type</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP/M 80 22</td>
<td>$150.00</td>
</tr>
<tr>
<td>CP/M 86 (Disk 18086/88)</td>
<td>$199.00</td>
</tr>
</tbody>
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### SIERRA DATA S-100 BOARDS

<table>
<thead>
<tr>
<th>Board Type</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>SDS-SBC-100-256 (4mhz) master 2 serial 2 par/ floppy controller/64 ram</td>
<td>$655.00</td>
</tr>
<tr>
<td>SDS-SBC-1002/4mmslave/256 static 2 par/ floppy controller</td>
<td>$649.00</td>
</tr>
</tbody>
</table>

### CONTACTS

- Buyer's Discount Guide
- Minimum Shipping $3.00
- Toll Free 1-800-545-2633 in the Continental U.S.A.
<table>
<thead>
<tr>
<th>Item Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disk II</td>
<td>$269.00</td>
</tr>
<tr>
<td>Monitor II</td>
<td>$59.00</td>
</tr>
<tr>
<td>CPN 3.0 Card</td>
<td>$269.00</td>
</tr>
<tr>
<td>Z-Card II</td>
<td>$119.00</td>
</tr>
<tr>
<td>Smartterm</td>
<td>$139.00</td>
</tr>
<tr>
<td>RF Modulator</td>
<td>$18.00</td>
</tr>
<tr>
<td>ASTAR COMPOSER</td>
<td>$18.00</td>
</tr>
<tr>
<td>Beginner's Kit (5 hrs. time)</td>
<td>$39.95</td>
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<tr>
<td>Software for life</td>
<td>$59.00</td>
</tr>
<tr>
<td>GENERIC 80 Col. Video (Videx Compatible)</td>
<td>$99.00</td>
</tr>
<tr>
<td>Joy Stick</td>
<td>$20.00</td>
</tr>
<tr>
<td>Keyboard</td>
<td>$175.00</td>
</tr>
<tr>
<td>Parallel Interface</td>
<td>$49.00</td>
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<tr>
<td>Mach III (with firing button)</td>
<td>$42.95</td>
</tr>
<tr>
<td>Micro-Modem II</td>
<td>$259.00</td>
</tr>
<tr>
<td>Micro-Modem II w/terminal board</td>
<td>$279.00</td>
</tr>
<tr>
<td>System Saver/Modem/Trams Pro</td>
<td>$75.00</td>
</tr>
<tr>
<td>KENSINGTON Graphics</td>
<td>$89.00</td>
</tr>
<tr>
<td>Graphics Tablet</td>
<td>$44.00</td>
</tr>
<tr>
<td>ジョイスティック for life</td>
<td>$149.00</td>
</tr>
<tr>
<td>View Max 80 (80 Col for 25 I/O)</td>
<td>$149.00</td>
</tr>
<tr>
<td>View Max 80E (80 Col w/46K Memory)</td>
<td>$139.00</td>
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<tr>
<td>Premium Soft Card IIE</td>
<td>$139.00</td>
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<tr>
<td>Multi-Plan</td>
<td>$189.00</td>
</tr>
<tr>
<td>Softcard (256)</td>
<td>$239.00</td>
</tr>
<tr>
<td>MICROTEK DUMPLING 164K/Interface and Graphics</td>
<td>$235.00</td>
</tr>
<tr>
<td>64k Buffer</td>
<td>$235.00</td>
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<tr>
<td>DUMPLING GX-P/Par Interface Card and Cable 99</td>
<td>$235.00</td>
</tr>
<tr>
<td>Parallel Interface Board FBW11</td>
<td>$61.00</td>
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<tr>
<td>IBM 16 (16K Add-on Memory)</td>
<td>$99.00</td>
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<tr>
<td>Apple Cat II w/Software</td>
<td>$269.00</td>
</tr>
<tr>
<td>ORANGE MICRO W/GRAPHICS</td>
<td>$119.00</td>
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<tr>
<td>Grappler + (Graphics Interface)</td>
<td>$175.00</td>
</tr>
<tr>
<td>Buffer Board</td>
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</tr>
<tr>
<td>Joy Stick-For Apple II</td>
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<tr>
<td>Paddles</td>
<td>$29.00</td>
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<tr>
<td>Selecta Port</td>
<td>$39.00</td>
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<td>VIDEOKAN</td>
<td>$279.00</td>
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<td>Ultratext</td>
<td>$279.00</td>
</tr>
<tr>
<td>VISTA A800 Floppy Controller for 8&quot; Drives A-800-1 Cable</td>
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</tr>
<tr>
<td>DISKETTE STORAGE</td>
<td></td>
</tr>
<tr>
<td>DISKETTE STORAGE</td>
<td></td>
</tr>
<tr>
<td>Diskette Storage</td>
<td></td>
</tr>
<tr>
<td>Diskette Storage</td>
<td></td>
</tr>
<tr>
<td>TOLL FREE 1-800-545-2633</td>
<td></td>
</tr>
</tbody>
</table>
200 Watts for 5 Minutes of Uninterruptable Power With AC Surge and EMI/RFI Filtering Built In. Perfect for Morrow Micro Decision, IBM PC," + etc.}

**NOW! The Affordable UPS For Your Personal Computer!** $359.00

**MANNESSMANN TALLY**

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**SALE** $60.00 !!

ORDER TOLL FREE (800) 423-5922 - CA, AK, HI CALL (818) 709-5111
**DRIVES & ENCLOSURES**

### 5¼" FLOPPY DISK DRIVES

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCMPI92* MPI Full Height SS 48TP (5 lbs.)</td>
<td>$290.00</td>
</tr>
<tr>
<td>BCMPI52* MPI Full Height OS 48TP (5 lbs.)</td>
<td>$270.00</td>
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<tr>
<td>BCMPI91* MPI Full Height SS 56TP (5 lbs.)</td>
<td>$310.00</td>
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<tr>
<td>BCMPI51* MPI Yo-Height SS 48TP (4 lbs.)</td>
<td>$260.00</td>
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<tr>
<td>BCMPI502 MPI Yo-Height OS 48TP (4 lbs.)</td>
<td>$300.00</td>
</tr>
<tr>
<td>BCTNOTM100 TIandon Full Height SS 48TP (5 lbs.)</td>
<td>$290.00</td>
</tr>
<tr>
<td>BCTNOTM101 TIandon Full Height OS 48TP (5 lbs.)</td>
<td>$300.00</td>
</tr>
<tr>
<td>BCTNOTM114 TIandon Full Height OS 48TP (5 lbs.)</td>
<td>$320.00</td>
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### 8" Floppy Disk Drives

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>BCMPI411 Shugart Full Height SS (11 lbs)</td>
<td>$460.00</td>
</tr>
<tr>
<td>BCMPI421 MFM Full Height SS (11 lbs)</td>
<td>$460.00</td>
</tr>
</tbody>
</table>

### Dual 8" Disk Enclosures

All of these rugged enclosures feature: (1) Interim air cooling; (2) power supply with the heat producing elements mounted to outside of cabinet; (3) solid state controller. The rear panels are secured to the appropriate data cables.

**BUY CABINETS WITH DRIVES AND SAVE!**

**15M Byte Hard Disk For IBM PC™**

50% More Capacity Than The XTI™

- Plug and Run — ready to go right out of the box!
- Complete with controller card, data cable, & internal mounting hardware.
- Total PC/XT Compatible — will boot directly from the hard disk under DOS 2.0.
- No special software needed.
- OK BIOS emulates XT command set.
- Controller will support up to 2 hard drives.
- Hard disk can be partitioned into 4 operating systems.
- 2:1 interleave (data transfer rate 3 times faster than XT)!

**INTERNAL 15M Byte Hard Disk With Controller**

**$1495**

**EXTERNAL 15M Byte Hard Disk With Controller**

The 15MByte drive is mounted in an ATH500 cabinet with power supply. All hardware specifications are the same.

**$1695**

**Backed By a 6-Month Warranty!**

---

**5¼" DOUBLE DENSITY DISKETTES**

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCMXI1200M Solt 40 10 12 heads</td>
<td>$32.00</td>
</tr>
<tr>
<td>BCMXI1200M (Hard) 10 12 heads</td>
<td>$32.00</td>
</tr>
<tr>
<td>BCMXI1302M Solt 40 10 12 heads</td>
<td>$34.00</td>
</tr>
<tr>
<td>BCMXI1302M (Hard) 10 12 heads</td>
<td>$34.00</td>
</tr>
<tr>
<td>BCMXI1400M Solt 80 10 12 heads</td>
<td>$40.00</td>
</tr>
<tr>
<td>BCMXI1400M (Hard) 10 12 heads</td>
<td>$40.00</td>
</tr>
</tbody>
</table>

**Go on The Gold Standard!**

Phone Today and Get On Our Priority Interrupt Mailing List!

**PRIORITY 1 ELECTRONICS**

961 Deering Ave., Chatsworth, CA 91311-5837

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**Connecting and Accessories**

**Double-Row Male Headers**
- Solder to PC boards for instant plug-in access (.025" square posts on a .100" x .100" matrix)

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>923662R</td>
<td>20 post double row male</td>
</tr>
<tr>
<td>923663R</td>
<td>26 post double row male</td>
</tr>
<tr>
<td>923664R</td>
<td>34 post double row male</td>
</tr>
<tr>
<td>923665R</td>
<td>40 post double row male</td>
</tr>
<tr>
<td>923666R</td>
<td>60 post double row male</td>
</tr>
</tbody>
</table>

**Gender Changers**

Used to connect 2 cables which have the same gender.

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>JRSRM-M</td>
<td>Connects 2 male (DB25P) cables</td>
</tr>
<tr>
<td>JRSF-F</td>
<td>Connects 2 female (DB25S) cables</td>
</tr>
</tbody>
</table>

**D-Sub Connectors**

**Solder-Type Contacts**

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>DE9P</td>
<td>9 Pin Plug</td>
</tr>
<tr>
<td>DE9S</td>
<td>9 Pin Socket</td>
</tr>
<tr>
<td>DE9H</td>
<td>Hood for DE9 Series Connectors</td>
</tr>
<tr>
<td>DA15P</td>
<td>15 Pin Plug</td>
</tr>
<tr>
<td>DA15S</td>
<td>15 Pin Socket</td>
</tr>
<tr>
<td>DA15H</td>
<td>Hood for DA15 Series Connectors</td>
</tr>
<tr>
<td>DB25P</td>
<td>25 Pin Plug (Meets RS232)</td>
</tr>
<tr>
<td>DB25S</td>
<td>25 Pin Socket (Meets RS232)</td>
</tr>
<tr>
<td>DB25H</td>
<td>Hood for DB25 Series Connectors</td>
</tr>
<tr>
<td>DC37P</td>
<td>37 Pin Plug</td>
</tr>
<tr>
<td>DC37S</td>
<td>37 Pin Socket</td>
</tr>
<tr>
<td>DC37H</td>
<td>Hood for DC37 Series Connectors</td>
</tr>
<tr>
<td>D50P</td>
<td>50 Pin Plug</td>
</tr>
<tr>
<td>D50S</td>
<td>50 Pin Socket</td>
</tr>
<tr>
<td>D50H</td>
<td>Hood for D50S Series Connectors</td>
</tr>
</tbody>
</table>

**Data Books**

<table>
<thead>
<tr>
<th>Part No.</th>
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<tbody>
<tr>
<td>210830</td>
<td>Intel Memory</td>
</tr>
<tr>
<td>210844</td>
<td>Intel Microprocessor</td>
</tr>
<tr>
<td>30001</td>
<td>National CMOS</td>
</tr>
<tr>
<td>30003</td>
<td>National Linear</td>
</tr>
<tr>
<td>30005</td>
<td>National TTL Logic</td>
</tr>
<tr>
<td>30009</td>
<td>Intel Data</td>
</tr>
<tr>
<td>30013</td>
<td>Zilog Microprocessor</td>
</tr>
</tbody>
</table>

**SPEAKER**

- 1-3/16" Square • 5/32" Thick |
- 8 Ohm • 40 Watt |
- Stainless steel diaphragm • Ultra Slim |
- For alarms, music sounds, telephone equipment, computers, speech aids, etc.

**Part No.** TS30S

**Joysticks**

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>JS100K</td>
<td>10K Linear Taper Pots (with knob)</td>
</tr>
<tr>
<td>JS150K</td>
<td>15K Linear Taper Pots (with knob)</td>
</tr>
<tr>
<td>JVC-40</td>
<td>40K Video Controller in case (w/knob)</td>
</tr>
</tbody>
</table>

**DC5000**

- 20-pin 36" Single-Ended Socket |
- 24-pin 36" Single-Ended Socket |
- 34-pin 36" Single-Ended Socket |
- 40-pin 36" Single-Ended Socket |
- 50-pin 36" Single-Ended Socket |
- 20-pin 6" Double-Ended Socket |
- 20-pin 12" Double-Ended Socket |
- 6" Double-Ended Socket |
- 25-pin male 10" Double-Ended Plug |
- 25-pin male 10" 25-pin female |
- 36-pin Centronics 5' male |
- 36-pin Centronics 5' male to female |
- 36-pin Centronics 5' male to male |

**Micro Charts**

Instant Data on the Most Popular Computer and Microprocessor Parts

- Fully decoded data
- Compact 8" x 11" size
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- Clear and concise two-sided tables for:
  - Full instruction set, disassembly, ASCII, base conversion, pinout & much more...

**Part No.**

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- ML6502: 6502 (65XX)
- ML7400: 5400/7400 TTL Pinouts
- ML8080A: 8080A/8085A

**JE750 4-Digit Fluorescent Alarm Clock Kit**

The JE750 Alarm Clock Kit is a versatile 12-hour digital clock with 24-hour alarm. The clock has a bright 0.5" high blue-green fluorescent display. The display will automatically dim with changing light conditions. The 24-hour alarm allows the user to disable the alarm and immediately re-enable the alarm to activate 24 hours later. The kit includes all documentation, case and wall transformer. Other features: flashing colon, alarm tone 500Hz once per sec., 10 minute snooze alarm, am/pm indicator. Size: 9 X 13 X 1.25".

**Part No.** JE750 Kit

**Centronics**

- Solder Type |
- Insulation Displacement Type

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>CEN36M</td>
<td>36 Contact Male-Insulation Displacement</td>
</tr>
<tr>
<td>CEN36F</td>
<td>36 Contact Female-Insulation Displacement</td>
</tr>
<tr>
<td>57-30380</td>
<td>36 Contact Male - Solder</td>
</tr>
<tr>
<td>57-60380</td>
<td>36 Contact Female - Solder</td>
</tr>
</tbody>
</table>

**D-Sub Connectors**

**Insulation Displacement Cables**

<table>
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<th>Part No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>S20-36</td>
<td>20-pin 36&quot; Single-Ended Socket</td>
</tr>
<tr>
<td>S26-36</td>
<td>26-pin 36&quot; Single-Ended Socket</td>
</tr>
<tr>
<td>S34-36</td>
<td>34-pin 36&quot; Single-Ended Socket</td>
</tr>
<tr>
<td>S40-36</td>
<td>40-pin 36&quot; Single-Ended Socket</td>
</tr>
<tr>
<td>S50-36</td>
<td>50-pin 36&quot; Single-Ended Socket</td>
</tr>
<tr>
<td>S20-6S</td>
<td>20-pin 6&quot; Double-Ended Socket</td>
</tr>
<tr>
<td>S20-18S</td>
<td>20-pin 18&quot; Double-Ended Socket</td>
</tr>
<tr>
<td>S26-18S</td>
<td>26-pin 18&quot; Double-Ended Socket</td>
</tr>
<tr>
<td>S50-18S</td>
<td>50-pin 18&quot; Double-Ended Socket</td>
</tr>
<tr>
<td>DB25P-10-P</td>
<td>25-pin male 10&quot; Double-Ended Plug</td>
</tr>
<tr>
<td>DB25P-10-F</td>
<td>25-pin male 10&quot; 25-pin female</td>
</tr>
<tr>
<td>CEN36M-5</td>
<td>36-pin Centronics 5' male</td>
</tr>
<tr>
<td>CEN36M-5-F</td>
<td>36-pin Centronics 5' male to female</td>
</tr>
<tr>
<td>CEN36M-5-M</td>
<td>36-pin Centronics 5' male to male</td>
</tr>
</tbody>
</table>
RF MODULATOR
(ASTEC UM1082) QUANTITIES LIMITED

- PRESET TO CHANNEL 3
- USE TO BUILD TV-COMPUTER INTERFACE
- +5 VOLT OPERATION

POWER SUPPLIES
IDEAL FOR HOBBIEST BENCHMARK & DO-IT-YOURSELF 90-DAY WARRANTY! NEW & UNUSED QUANTITIES LIMITED!

ASTEC AA11190
- QUAD OUTPUT SWITCHING
- DESIGN AS USED IN APPLE II!
- +5 @ 1.5A, -5 @ 1.5A
- +12 @ 500mA
- AUXILIARY AC OUTLET
- QUANTITIES LIMITED!

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* +5 VOLT OPERATION
* +12@ 2.5A; -12@ .30A; 15.5"x4.5"x2"

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Model 2PC2241
- DESIGNED FOR DEC EQUIPMENT
- FUSE PROTECTED
- LINEAR DESIGN
- AUXILIARY AC OUTLET
- +5 @ 4A; -15V @ 1.5A; 12.25"x4.475"

QUANTITIES LIMITED!

OUR BUYER BLEW IT...
& BOUGHT TOO MANY OF THESE!

4116 250NS 8/7.95

RF MODULATOR
(16K EPROMS) $39.50 EA

4116
250 NS 8/$79.50

CAPACITORS
TANTALUM

<table>
<thead>
<tr>
<th>VALUE</th>
<th>PN</th>
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<tr>
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<tr>
<td>0.1F</td>
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DISC

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47uf mono 50V, 0.30uf mono 25V

ELECTROLYTIC

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<tbody>
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47uf mono 50V, 0.30uf mono 25V

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3uf mono 50V, 0.1uf mono 25V

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6pin ST, 10pin ST

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24pin 1.25, 48pin 1.25

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100K, 500K

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330, 0.1F, 0.2F, 0.3F, 0.4F

1K, 10K, 100K

220, 470, 1000

33, 100, 1K, 10K, 100K

1, 10, 100, 1K, 10K, 100K

4.7, 10, 100, 1K, 10K, 100K

1uf, 4.7uf, 10uf, 100uf

22uf, 47uf, 100uf

10uf, 47uf, 100uf

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FOR SALE: Apple II Plus compatible 48K Syscom Computer with 16K Apple language card, RF modulator, disk controller card (3.2 or 3), Radio Electronics disk drive, and ten disks of software (finance, utilities, games, etc.). All in super condition. $1050 takes it. (COD OK with $100 down payment) M. C. Smalley, 4793 Grant, Saginaw, MI 48633. (517) 791-2733.

WANTED: A Commodore 4040 dual-drive disk. Also, an interface that will let me run a Commodore 64 with a 4040 dual-drive disk (or a 2031 single-drive disk) and a Commodore 4022 printer. Also, numerous Commodore programs for sale. Melvin Sill, 412 Holybrook Dr., Midland, MI 48640. (517) 631-7607.

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FOR SALE: Racal-VIDAC 1200-bps modem. Model VA 1250, 55 x 55, 3.5" disk. Great buy but half duplex and uses Bell or Western Electric 202, the original rate protocol or computer interface. $91 or best offer. Adam Sundor, 4537 Osage Ave., Philadelphia, PA 19143. (215) 748-6463.

FOR TRADE: Apple owners including MicroTec. Send (air mail) me a list of your software, and I will send me in exchange an Apple. [Z. N. Nielsen, ARAMCO, POB 4750, Ras Tanura, Saudi Arabia.]

NEEDED: Word-processing success stories bought by editor especially looking for form letters you've written that use: bureaucratic red tape. get jobs. settle grievances, etc. I'll call you. Hugh Deadwyler, POB 419, Newell, NC 28126.

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